EARLY EXPERIMENTS IN SUBMARINE WIRELESS

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Three articles recently appearing in THE SUBMARINE REVIEW discuss the history of submarine radio communications in the United States Navy.[1] The first of these chronicles submarine radio developments through the 1920s, devoting a majority of space to the First World War (1914-18) and after. The article's authors point out that by 1910 several U.S. submarines had been equipped with transmitters and receivers; they also describe a *primitive* antenna system installed on OCTOPUS (C-1) around the same time.[2] Yet OCTOPUS appears not to have been one of the original test platforms for submarine radio communications. That honor belongs to several other boats, notably STINGRAY (C-2), NARWHAL (D-1), and GRAYLING (D-2), each of which conducted important wireless experiments in 1909-10.

This article examines those experiments, as well as another series of tests performed in 1915 that likely were the first in which American naval personnel used a floating-buoy antenna designed for a submarine. In aggregate, these experiments demonstrate that the individuals who worked with submarines a century ago were aggressively trying to get radio on boats and out to sea. Before exploring such efforts, however, a quick overview of the Navy's work with wireless prior to 1909 is necessary.

The first United States naval officer to communicate from a warship via electromagnetic radiation was Bradley A. Fiske, who in 1887 signaled between his ship and a nearby pier. Fiske accomplished this by passing current through copper plates suspended beneath his ship and the pier, but when he tried to implement this system on moving vessels it failed to work. Fiske went on to other endeavors, one of which involved inventing and developing the stadimeter, a device well known to later generations of submariners.[3]

While Fiske was perfecting his stadimeter, the U.S. Navy experimented with ways to extend the range at which signals could be sent and received. One interesting avenue of research involved messenger pigeons, but this work barely had begun when a new technology arrived on the scene.[4] That technology was wireless telegraphy, which Guglielmo Marconi first demonstrated to American naval officers in the fall of 1899. Marconi's demonstration showcased the potential of radio when during one trial two cruisers thirty-six nautical miles apart, communicated successfully.[5] But Marconi had not yet solved the problem of interference, and he insisted on annual royalty payments, something the Navy Department could not legally disburse. A few years passed before the Navy purchased its first radios, from a German company, in February 1903. The fleet utilized these several months later in an exercise conducted off the New England coast.[6]

The Battle of Tsushima (27-28 May 1905), during which the Japanese naval commander used wireless more judiciously than his Russian counterpart, seems to have created a new sense of urgency within the Navy Department over the adoption of radio. Yet exercises conducted in July 1905 and January 1906 revealed that interference was still a major problem.[7] Spark gap transmitters, the only reliable type during the first decade of the twentieth century, produced highly damped waves (i.e., their energy was dispersed over an extremely wide frequency band), and early receivers were temperamental, particularly under the harsh conditions of shipboard use. Fortunately, better equipment was on the way. Dependable arc transmitters would become available in time for World War I, but even before then Marconi and others introduced the *quenched* spark gap, a transmitter that minimized damping and thus helped overcome the interference problem. Receivers improved too, especially after Greenleaf W. Pickard patented his crystal detector near the end of 1906. Soon thereafter, Pickard founded a company that sold many of these devices to the U.S. Navy.[8]

By the end of the first decade of the twentieth century, then, wireless technology had advanced to the point where submarine radio was a realistic possibility. The Bureau of Equipment, which held responsibility for radio, was favorably inclined toward the idea but needed a few subs on which to conduct experiments. Fortuitously, in the spring of 1909 the Fore River Ship and Engine Company in Quincy, Massachusetts, had just launched and was completing work on three submarines: STINGRAY, TARPON, and NARWHAL.[9] STINGRAY and TARPON were C-class boats, designed by Lawrence Y. Spear and built in Quincy under a subcontract from the Electric Boat Company. Each had a single hull, contained internal ballast tanks, and displaced 275 tons submerged. NARWHAL, built under the same contractual arrangement, was nearly identical in design but larger, displacing 337 tons submerged. She was the lead ship of the U.S. Navy's D-class submarines.[10]

Testing commenced in June 1909 with a schedule that called for experiments on both STINGRAY and TARPON, but the latter had an unrelated material problem so STINGRAY became the sole test platform. She received a compressed air (i.e., quenched) spark gap transmitter designed by Canadian-American inventor Reginald Fessenden, but naval electricians quickly discovered a broken condenser on that device.[11] As such, no transmitting tests could be performed. STINGRAY succeeded in receiving messages from the nearby Boston Navy Yard, however, a feat that may have been a first for an American submarine.[12]

A few weeks later the Bureau of Equipment used another submarine, NARWHAL, for a wireless experiment designed to ascertain if underwater reception of radio was possible. Of course, this was similar to what Bradley Fiske had tried to accomplish more than twenty years earlier. This time around, the navy installed two brass plates below the waterlines of NARWHAL and a service vessel. Electricians ran insulated leads vertically up from these plates to each ship's deck. Initially the service vessel, then NARWHAL, succeeded in receiving signals from a nearby warship. When the leads were run from NARWHAL's deck down the hatch and into the pressure hull, though, the signals became very weak. This led George H. Clark, the radio expert observing the experiment, to report "that the presence of a metallically continuous screening around the leads from the under water plates to the receiver is very detrimental."[13]

Still needing to determine the feasibility of underwater wireless communications, in June 1910 the Bureau of Equipment conducted more tests on another D-class submarine, GRAYLING. These experiments initially mirrored those done on NARWHAL, with metal plates (this time copper, instead of brass) being submerged beneath the hull. The receiver on GRAYLING was almost certainly better than the one used the previous year, although electricians learned that one type of crystal detector "was very quickly put out of commission by the battery gas present within the boat."[14] After the initial configuration demonstrated reliable signal reception, sailors moved the copper plates topside and hung them on oars lashed to GRAYLING's diving masts (figure 1).

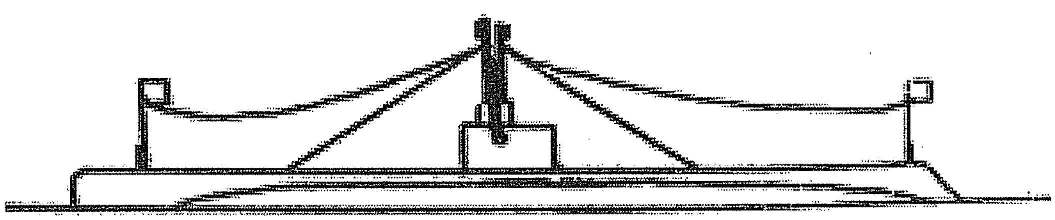

Figure 1. A sketch by George H. Clark showing an antenna arrangement during GRAYLING's wireless experiments in 1910. Courtesy of the National Museum of American History Archives Center (NMAH Archives). All four figures in this article are digital images taken by the author from documents in the George H. Clark Radioana Collection, series 100, box 293. See note 12 for citation information.

The submarine then submerged to various depths while moored to the pier. The copper plates touched water when GRAYLING submerged to ten feet, and were covered completely at twelve feet. Signals could be heard to a submerged depth of fifteen feet (i.e., the top of the plates were three feet beneath the water), but no deeper. According to George Clark, the GRAYLING experiments demonstrated conclusively "that there is some penetration of sea water by electro-magnetic waves, but that this is not sufficient to enable a method of wireless communication . . . to be employed in practice."[15]

Clark captured the essence of a problem that continues to plague submariners even today: how to communicate while submerged. Recently the Defense Advanced Research Projects Agency, as part of their TRITON program, awarded a $31.8 million contract for the construction of a blue-laser underwater communications system slated for trials in July 2012. Meanwhile, Lockheed Martin continues its work on buoys that potentially will allow for better two-way communications between submarines and shore stations, ships, and/or aircraft.[16] In the early twentieth century the Triton program would have represented science fiction, but the buoy concept was certainly comprehensible. And while today's engineers wrestle with issues of how to maintain radio connectivity at *both* depth and speed, naval personnel in the 1910s had their own idea about how to transmit from a submerged submarine. That idea centered on a floating-buoy antenna.

Cold War submariners undoubtedly will recall the BRA-8, a towed-communications buoy used by SSBNs to receive messages while on patrol. Its original forebear never had a name, but dates to 1915, when American naval personnel tested a floating-buoy transmitter. Known sources do not positively identify who first conceived of such a device, but many submariners surely would have liked the idea of being able to send messages without having to surface.[17] The experiments on GRAYLING in 1910 had demonstrated that a sub could receive messages while partially submerged, but transmitting through water was an altogether different matter. Likely prompted by someone familiar with submarines, the Bureau of Steam Engineering, which by then had assumed responsibility for naval radio, explored the potential of the floating-buoy transmitter in November 1915. The bureau's tests involved two different arrangements for exciting a *small* antenna mounted on a buoy that was to be "carried in a 'nest' in the submarine [and] so arranged that upon being released, it will float to the surface with its antenna."[18] The first arrangement proposed locating the entire transmitter inside the submarine, with an insulated cable running up to the antenna (figure 2).

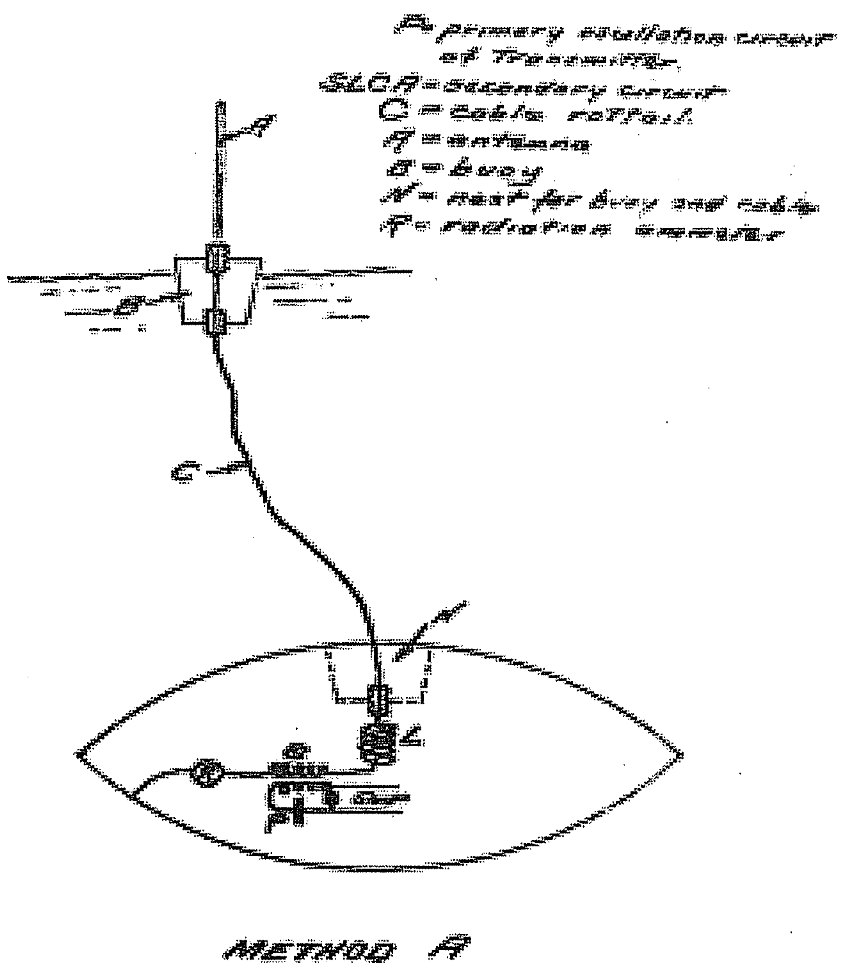

Figure 2. Schematic of a floating-buoy transmitter tethered to a submarine. In method A, shown here, the entire transmitter is inside the submarine. Courtesy of the NMAH Archives. See note 18 for citation information.

The second arrangement proposed placing a majority of the transmitting equipment on the buoy itself (figure 3).

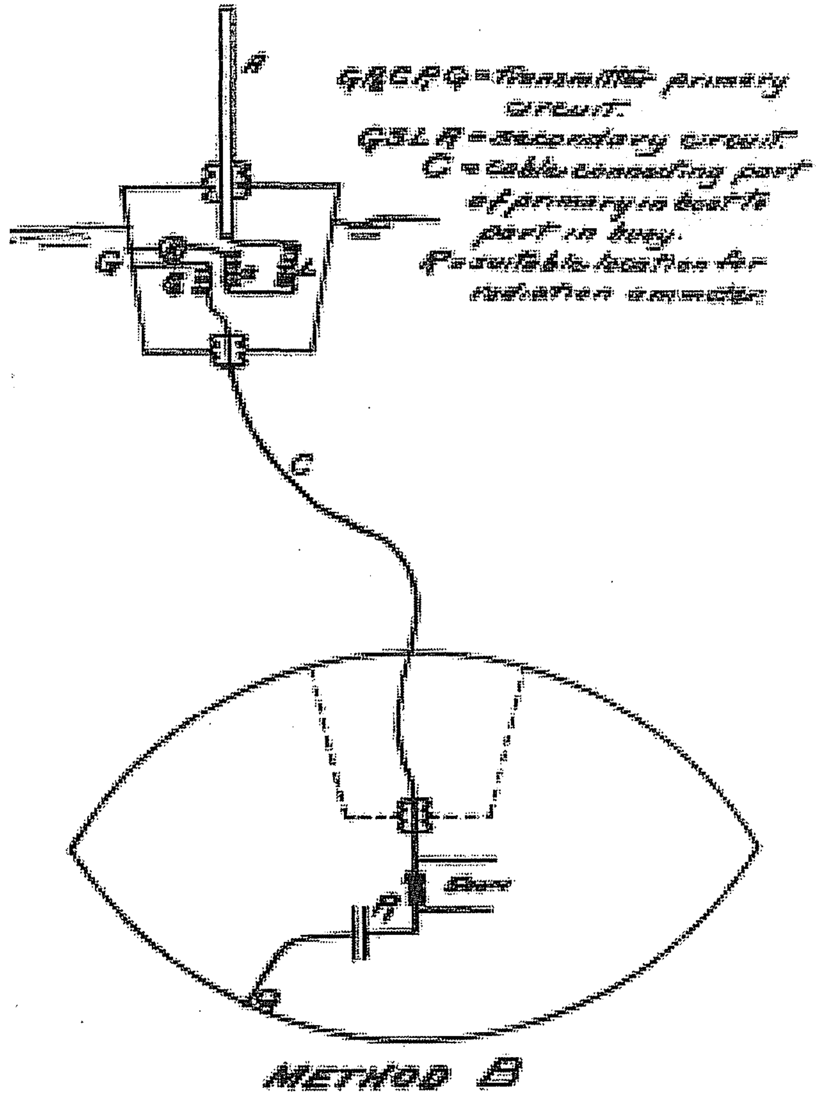

Figure 3. Schematic of a floating-buoy transmitter tethered to a submarine. In method B, shown here, most of the transmitting equipment is on the buoy. Courtesy of the NMAH Archives. See note 18 for citation information.

Standard shipboard antennas of the era were usually quite long, often 80 feet or more in length. Obviously this would not work for a buoy carried by a submarine, so the bureau tested three relatively compact antennas during the trials. The first was a 20-foot tall vertical pipe antenna with kite aerials; the second was simply a 10-foot tall pipe, apparently borrowed from the navy's stock of interior communications voice tubes; and the third was a spiral antenna made of looped copper wire (figure 4).

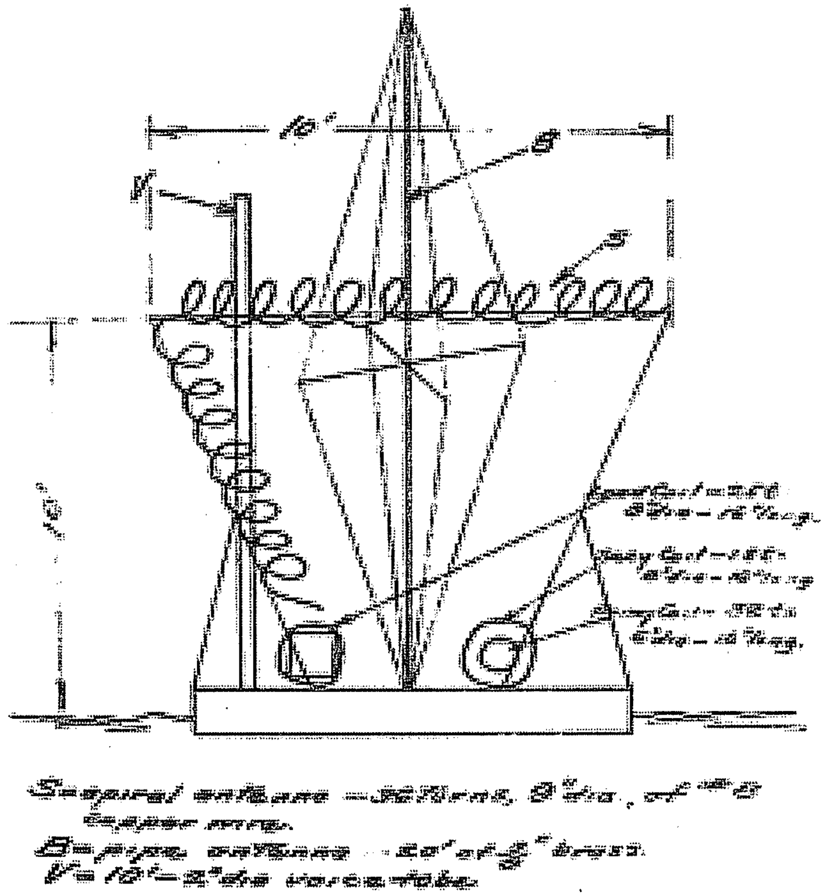

Figure 4. Sketch of the three antenna configurations tested during the U.S. Navy's floating-buoy transmitter experiments of November 1915. The kite aerial worked best (annotated "B"), although the 10-foot antenna (annotated "V") clearly would have been the easiest to store on a submarine. Courtesy of the NMAH Archives. See note 18 for citation information.

The recently launched destroyer CONYNGHAM (DD-58), moored in Philadelphia, simulated a submarine with a specially installed spark-gap transmitter equal in power to that which could easily be fitted on a sub. After a routine check of CONYNGHAM's own antennas, a 180-foot insulated lead was placed in the water and attached to the floating buoy. Each of the three antennas radiated at between 4.5 and 4.8 amperes, inclusive, with the tallest antenna giving the best results.[19] Yet the signals were not sufficiently strong to be heard by wireless operators just eight miles away. Would the results be better when electricians moved transmitting apparatus onto the buoy itself? Unfortunately, the answer was no. In fact, the results were significantly worse, with a maximum radiated signal of only 1.0 ampere. Although the first arrangement had proven superior, it was nevertheless inadequate, leading the officer who observed the tests to report "that it will probably be impossible to work the desired 30-50 miles with a 1/4 KW set, and the small antenna that can be used."[20] In short, the trials revealed that a promising idea was simply not practicable with the technology then in existence.

Indeed, the promise of a floating-buoy transmitter would not be realized until the advent of high-frequency radio, and routine use of such devices would have to await the Cold War, when the BRT-1 SLOT (Sub Launched One-way Transmitter) buoy became standard equipment on board U.S. submarines. While such developments lay well in the future, the experiments conducted on STINGRAY, NARWHAL, GRAYLIONG and CONYNGHAM in the early twentieth century made clear to American naval personnel the basic limitations of early submarine radio. They also marked a critical first step toward solving the inherent challenges of submarine communications.

ENDNOTES

1. Edward Monroe-Jones and Robert Baker, "A Summary History of Submarine Radio Communication: Part One," THE SUBMARINE REVIEW 28, no. 3 (July 2010): 37-49; idem, "A Brief History of Submarine Radio Communication: Part Two" THE SUBMARINE REVIEW 28, no. 4 (October 2010): 71-82; and idem, "A Brief History of Submarine Communication: Part Three," THE SUBMARINE REVIEW 29, no. 1 (January 2011): 106-111.

2. Submarines commissioned after USS HOLLAND were given fish names until 17 November 1911, at which point the Navy Department started assigning class letters and numerals (e.g., PLUNGER became A-1, ADDER became A-2, VIPER became B-1, etc., etc.).

3. Bradley A. Fiske, *From Midshipman to Rear Admiral* (New York: Century Company, 1919), 72-76, 99-101, 208-209; and Paola E. Coletta, *Admiral Bradley A. Fiske and the American Navy* (Lawrence: University Press of Kansas, 1979), 40-41.

4. Henri Marion, "Homing Pigeons for Sea Service," United States Naval Institute Proceedings 22, no. 1, (1896), 643-654.

5. John B. Blish, "Notes on the Marconi Telegraph," *United States Naval Institute Proceedings 25*, no. 4, (1899), 857-864.

6. Bureau of Equipment (BuEq) to Secretary of the Navy (SecNav), 1 October 1902, in *Report of the Secretary of the Navy, 1902* (Washington: U.S. Government Printing Office, 1902), 376; BuEq to Bureau of Supplies and Accounts, 28 February 1903, and BuEq to Commander-in-Chief, North Atlantic Fleet, 27 July 1903, in boxes 87 and 19, respectively, General Correspondence, 1899-1910, Records of the Bureau of Equipment, Records of the Bureau of Ships, Record Group 19, National Archives Building, Washington, D.C. (hereafter cited as RG19/BEQ).

7. Lieutenant Louis A. Kaiser, third endorsement to file no. 118, 540, 24 August 1905, box 36, RG19/BEQ; and SecNav to Commander-in-Chief, North Atlantic Fleet, 2 February 1906, summarized in Linwood S. Howeth, *History of Communications-Electronics in the United States Navy* (Washington: U.S. Government Printing Office, 1963), 111-112.

8. Greenleaf W. Pickard, "Means for Receiving Intelligence Communicated by Electric Waves," U.S. Letters Patent No. 836, 531, 20 November 1906; and Maurice L. Sievers, *Crystal Clear: Vintage American Crystal Sets, Crystal Detectors, and Crystals* (Chandler, Ariz.: Sonoran Publishing, 2008), 15-16.

9. BuEq to SecNav, 14 October 1909, in *Report of the Secretary of the Navy, 1909* (Washington: U.S. Government Printing Office, 1909), 264. The Navy later redesignated TARPON as C-3.

10. K. Jack Bauer and Stephen S. Roberts, *Register of Ships of the U.S. Navy, 1775-1990* (Westport, Conn.: Greenwood Press, 1991), 254-256.

11. On early radio transmitters the condenser was a system of conducting and insulating materials used to store electrical energy.

12. George H. Clark to Lieutenant Commander Cleland Davis, 12 June 1909, box 293, History of Naval Radio (Series 100), George H. Clark Radioana Collection, Archives Center, National Museum of American History, Smithsonian Institution, Washington, D.C. (hereafter cited as CC/100). Clark does not specify STINGRAY's location during the tests, but she likely received these messages while moored.

13. Ibid.

14. George H. Clark to BuEq, 13 June 1910, box 293, CC/100.

15. Ibid.

16. The acronym TRITON stands for Tactical Relay InformaTIOn Network. Assistant Secretary of Defense Press Release, 24 September 2010, http://www.defense.gov/contracts/contract.aspx?contractid=4374 (viewed 31 May 2011), and "Lockheed Martin Awarded $35.8 Million Navy Contract to Expand Submarine Communication Capabilities," 3 February 2009, http://www.yourdefencenews.com/news_item.php?newsID=22894 (viewed 31 May 2011).

17. Archival records show that a civilian inventor proposed a floating-buoy antenna to the Navy in 1912, but the service found it operationally impractical. Engineer Officer to Commandant [New York Navy Yard?], "Re-method of installing radio telegraph antenna on submarine torpedo boats for operation after submersion," 22 May 1912, box 292, CC/100.

18. D. Pratt Manney, "Report on Tests of Two Methods for Radio Communication from a Submerged Submarine," 30 November 1915, box 293, CC/100.

19. At the time of these tests antenna radiation generally was expressed in amperes rather than watts.

20. D. Pratt Manney, "Report on Tests of Two methods for Radio Communication from a Submerged Submarine," 30 November 1915, box 293, CC/100.