"FIRE IS ALMOST CERTAIN TO FOLLOW:"
THE DEVELOPMENT OF FIRE-FIGHTING TECHNOLOGY
IN THE UNITED STATES NAVY, 1920-1942

A Thesis
Presented in Partial Fulfillment of the Requirements for
the Degree Master of Arts in the
Graduate School of The Ohio State University

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The Ohio State University
1998

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ABSTRACT

By the last year of the Second World War, US Navy fire fighting capability was superior to that of any other maritime force. This capability saved many ships from destruction. Many naval historians, following the lead of Samuel Eliot Morison in his History of United States Naval Operations in World War Two, credit this fire fighting mastery to a program of training and research and development that followed Pearl Harbor.

In fact, the US Navy set the foundation for this fire fighting capability in the 1930s. The spur for this effort was the deployment of the great fleet carriers Lexington and Saratoga, the largest and fastest major US warships of the era. Each big carrier had aboard some 140,000 gallons of highly volatile aviation gasoline. The entry of the big carriers into service, therefore, promoted the development of several types of key fire fighting equipment, including steam and carbon dioxide smothering systems, chemical and mechanical foam projectors, the portable self-powered pump, and, especially, the fog nozzle.

This thesis also explores the key role of several US naval officers in the development of this technology. In the 1930s, Edward Cochrane, later head of the Bureau of Ships, Joseph M. Kiernan of the Bureau of Construction and Repair, and acting Chief
of Naval Operations Joseph Taussig strove for the development and adoption of this fire fighting gear despite the inertia of an often complacent naval bureaucracy. As a result of their efforts this essential fire fighting equipment had been examined, tested, and put into service, if in small quantities, before Pearl Harbor.

The US Navy also drew on US civilian and foreign nations’ expertise and experience in fire fighting before our entry into war. In the 1930s, the Navy established an informal program of information exchange with civilian fire fighting organizations. The Navy also monitored foreign knowledge of fire fighting, gaining vital information before Pearl Harbor from the British wartime experience.

The Navy, however, did not match its exploration of fire fighting technology with the development of fire fighting practice. In the 1930s it failed to realize the importance of training its crews in sophisticated fire fighting techniques. Even so, the US Navy recognized the need for fire fighting schools and regular training before America’s entry into the war.

In brief, this paper confirms a number of beliefs about new technology. Its adoption is fostered by the work of a small group of visionaries who push for the new development in the face of initial setbacks and organizational inertia. Second, the Navy’s experience with fire fighting stresses the importance of training. The best equipment in the world will not function without trained personnel. By the end of the war the US Navy had both.
For Joseph and Veronica Snyder
who made it possible
ACKNOWLEDGMENTS

I must first express deep gratitude to my advisor, Dr. John Guilmartin, for his steady guidance and encouragement. Sincere appreciation is also due Dr. Allan R. Millett and Dr. Alan Beyrenchen, members of the thesis defense committee, for their insight and well-chosen suggestions for improvement. I am also indebted to Dr. Peter Maslowski of the University of Nebraska for the loan of an important document.

I also gratefully acknowledge the remarkable assistance given by William Roberts (Lt. Cmdr., USNR, ret.) and William Roberts, Jr. (Cmdr, USN, ret.) To this thesis they contributed considerable time and scarce original documents. Commander Roberts, in particular, drew on his expertise as a naval engineer to save this landlubber from some embarrassing technical errors.

Expertise also characterizes Rebecca Livingston and Barry Zorby of the National Archives. Thorough professionals, they often knew what I needed better than I did, and were essential guides through the maze of US naval records.

My friends Edward and Annette Eliasberg, Kathy and Greg Tkac, and Lois Alberelli also deserve my thanks for their assistance. They gave generously of their hospitality, time, and
other resources. Without their kindness I could not have conducted the research necessary for this project.

My fellow graduate students, Paul Westermeyer, Amy Vail, and Elliot Meadows provided valuable editing assistance, constructive comments, and necessary support.

Finally, but hardly least, substantial recognition is due my family. I have no ability to repay, in word or deed, the love and material assistance of my grandmother, Veronica Snyder. She and my late grandfather, Joseph Snyder, set me an example of excellence and fortitude few today can match and none can surpass. I have been privileged to know and love them.

My brother, Ken Snyder, has been a powerful reinforcement and serves to ground me in reality when I find myself wandering away from that domain. He shares with my mother a remarkable ability to keep me moving in the right direction. I love him, respect his considerable abilities, and owe him a great deal.

My mother, Joanna Snyder, deserves very special mention indeed. The finest student in our family, she has been a model of courage, compassion, and brilliance my entire life. No one could find a better mother, and I love her deeply.

It is no exaggeration to say that without the aid of these people this work could not have been possible. It is also no exaggeration to say that any errors of fact or interpretation found in these pages are my responsibility alone.
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<tr>
<td>BuShips</td>
<td>Bureau of Ships</td>
</tr>
<tr>
<td>C&amp;R</td>
<td>Bureau of Construction and Repair</td>
</tr>
<tr>
<td>ONO</td>
<td>Chief of Naval Operations</td>
</tr>
<tr>
<td>NARA</td>
<td>National Archives and Records Administration</td>
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<td>ONI</td>
<td>Office of Naval Intelligence</td>
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<td>Records of the Bureau of Ships, 1794-1943 and predecessors; specifically, the Records of the Bureau of Construction and Repair, 1843-1940</td>
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CHAPTER 1

INTRODUCTION

"Regardless of the nature of a battle casualty, be it from bomb, torpedo, or shell hit, fire is almost certain to follow."

— Lecture at Naval Training School, (Damage Control), Philadelphia, 1942

The performance of the United States Navy in the beginning of World War Two has drawn considerable criticism, especially in the sphere of fire fighting. Several major US naval vessels, some historians note, were lost to fires which spread out of control, fires that might have been quenched with the benefit of equipment, doctrine, and practice equal to that found late in the war. Despite these observations, the history of naval fire fighting, and certainly the developments in this field in the 1930s, remains too little examined.

Numerous authors have noted the frequency with which fire disabled or destroyed ships in that conflict. In this context the loss of Lexington on May 8, 1942 in the battle of the Coral Sea is

1. Digest of the Course of Study at the Naval Training School (Damage Control), Philadelphia, PA, (US Navy Department, Naval Training School (Damage Control) Philadelphia, private printing, May, 1944.) 113. I am indebted to Dr. William Roberts for the loan of this document. (hereafter cited as Digest of the Course of Study . . .).
significant. While this prominence is understandable — *Lexington* was the first U.S. aircraft carrier lost to enemy action in the war, the first capital ship loss following Pearl Harbor, and, to this day, the largest U.S. warship lost in action\(^2\) — it has had unfortunate historiographical ramifications, distorting our understanding of a key aspect of U.S. Navy damage control in World War Two: fire fighting.

During the battle of the Coral Sea in May, 1942, at least two torpedoes and one bomb struck *Lexington*. Within an hour after the attack the crew had corrected a list and put out the fires. The ship was moving at 25 knots and recovering aircraft. Gasoline fumes then exploded, causing major fires and killing many crewmen. Over the next several hours *Lexington* suffered many more gasoline vapor explosions, which eventually forced the abandonment of the carrier.\(^3\)

This early and apparently unnecessary loss of a key vessel appeared to generate a great deal of activity on the part of the

\(^2\) At 38,000 tons (design displacement after the 1936 refit) *Lexington* was some four thousand tons heavier than USS *Arizona*, the second largest warship loss of the U.S. Navy. Norman Friedman, *U.S. Aircraft Carriers: An Illustrated Design History*, (Annapolis, MD: U.S. Naval Institute, 1983), 390; Norman Friedman, *U.S. Battleships: An Illustrated Design History*, (Annapolis, MD: U.S. Naval Institute, 1985), 440. While USS *Langley* was sunk earlier, it was no longer functioning as an operational aircraft carrier but as an aircraft transport.

Navy regarding fire fighting. Several historians noted this activity and concluded — logically, but as will be demonstrated, erroneously — that the late-war American excellence in fire-fighting stems from this incident.

All too few historians, however, have seriously assessed the importance of fire fighting in ensuring ship survival. One group of writers, including Fleet Admiral Chester Nimitz, has noted the importance of fire in causing combat casualties but have had little to say regarding fire fighting. Conversely, other historians have noted the US superiority to the Japanese in fire fighting as an important tactical — indeed strategic — advantage, but offer no details.4

A final group of naval historians comments on the American World War Two fire fighting practice and doctrine, but fails to identify correctly when the Navy established the foundations for this superiority or what caused it. The "semi-official" historian of the US Navy in the Second World War, Samuel Eliot Morison, gave his views regarding the origins of the American fire-fighting superiority in the fourteenth and last volume of his series, Victory in the Pacific. (Morison's work is worth quoting in full, and so appears in the appendix to this work, together with a general historiographical review.)

The only academic paper which has to date addressed this topic was a University of Nebraska master's thesis on damage control. This work investigated damage control in the US Navy in World War Two. It examined fire fighting during the conflict but not its pre-war antecedents. This thesis gave interwar naval fire fighting developments short shrift and, in so doing, it appeared to follow the view Morison propounded.

These naval historians have left a misleading impression. Documents in the National Archives, US naval records from 1920 to 1941, reveal that the US Navy was quite concerned about fire as a damage control problem well before Pearl Harbor. Despite the lack of resources available as a result of the Depression, the Navy, driven by the initiative of a small number of officers, undertook significant efforts to develop more effective fire fighting apparatus.

5. Robert A. Osmundsen, "Damage Control and Fire Fighting in the United States Navy During World War Two," (M.A. thesis, University of Nebraska/Lincoln, December 1994); I am indebted to Dr. Peter Maslowski, Mr. Osmundsen's adviser, for the loan of this document.

6. Osmundsen, "Damage Control . . ."; 1-2, 35, 55; he stated, for example, on page 35 that before the war "the only installed extinguishing system on board every warship was ammunition magazine sprinkling. . . . [t]he evolution of wartime damage control included the invention [emphasis added] and adoption of new equipment. Much of the equipment used in 1945 was not available on 7 December 1941." (35). Osmundsen may be technically accurate but the impression he leaves is misleading. An examination of the S93 (fire fighting) files of the Bureau of Construction and Repair [C&R] in the Archives shows that the vessels built or seriously modernized in the 1930's had foam systems or sprinklers or both in firerooms and other engineering spaces; had added some form of portable self-powered pump; and, if an aviation ship, had some form of protection for shipboard gasoline. Perhaps the World War One vintage vessels were this short of fire fighting gear, but the more modern ones were not.
In brief, before its entry into the war the Navy did its job, attempting to anticipate problems and devising solutions before being confronted with its own burning ships. While some of the approaches considered and adopted may have been less than ideal, the Navy did not neglect the issue. It did, in any event, use this time to build a foundation for later excellence in fire fighting.

The personnel involved in the development of fire fighting equipment and techniques between the First and Second World Wars proved to be of high quality. Contributing to the exploration of new fire fighting technology were Ernest King, William Halsey, Raymond Spruance, Aubrey Fitch, and Joseph Taussig, men who either then or later reached very senior positions in the Navy.

While the Navy made credible efforts to improve fire fighting equipment during the 1920s and 1930s, it neglected the human element — doctrine and training — in fire fighting. In short, the Navy, while seeking improved equipment, made no effort to improve its level of fire fighting practice from that of World War One or to devise realistic drills. Shortly before Pearl Harbor, however, the Navy learned from British experience with battle damage and decided to establish fire fighting schools to disseminate more sophisticated fire fighting techniques.  

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The state of fire fighting equipment, doctrine, and practice proved important in the Second World War because fire kills ships. Fire may not cause them to sink, but spreading fires can destroy a war vessel's ability to carry out its mission, to steam, steer, and use its weapons. Fire can and will halt its propulsion, stop its pumps, drive its crew from their posts, and otherwise cause havoc. If fire spreads to the magazines, it will cause the ship to sink — in pieces.

The US Navy recognized this in the Second World War. As a 1944 Navy document pointed out, "If he [the enemy] keeps on losing ships by fire, and we can reduce our losses by that means, we shall be a long way on the road to victory."  

Naval history has demonstrated that fire is a major factor in combat damage. In both world wars, uncontrolled fires destroyed numerous vessels. A partial list includes HMS Good Hope and Monmouth at the battle of Coronel (1914), their nemeses SMS Scharnhorst and Gneisenau later that year at the Falklands, SMS Mainz at Heligoland Bight, and HMS Black Prince at Jutland. In the Second World War, losses wholly or primarily due to fire included, in addition to Lexington, the British cruiser Southampton in January, 1941, the USS Astoria, Quincy, and

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8. *Digest of the Course of Study . . .*, 111.

9. Walter H. Bradley, treasurer of Pepperell Manufacturing Co., Boston, letter to Assistant Secretary of the Navy Theodore Roosevelt, Jr., May 9, 1922, file reference number 26630-64, box 1979, RG 80, NARA; Bradley was apparently drawing on a published British work of 1921.
Vincennes at Savo Island, the Japanese cruiser Mikuma at the battle of Midway, and numerous smaller American ships off Okinawa in 1945.¹⁰

About 1930, certain naval officers, especially the carrier captains, saw that the quality and quantity of fire fighting equipment was inadequate. They and their superiors pushed the responsible bureau of the Navy, the Bureau of Construction and Repair (henceforth abbreviated C&R) to re-examine the demands of fire fighting, develop new equipment, and issue it to the fleet. While the Navy made mistakes in this process, and failed to issue the new devices to the fleet in adequate quantities, it developed most of the highly capable fire fighting appliances of World War Two before the onset of war. Even the inability of the Navy to issue such devices in adequate number may have been a matter more of economics rather than bureaucratic inertia. The Depression had cut naval budgets severely.

CHAPTER 2

THE PROBLEM OF FIRE

Examination of what the Navy did in the 1930s and assessment of the value of its efforts requires a basic knowledge of fire. Once ignited, fire is sustained by an “unholy trinity” of fuel, heat, and oxygen. So long as all three are available, the fire will continue; should any one be denied, the fire will go out.\textsuperscript{11}

Fire fighting aboard ship is much less cost-effective than fire prevention. Since heat is an inevitable product of a shell or bomb explosion, and as oxygen will certainly be present, the best option to prevent a fire is to deny it fuel. Fortunately, most ships are steel, which only burns at extraordinarily high temperatures and oxygen concentrations; unfortunately, other furnishings are not so accommodating, and paint is both necessary and flammable. Complete fuel denial, then, is not realistic.

\begin{footnotesize}
\begin{enumerate}
\item[11.] Thomas J. Kelly, \textit{Damage Control: A Manual for Naval Personnel}, (New York: D. Van Nostrand & Co., 1951,) 86-7. Kelly’s first edition was published in 1944. See also Loren Bush, and James McLaughlin, \textit{Introduction to Fire Science}, (Beverly Hills, CA: Glencoe Press, 1970,) 34-5. Bush and McLaughlin note that fire requires a “reaction chain” in which combustible material decomposes into compounds which recombine with oxygen. Interruption of this reaction chain can also halt a fire. As this formulation would be an anachronism for the 1940s this work will not discuss approaches to fire fighting based on this concept.
\end{enumerate}
\end{footnotesize}
The nature of the fuel determined the nature of the fire and the best means of fighting it. In the 1940s the Navy had three classifications for fire. Class A included solid combustibles that leave embers, such as cloth, rope, or wood; water was the preferred means of extinguishing Class A fires. Class B fires involved combustibles that left no embers, notably flammable liquids such as petrochemicals and grease. Class C included fires in electrical equipment; the Navy ordained the use of non-conducting agents, such as carbon dioxide, to fight both Class B and Class C fires.\[12\]

Most US naval fire fighting drill in the interwar period focused on Class A fires, fought with the application of water. Water cools the fire by boiling when it contacts the heated air and fuel (reducing heat) and the steam produced helps to choke off the oxygen supply. At sea level, one pound of water requires 122 British Thermal Units (BTU) to go from 90°F to 212°F and an additional 970 BTU to vaporize into steam. As such, a gallon of water (some eight pounds) can draw roughly 8,700 BTU of heat energy out of a fire. This same gallon, which has a volume of about .13 cubic feet of water, will, when boiled, produce about 220 cubic feet of oxygen-denying steam.\[13\]

US Navy researchers recognized as early as 1930 that the smaller the particles of water in contact with the fire, the more

\[12\] Kelly, *Damage Control*, 87-8.

easily and quickly they will absorb heat and produce steam. This makes a mist or fog more desirable than a solid stream of water.\textsuperscript{14}

Another option is the use of inert gas, such as carbon dioxide (CO$_2$) to choke off the oxygen and so bring the fire to a halt. Carbon dioxide does not damage components as a sea water spray might. It does not, however, maintain the necessary concentration where air is moving briskly, such as on the deck of a moving ship. If the space in which the gas is released is too confined, such as in an small below-decks compartment, it might deny oxygen not only to the fire but to the fire fighters as well. Moreover, carbon dioxide's cooling effect is limited.\textsuperscript{15}

Another suitable weapon that both cooled and asphyxiated fire was foam produced by a mechanical churning or a chemical reaction. Chemical foams of this era usually contained aluminum sulfate, sodium bicarbonate, and a protein-based agent to stabilize the bubbles. Mechanical foam initially used hydrolyzed soybean protein as the base. Later formulae included proteins derived from fish scale, horn and hoof meal, or peanuts and corn.\textsuperscript{16} Foam adheres to surfaces, even to the top of a burning liquid, and so places a barrier between the burning material and the oxygen.


\textsuperscript{15} Kelly, \textit{Damage Control}, 87-8.

required to sustain the fire. Foam does not, however, cool the fire as well as water; in fact, it may hold in the heat.\textsuperscript{17}

Actual use of the three basic extinguishing agents noted above is more complex than it appears. While CO\textsubscript{2} could extinguish a Class A fire, its lack of cooling effect might leave the material hot enough to flash into flame again once the CO\textsubscript{2} dissipated. Water, most effective on a Class A fire, could readily harm electrical equipment in or close to a Class C fire and was horrendously counterproductive when sprayed as a stream indiscriminately on the burning liquid fuel of a Class B fire. The impact of a water stream will spread the burning liquid. The gasoline, moreover, floats on top of the water and continues to burn.

The presence of such a hazardous material as gasoline exacerbated fire prevention and fire fighting problems. After 1930 high performance aircraft appeared more frequently on shipboard. Operation of these aircraft demanded gasoline; aviation ships, (aircraft carriers and seaplane tenders) therefore, found themselves with large quantities of a highly flammable substance aboard.\textsuperscript{18}


\textsuperscript{18.} J. S. S. Brume and J. G. King, Fuel: Solid, Liquid, and Gaseous, (New York: St. Martin's Press, 1967,) 297, 305. The energy of combustion of gasoline is almost ten percent higher per unit of mass than that of unrefined crude oil.
The incendiary properties of gasoline were, in fact, at the heart of the damage control problem. Liquid gasoline does not burn. Its highly volatile vapors, however, more than compensate for this. They are extraordinarily flammable, even explosive. Liquid gasoline vaporizes whenever it exposes a surface to the air or any void at a temperature over -45° Fahrenheit. Both gasoline vapor and liquid, moreover, move readily, pass easily through relatively small openings, and, as they are heavier than air, tend to gather in inconvenient places. Gasoline also presents the danger of flashback; if gasoline vapor emitted from a tank ignites at any point in a ship, the flames will travel back along the trail of vapor and ignite the vapors present in and around the tank.\(^{19}\) This can rupture the tank, and release much more gasoline vapor to feed the fire.\(^{20}\) In brief, gasoline is second only to ammunition as the most hazardous substance aboard ship. As ammunition is stored in carefully-designed and well monitored magazines and moves only along well-guarded routes, in some regard gasoline may be more hazardous.

The Navy grew more interested in fire fighting after the introduction of several large aviation ships around 1930. The scale of the problem aboard those vessels was formidable: *Lexington*-class carriers at full load carried some 140,000

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gallons of aviation gasoline. Even a fairly small seaplane tender, the USS Wright, carried 7,000 gallons in 1935.\textsuperscript{21} Other ships carried considerably less gasoline; but battleships and cruisers carried scouting and fire direction seaplanes\textsuperscript{22} and most warships carried gasoline-powered small boats.\textsuperscript{23}

Electrical fires were another special case, albeit less worrisome than gasoline fires. In the 1930s, a large number of the newest and largest ships of the Navy, including the most recently commissioned battleships and the fleet carriers Lexington and Saratoga, had turbo-electric drive. In this propulsion system steam-powered turbines drove generators that powered electric motors that turned the propeller shafts. These systems involved high voltages and strong electrical currents, and were quite vulnerable to both fire and water damage. The Navy did install banks of CO\textsubscript{2} cylinders in gasoline and dope storerooms in


\textsuperscript{23} E. O. Love, Special Representative of the U.S. Fire Protection Corporation, letter to C&R, October 22, 1933; file S15-(6), box 3976, RG 19, NARA.

13
the 1930s.\textsuperscript{24} The Bureau of Engineering was responsible for installation of fixed fire fighting equipment in engineering spaces. A more detailed discussion of CO\textsubscript{2}, foam, and specialized engineering-space apparatus will appear later in the paper.

With the basics of fire fighting in mind, let us review briefly the history of fire fighting at sea. Fire was a constant threat in the era when ships were wooden and powered by sail; the vessels of the day, with wooden structures, canvas sails, hemp cordage, and coats of pitch and tar were floating bonfires in waiting. Fire destroyed many vessels, in action and out; a short list might include FNS \textit{L'Orient} at the Battle of the Nile and \textit{Achille} at Trafalgar; HMS \textit{Queen Charlotte} burned by accident in 1802 as did a British prize after the Battle of the Saintes in 1782.\textsuperscript{25} While the risk was high, the means to fight fire were puny, limited to fire buckets, sand, and some manually operated low pressure pumps.\textsuperscript{26}

\textsuperscript{24} Shipborne aircraft of this era were often fabric-covered. Dope was the term for nitrocellulose-based paints which sealed and tightened this fabric, and so was commonly present aboard aviation ships. Dope is quite flammable.


The introduction of iron vessels appeared to ease much of this danger. The structure of the ship was non-flammable and improved engines reduced the need for sails and cordage. All was not well, however; wooden decks remained, the iron structure required paint to protect it from corrosion, and the fires of the boiler rooms, engine lubricants, and the coal in the bunkers offered a threat. Even in peacetime several vessels suffered catastrophic fires, including the USS Kearsarge in 1904, the IJNS Mikasa in 1912, the FNS Jeanne d'Arc in 1913, and others.27

The problem was more evident in combat. At the battle of Santiago in 1898, two modern French-built Spanish cruisers, the Maria Teresa and Vizcaya, burned fiercely when hit by American shells. They had to be beached while they still floated and their engines yet ran to permit their crews to escape.28 Many Russian ships burned furiously in combat during the Russo-Japanese War, most noticeably at the battle of Tsushima in 1905.


CHAPTER 3

THE US NAVY IDENTIFIES THE PROBLEM

The US Navy's Office of Naval Intelligence (ONI) began to collect information on battle damage and fires at sea no later than the Russo-Japanese war of 1904-5. They obtained a copy of a Russian document, an analysis of the damage Russian ships experienced at the Battle of Tsushima, translated it, and forwarded it to the Bureau of Construction and Repair (C&R), (which then had responsibility for US naval vessel design.) This analysis stressed that fires had hastened the loss of several Russian capital ships, and recommended that commanders remove wooden fixtures, paint, and linoleum from warships to prevent fires.29

ONI continued to investigate this subject in World War One. Reports, which went to both the General Board and C&R, noted the ships lost in the first year of the war due to fire in the battles of Coronel, the Falklands, Heligoland Bight, and the Dogger Bank. Witnesses to these actions contended that burning paint was a major factor in this fire damage. These reports also noted the

29. Author known only by initials N. E. K.; report to ONI, "Resume of attached Russian document," register number 5013, file 0-6-c, box 1224, RG 38, NARA.
efforts of both the Kriegsmarine and the Royal Navy to remove burnable items from their ships. By late 1915, the British had removed much of their paint. The Germans had been more thorough, removing most of their interior paint, replacing the exterior paint with an allegedly fireproof compound, and removing all linoleum.\footnote{30}

ONI’s presentation of this information to the naval hierarchy evoked a reaction in 1915. The General Board of the Navy, a set of senior naval line officers who advised the Secretary of the Navy, worried about the dangers of fire and urged certain precautions. The Board called for the Navy to remove all interior paint above the armored decks of US warships, to eliminate highly-flammable shellac compounds, and remove flammable objects where practical.\footnote{31}

The Board, however, was an advisory body; it had no command authority.\footnote{32} The Bureau of Construction and Repair had a great deal of autonomy; it and it alone had responsibility for the

\footnote{30. Director of Naval Intelligence [no name given on document], memo to the Navy’s General Board and C&R, [no subject line], March 8, 1915, register number 5013, file O-6-c, box 1224, RG 38, NARA; see also Lt. Comdr. Humes H. Whittlesey, USN (Ret.) Acting Director of Naval Intelligence, memo to Aid[e] for Operations, “Protection Against Fire in Action,” March 18, 1915, register number 5013, file 0-6-c, box 1224, RG 38, NARA; see also Source “Z-310,” “Fires in Action Resulting From Painted Metal Work On Board Ship,” report of July 16, 1915, register number 5013, file 0-6-c, box 1224, RG 38, NARA.}

\footnote{31. “Extract from Recommendation of the General Board,” no date on document but from place in the file probably mid-1915; register number 5013, box 1224, RG 38, NARA.}

interiors of US naval vessels, and it disagreed. Removal of paint, it contended, especially non-conductive paint, would make the interiors of the ships vulnerable to extremes of temperature and hence unlivable. Corrosion, furthermore, would markedly accelerate without paint.

C&R furthermore, did not believe ONI reports on the dangers of paint-fed fires. "[W]hile there are unsubstantiated statements as to burning paint, the Bureau [C&R] is unable to discover any direct and convincing evidence that there had been any serious combustion of paint on foreign vessels. The principal fact that appears to be established is that the Germans and possibly the English are scraping off a great deal of paint from their ships."

C&R also doubted that American ships were as vulnerable as foreign vessels. "If there have been cases of paint burning on foreign ships, it does not follow that the paint used in the United States Navy would do the same... The residue of the [paint] vehicle, [mainly linseed oil,] after drying, will burn... Experiments... showed as a minimum temperature of ignition for such paint, 1650° Fah[renheit.]... it is possible, in the case of very thick paint upon metal, to ignite it by placing upon it a red hot piece of iron, but the paint stops burning immediately upon removing the iron, for the simple and obvious reason that the ignited paint can not keep the iron bulkhead at a red heat, and as soon as the temperature falls below this point, the paint ceases
to burn.” The Bureau of Construction and Repair concluded that for all practical purposes, paint on US vessels would not burn.\(^{33}\)

This view may be understandable. In the Second World War, the US Navy discovered that linseed-based paint would not burn even when heated by a blowtorch; it would, however, burn fiercely if the compartment in which it was applied was already burning or if enough heat reached a coat of paint through a bulkhead.\(^{34}\) The 1915 tests had included testing paint with a point-source of heat (the aforementioned red-hot iron) and with a shell explosion.\(^{35}\) They did not attempt to determine if paint would burn in an already burning compartment. The latter test might not be obvious.

Another possibility is that the 1911 tests of the Bureau of Construction and Repair cited in their 1915 statement had not

\(^{33}\) "Extract from an Endorsement by the Bureau of Construction and Repair to a Recommendation of the General Board," no date on document but from place in the file probably mid-1915 [certainly a response to the document in the footnote above]; register number 5013, box 1224, RG 38, NARA.

\(^{34}\) Digest of the Course of Study . . . , 104-5.

\(^{35}\) "Extract from an Endorsement by the Bureau of Construction and Repair to a Recommendation of the General Board". An explanation of this phenomenon may be found in John C. Zola, "High Heat and Flame Resistant Mastics," in Fire Retardant Paints, (Washington D.C., American Chemical Society, 1954,) 84. The high heat conductivity of a material, such as structural steel, in contact with a fuel may serve to keep that fuel from attaining ignition temperature. It does so through the rapid conduction of the heat away from the fuel. This is illustrated by the resistance to combustion or melting of the relatively thin wire gauze over a lit Bunsen burner. This high heat conductivity works well if the area over which the heat is applied to the fuel is a small part of the total. While Zola was discussing the flammability of mastics (such as linoleum) in contact with metal, the principle would apply as well to paint.
included the presence of large quantities of burning gasoline, a frequent concomitant of battle damage a generation later. Such burning gasoline was present on the *Lexington*, the cruisers at the battle of Savo Island (in the gas tanks for their scouting aircraft), and on the kamikaze-damaged vessels off Okinawa.

After the war was over, ONI continued to obtain information on the German fire fighting effort. They interviewed an Austro-Hungarian naval officer, a captain in charge of a major repair yard, who had inspected German ships which had been heavily damaged in the battle of Jutland. Despite receiving up to 20 heavy shell hits each, none of the ships showed any traces of a serious fire.

In general, however, the US Navy appeared to consider the question of flammability and shipboard fire fighting solved in the early to mid-1920s. For example, most material found in the C&R fire equipment files of the 1920s related to the use and abuse of relatively small portable fire extinguishers. A considerable correspondence existed on the problem of preventing sailors from using the carbon tetrachloride charges in the extinguishers as “do-it-yourself” dry cleaning fluid.

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36. "Extract from an Endorsement by the Bureau of Construction and Repair to a Recommendation of the General Board."

37. U.S. Naval Attaché, Berlin [no name given] report to ONI, “Germany-Austria; Operations; Historical,” January 19, 1923, serial no. 16, file reference number 910/300, register number 16087, file O-10-a, box 1247, RG 38, NARA.
An exchange of letters is suggestive. Walter Bradley, treasurer of a manufacturing company in Boston, had made the acquaintance of a maritime fire expert, F. J. Horie. Bradley wished Horie to advise the Navy about fire prevention and fighting methods. Bradley, close enough to Assistant Secretary of the Navy Theodore Roosevelt Jr. to address him as “Dear Ted,” pressed Roosevelt to accept Horie’s services for transportation costs alone. Roosevelt repeatedly refused. Marginal notes on Bradley’s letters indicate that Roosevelt forwarded them to the Bureau of Construction and Repair for comment. (If C&R replied to Roosevelt in regard to these notes, their responses were not preserved in this file.)

This is clearly not conclusive. For any number of reasons the Navy Department may not have chosen to enlist the services of an outsider in this field. Roosevelt’s statements, however, indicate a certain complacency at high level about shipboard firefighting.

This complacency was not complete, however. In 1920 C&R installed a fixed foam fire fighting system in the firerooms of the then-new battleship USS Colorado. This system was, however, of relatively small capacity. The US Navy apparently installed

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38. Letters of Walter H. Bradley to Assistant Secretary of the Navy Theodore Roosevelt Jr. of January 21, May 9, and June 29, 1922; copies of letters of Roosevelt to Bradley, January 25, May 25, and July 22, 1922; all located in file 26630-64, box 1979, RG 80, NARA.

similar systems in other major vessels in the 1920s, although without much urgency. As late as 1928 a number of tugs which had been slated to obtain this foam system were still waiting for its installation.  

One may conclude, then, that the US Navy did not ignore firefighting from 1915 to 1930, but that for whatever reason (possibly complacency or cost constraints) it did not actively seek new answers to the fire problem.

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40. Henry Williams, [no bureau listed on document; from location, probably C&R. The document is a carbon; the original presumably had the bureau designation as part of the header of the stationary.] memorandum to Commander in Chief, Battle Fleet, and copy to Commander Scouting Fleet, “Foam Fire Extinguishers for Engine Rooms, Boiler Rooms, and Pump Rooms of Oil Burning Vessels,” December 29, 1928, file S93-(3) (DD) vol. 1, box 4297, RG 19, NARA. Williams apparently considered the utility of this system questionable.

41. John H. Dayton, Office of Commandant, Mare Island Navy Yard, memorandum to Chief of C&R; “Foam Fire Extinguishers — Installation on Tugs . . . .”, August 27, 1928, file reference number AT/S93; located in file S93-(3), vol. 1, box 4297, RG 19, NARA.
CHAPTER 4

AIRCRAFT CARRIERS AND PROTECTION AGAINST FIRE

A correlation exists between the introduction of large aviation ships into the Fleet in the late 1920s and an apparent increase of interest in fire fighting in the US Navy in 1930. A cryptic reference exists in a letter by Captain Cyrus W. Cole of office of the Chief of Naval Operations (CNO) written in 1933, to a fire on a Lexington-class carrier some three years before due to improper handling of the gasoline system. In any event, a flurry of letters appeared in the files calling for an increase in the fire protection on the Lexington and Saratoga.

In July, 1930, Captain Frederick J. Horne, commander of the Saratoga, and later an admiral, wrote to the Chief of the Bureau of Construction and Repair that “... it is considered imperative that certain alterations and additions to the fire fighting apparatus of the Saratoga be authorized and be undertaken at the earliest practicable opportunity ... as the fire hazards existing on board are far more serious than on other types of men-of-war.” Horne

considered the gasoline in the tanks and the gasoline-filled aircraft in both the hangar and on the flight deck to be extraordinarily hazardous. The system then existing to combat fires that might appear in these areas relied on the use of a sprinkler system, which Horne considered would prove ineffective against a gasoline fire. He believed that the Navy should install a system to flood with carbon dioxide the hangar deck and other volumes where flammables were present, and install a remote-control foam system on the flight deck.43

Horne's concern was strongly echoed by other ranking officers. His counterpart on the Lexington, Ernest J. King, considered the Lexington "... equally concerned with the Saratoga in any measures that will minimize the extent of possible fire damage. The fire hazards existing on the two carriers are identical." King added "[I]t may be considered axiomatic that the fire hazard is enormous, ever present and real; that the protection now afforded is inadequate; that increasing the protection is urgent, possible, and imperative."44 Admiral Joseph M. Reeves, Commander of Aircraft Squadrons, Battle Fleet, also forcefully endorsed the letter of the Commander of the

43. Frederick J. Horne, Commanding Officer, USS Saratoga, memorandum to Chief of the Bureau of Construction and Repair, "Fire Hazard and Fire Protection, USS Saratoga," July 10, 1930, file reference CV3/S93 (4444), date reference (300710), box 1640, RG 80, NARA.

Saratoga. "[Reeves] fully concurs . . . regarding the urgent necessity for additional fire fighting equipment on these vessels [the Lexington and Saratoga] and strongly recommends that the installation of this equipment proceed with number one (1) priority."45

Possibly as a result of this pressure, C&R authorized a series of experiments, conducted at the National Bureau of Standards in Washington and the Naval Aircraft Factory in Philadelphia to determine the extent of the dangers of fire and the best means to combat them. They built "mock-ups" of sections of a carrier hangar (at the Bureau of Standards) and flight deck (Philadelphia), stocked them with obsolete aircraft, and ignited small quantities of gasoline (from 10 to 40 gallons) splashed on the aircraft and the deck below. The experimenters used various methods, including carbon dioxide gas, foam generators, and water from sprinklers and hoses — the latter with both spray and solid stream nozzles — to quench each fire.46

The carrier captains criticized the realism of the tests. King commented that the tests had used high pressure equipment


(150 psi. for their foam generators, vs. 84 psi. for the foam generators aboard Lexington) and had failed to consider the effects of exploding aircraft gasoline tanks.\textsuperscript{47} F. R. McCravy, the captain of the Saratoga in early 1931, argued that the Bureau of Standards had used too few aircraft in the tests (four versus the fifty-two normally present in the hangar of Saratoga).\textsuperscript{48} C&R defended the tests, contending that they had spilled more gasoline than would spill during an actual fire and that exploding gasoline tanks were unlikely.\textsuperscript{49}

As a direct result of the tests, C&R augmented the fire fighting equipment on the two big carriers. In refits in the fall of 1930, the yards installed some 50 percent more foam generators and plugs for hose attachment and doubled the number of fire extinguishers allotted.\textsuperscript{50}

\textsuperscript{47} Ernest J. King, Commanding Officer USS Lexington, memorandum to Commanding Officer Carrier Divisions, “Fire Protection,” Feb. 13, 1931, file reference number CV2/S93 (Y1) vol. 1; located in file CV/S93, box 1577, RG 19, NARA.


In any event, these tests influenced American naval fire fighting concepts for much of the decade. They substantiated the value of foam for fighting a gasoline fire. Even when applied in a high wind, it would cling to the surfaces of gasoline pools and to the burning aircraft and deny the fire oxygen, extinguishing it quickly and completely. They showed that carbon dioxide gas, although good against small fires, was of limited utility against large ones and had no value in conditions of moving air — like those on the flight deck of a moving carrier. The gas simply blew away too quickly to choke off the oxygen from the fire. The tests also demonstrated the greater fire-quenching efficacy of sprayed water as opposed to a solid stream.  

Other conclusions, however, eventually proved less justifiable. The results of both the hangar and the flight deck fire simulations wrongly reduced concern over exploding aircraft gasoline tanks and the subsequent spread of fire. C&R decided that fires did not spread from one aircraft to its neighbors.  

C&R also concluded from the flight tests that maintaining a high relative wind (which is the sum of the natural wind velocity

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52. C&R Circular Memorandum, “Tests to Determine . . . ,” 10, paragraph 12; see also George H. Rock, Chief of C&R, memorandum to Commander in Chief, Battle Fleet, “USS Lexington (CV 2) and USS Saratoga (CV 3), Fire Hazard and Fire Protection,” (date inadvertently omitted) file CV/S93 (DV), box 1577, RG 19, NARA.
and the speed of the ship) helped to combat a fire. The tests were conducted on a mock-up of a flight deck in a 55 mph wind produced by a set of airplane propellers. They indicated that a high wind would in fact reduce or blow out a blaze. This was contrary to the previous doctrine that called for carrier captains to maneuver to lessen the relative wind over the flight deck in the event of a fire. The Navy now ordered carrier commanders to increase this relative wind in the event of a fire.  

As has been mentioned, C&R determined from the tests that sprayed water fought a fire more effectively than a solid water stream. Under the "high relative wind" doctrine, however, it concluded that a solid stream of water would atomize in such wind and produce an effective spray.

"Special spraying nozzles appeared to be of no practical value for use with an airstream, as water from an ordinary [water-stream] nozzle is completely atomized upon striking the moving air... It is not desirable to use water in the case of a fire in still air, as, even with the spray nozzle, the fire would not be completely encompassed with spray, believed necessary for the use of water in extinguishing a gasoline fire."  

Later experience invalidated this conclusion. A water spray proved far more effective in putting out a fire than a solid stream.

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It was even effective in still air. The "high relative wind" doctrine tended to spread any fire on the forward part of the ship. It functioned, furthermore, only when the ship's mobility was unimpaired. Reduction of mobility was a likely result of battle damage.

The Navy very soon rejected the idea that a high relative wind would atomize a solid water stream. Following expressions of doubts from carrier commanders, the Navy re-tested the concept in September 1931. The Aeronautical Engine Laboratory determined that while a high wind would effectively blow out a fire, the required relative wind velocity was more than 140 mph, somewhat in excess of the top speed of the *Lexington*-class carriers.

The repudiation of the "high relative wind" concept should have caused a re-evaluation of the solid-stream nozzle. C&R did not re-examine this issue for some years. This paper will later examine how the Navy subsequently reconsidered the use of water-spray or "fog" nozzles.

Despite their inadequacies, the 1930 tests remained the standard USN reference for gasoline, hangar, and flight deck fires

55. Kelly, *Damage Control*, 94. Kelly has no hesitation about recommending the use of fog in areas, such as the interior of a ship, in which no relative wind (or any wind) would exist.

at least through the end of 1936. C&R submitted copies of these
tests to the Prospective Commanding Officers (PCOs) of the new
Enterprise-class carriers for their information on gasoline fires
and methods to combat them.\textsuperscript{57}

We may conclude, then:

\begin{itemize}
\item C&R and the Naval testing elements were trying to address
aviation-vessel fire fighting technology in the early 1930s;
and
\item they recognized the value of foam and the need to increase
allotments of fire fighting equipment on (at least) aviation
ships.
\end{itemize}

\textsuperscript{57} Sidney M. Kraus, Bureau of Aeronautics, memorandum to Chief of C&R,
"Aircraft Carriers, Fire Protection," December 8, 1936, file reference Aer-E-
343-AMS L11-1(3), located in file CV/S93, vol. 2, box 1577, RG 19, NARA.
CHAPTER 5

THE ADOPTION OF FIRE-FIGHTING FOAM, 1924 TO 1942

The Navy continued to investigate improvements to fire fighting equipment during the 1930s. As has been already mentioned, all oil-burning vessels had had a foam generator installed in their engineering spaces since the 1920s. By the early 1930s, such 40 gallon (known as "twin-twenty" generators from their two 20 gallon tanks) dispensers were standard. These were relatively primitive devices with a limited capacity of forty gallons of foam which had originally used a charge that mixed glucose and glue. The Navy later converted these devices to use a commercial chemical protein-based Foamite charge.\(^{58}\)

There were, however, problems. These antique pieces of equipment (originally fitted on World War One era destroyers — the famous "four pipers") could discharge foam for no more than two minutes. They worked under steam pressure, and even though located in the engineering spaces suffered a one to two minute

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delay between time of activation and foam production. The foam generators installed on the carriers in the early 1930s were of larger capacity, some 200 gallons, but were a commercial product, purchased “off the shelf.”

The Navy had experimented with other options. In the spring of 1926, the Material Laboratory of the New York Navy Yard conducted a series of tests of the American-made Phonene and Amdyco foam charge chemicals. The laboratory tested these chemicals in 2 1/2 gallon extinguishers, in the twin-twenty foam generators, and, for the Amdyco charges, in that company's own generator. For some reason, while it tested the Phonene charges on small fires, it only tested the Amdyco chemicals for their expansion from powder into foam and the range of delivery of foam (some 40 to 50 feet.) The Material Laboratory deemed the Phonene effective, but less so, than the standard Navy glucose-glue charge, but considered the Amdyco chemical-generator combination more effective than the standard Navy charge in the


twin-twenty generator. The Office of Naval Intelligence had also in 1926 forwarded to the Bureau of Engineering various reports on German foam fire fighting equipment, noting its reported efficiency in quenching burning liquids.

In the mid-1920s, the Navy equipped the engineering spaces of the USS Colorado with several novel foam fire extinguishers. Research to date has not discovered the specifics of these devices, or if they were related to the Phomene or Amdyco equipment discussed above. By 1936, Colorado's captain stated that these extinguishers had proven inadequate in service. Their source of pressure was the ship's steam plant, which could well fail as a result of battle damage. The extinguishers had no remote control capability and the units' rubber hoses tended to deteriorate quickly in the heat of the ship's engineering spaces. He requested replacement of these extinguishers by new foam fire extinguishers with independent sources of pressure.


62. Dr. E. Dehning, article in Schiffbau, No. 13, (1925) translated by agent "Z" and forwarded to the Bureau of Engineering, received September 8, 1925, reference number 307; William W. Galbraith, Acting Director of Naval Intelligence, letter to C&R and Bureau of Engineering, "Foam Fire Extinguishers," August 15, 1926; both located in file S93, box 1764, RG 19, NARA.

In this decade, the Navy also saw chemical foam generators as useful protection for the engineering spaces for their new aircraft carriers. The original design for the *Lexington* class aircraft carriers in 1924 included a 200-gallon capacity foam extinguisher system in its fire and engine rooms.\(^{64}\) By 1928 the *Lexington* had aboard both twin-twenty and 200-gallon capacity foam fire extinguishers. USS *Saratoga* was equally blessed; C&R and the Bureau of Engineering approved the substitution of 200-gallon Amdyco foam units for the twin-twenty foam generators on the "flying deck" in 1927.\(^{65}\)

All of these foam generators were "chemical;" they used a chemical reaction between the foam powder and water supplied from the ship's fire mains to produce carbon dioxide bubbles in a

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In an endorsement to this letter, Admiral William D. Leahy, then Commander of Battleships, Battle Force, recommended this alteration, noting that the *Colorado* was the only battleship using this system; endorsement of February 20, 1936, reference number BB45/S93/950, same file. Other documents in the file, especially BB45/S93 (MB), dated June 20, 1938, indicate that the project was deferred to late 1938. A fireroom is a boiler room in which combustion is taking place. Some boiler rooms are not firerooms.


chemical slurry.⁶⁶ These chemical foam generators had disadvantages. The generators and the foam powder were expensive, and the generator capacity and the duration of the foam discharge were limited.

Chemical foam generators continued to have difficulties, especially with cost and durability of the protein-based chemicals. By the middle of the 1930s, the US Navy began to investigate "mechanical" foam dischargers, which used water pressure either to propel an agitator to churn a powder-water mix into bubbles or to admit compressed gas or air to a chemical-water mix — also to create bubbles. The private sector had originally developed this technology.

Commander Mahlon S. Tisdale contacted Ernest King, then chief of the Bureau of Aeronautics, in March of 1934 to recommend a British commercial mechanical-foam generator for testing. King forwarded this in April to C&R for their information.⁶⁷ The Navy sought out information on both US commercial and foreign developments. C&R also noted that the

⁶⁶ Robert N. S. Baker, C&R, letter to the National Foam System, Inc., (Philadelphia), May 17, 1934; file S93-(3) (S), vol. 1, box 4297, RG 19, NARA; the new charges for the 40 gallon foam generator (as opposed to the old "glucose-glue" charges) included 19.5 lbs. aluminum sulfate, 14.5 lbs. sodium bicarbonate, and "sufficient" foam stabilizer. This mass of chemicals was dissolved in roughly 20 gallons of water, producing some 40 gallons of foam mix; the 40 gallon capacity, therefore, was the capacity of foam, not powder or other ingredients.

⁶⁷ Mahlon S. Tisdale, letter to Ernest J. King, Chief of the Bureau of Aeronautics, March 27, 1934; memo from King to C&R, "Fire Fighting Equipment for Use on Carrier Flight Decks," April 17, 1934; both letter and memo are in file CV/S93, vol. 2; box 1577, RG 19, NARA. Tisdale saw and forwarded an article he had seen in the British journal The Engineer, issue of March 9, 1934.
Germans were still considerably ahead of American practice in this regard.\textsuperscript{68}

C&R asked the Naval Research Laboratory in Washington to conduct tests comparing the mechanical and chemical foam generators.\textsuperscript{69} During these tests, the Naval Research Laboratory compared the fire fighting efficiency of mechanical foam generators to the then-current-issue chemical foam generators. The tests showed that mechanical foam generators were effective against fire. They and their powder were cheaper than chemical generators and produced more foam from a single hopper-charge. Lightness and reliability also made them desirable. The laboratory concluded, however, that the mechanically-generated foam lacked adequate "body"\textsuperscript{70}. In brief, mechanical foam generators held promise but were not yet at a suitable level of effectiveness. C&R suggested that the foam generator tested

\textsuperscript{68.} William DuBose, Assistant Chief of C&R, memo to Director of Naval Intelligence, "Mechanical Foam Generators For Fire Extinguishing on Naval Vessels," July 2, 1936; file S93-(3) vol. 2 (TE), box 4297, RG 19, NARA. DuBose asked ONI to have the U.S. Naval Attaché in Berlin obtain information on German developments on this subject.

\textsuperscript{69.} Alexander H. Van Keuren, C&R, memorandum to Director, Naval Research Laboratory, Bellevue, Anacostia Station, Washington D.C.; "Foam Fire Extinguishing Equipment for Use on Naval Vessels," Feb. 1, 1935; file S93-(3) (TE) vol. 1, box 4297, RG 19, NARA.

\textsuperscript{70.} E. G. Lunn, Associate Physicist, Naval Research Laboratory, Anacostia Station, Washington D.C., "Report on ... Foam Fire Extinguishing Equipment for Naval Vessels: Test of Foam Generator," September 16, 1935; in file S93-(3), vol. 1, box 4297, RG 19, NARA.
might be the problem and that suitable modifications could produce adequate results.\textsuperscript{71}

A letter from the Naval Research Laboratory (NRL) in June 1936 stated that German developments in this field were in advance of American foam-generator technology. This document suggested that the Navy should obtain foreign information rather than attempt to continue "in-house" research on mechanical foam generators. The NRL, furthermore, suggested that the Navy obtain the rights to use "Tutogen" mechanical foam powder, noting that the cost of this substance per charge was only one tenth or less of the cost of an equal charge of the powder used by other mechanical foam generators. It was certainly far cheaper than "saponine," the charge used by the Navy in its chemical foam generators. The US Navy, this letter concluded, "was paying a high price for its foam fire protection."\textsuperscript{72} In the summer of 1937, the Assistant Chief of C&R asked the US naval attache in Berlin to procure a German mechanical foam generator for testing, and

\textsuperscript{71} Alexander H. Van Keuren of C&R, letter to the Director of the Naval Research Laboratory (NRL), via the Bureau of Engineering, "Foam Fire Extinguishing Equipment for Use on Naval Vessels," December 12, 1935, reference S93-(3), file S93, box 1764, RG 19, NARA.

\textsuperscript{72} Hollis M. Cooley, Director of the Naval Research Laboratory (NRL), letter to the Chief of C&R, "Foam Fire Extinguishers for Use on Naval Vessels -- NRL Problem P-37," June 25, 1936, reference SS/L9-7, file S93, box 1764, RG 19, NARA.
commented that the Navy's judge advocate general's office was investigating the patent situation in this regard.73

By 1941, many US naval vessels were equipped with some form of mechanical foam generator, in their machinery spaces, although many chemical foam units, including the aged twin-twenty, continued in service. The Navy did not, however, end the use of chemical foam. As late as May, 1942, the Lexington was lost with chemical foam generators in place.74

The first year of the war proved both mechanical and chemical foam units quite useful in combatting fires but possessed of certain limitations. Whether the powder charges functioned by mechanical agitation or chemical reaction, they deteriorated rapidly in conditions of high heat and humidity — both common in engineering spaces, especially in the South Pacific. The crew needed to inspect them carefully and frequently.75

73. Henry Williams, Assistant Chief, C&R, letter to the Director of the Naval Research Laboratory (NRL) via the Bureau of Engineering, “Fire Extinguishers -- Foaming Agents and Generator for Foam Fire Extinguishers,” August 13, 1937, reference S93-(3)(s), in file S93, box 1764, RG 19, NARA.

74. Samuel M. Robinson, Chief, BuShips, circular letter no. 65, “Hose for Foam Fire Extinguishers in Machinery Spaces,” (date inadvertently omitted by author) reference S93-1 (8648-250), C/L 65, EN 2/A2-11, located in file S93-(1), vol. 1, box 1630, RG 19, NARA; see also Osmundsen, “Damage Control . . .”, [interview with Lexington survivor regarding continued reliance on chemical foam aboard Lexington] 41.

Many foam generators were dependent on outside pressure for functioning. The Bureau of Ships attempted to address this problem by making foam generators compatible with the portable gasoline-powered water pump coming into widespread shipboard service.

Perhaps a more important problem is that foam production was limited by the number of reserve charges carried. At one minute of foam per canister even a large reserve supply of fifteen canisters per generator would last only a quarter-hour. Several shipboard fires in 1942 continued for several hours. There are indications that this short duration of foam production may have been a factor in the loss of the Lexington in May, 1942.\(^7\)

A superior option was a device that would combat effectively petroleum-product fires and which possessed an inexhaustible supply of fire fighting agent. Such a device existed; it was the fog nozzle.

\(^7\)Hoehling, *The Lexington Goes Down*, 139; Belote & Belote, *Titans of the Seas*, 83.
CHAPTER 6

THE FOG NOZZLE

As has been described earlier the Navy had explored — and rejected — the use of water spray nozzles in its airplane-fire fighting tests of 1930. Fortunately for the future well-being of the Navy's ships, this was not an absolute refusal. Some determined individuals continued to see virtue in water spray in fighting fires, and pressed on with efforts to see that the Navy continued to test the fog nozzle.

Fog or water spray fights fire more effectively than a solid stream of water. One pound of water will absorb almost 1100 BTU's of heat energy, ninety percent of which is absorbed in converting the water into steam. The speed at which the water absorbs this heat depends on the surface area of the water exposed to the heat of the fire. A large number of small droplets has far more surface area per unit of water volume than does a solid stream, and will so absorb the fire's heat energy more efficiently.\(^77\)

\(^77\). Bush, *Introduction to Fire Science*, 187-90. Fire fighters knew these features of fog during World War Two; see also Commander Harold J. Burke, USNR, "Impact of Wartime Fire Defense upon Peacetime Fire Fighting," *Fire Engineering*,
On July 10, 1936, Edward L. Cochrane of C&R wrote Battalion Chief Glenn G. Griswold of the Los Angeles Department of Forestry (Fire Warden), designer of the fog nozzle, to ask about the device. Griswold's reply of July 16, 1936, explained the origins of the fog nozzle. In 1925, Griswold designed it to improve the ability of the City of Los Angeles to fight forest fires. It had also proven useful fighting oil fires in his home town of Santa Fe Springs.

This use of a fine mist or fog quenched fires with less use of water, an important feature in fighting such fires far from a reliable water supply. The fine water spray, Griswold explained, absorbed heat and diluted burning vapors more efficiently than a solid stream. Griswold had consigned his patents to the Fog Nozzle Co. in 1930 so that it would build the nozzle for the city of Los Angeles.\(^78\)

Documentary evidence in the US Navy files indicates that the product of the Fog Nozzle Co. of the mid-1930s is similar, but not

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\(^{78}\) Glenn Griswold, Battalion Chief, City of Los Angeles Department of Forestry (Fire Warden), Letter to Edward L. Cochrane, C&R, regarding "Water Fog for Fire Control," July 16, 1936, no reference no. (as it is of private origin), file S93-17, box 4307, RG 19, NARA. No copy of Cochrane's original letter was present in the S93 files. Griswold's letter refers, however, to the date on which Cochrane sent his inquiry. It may be coincidental that the *Popular Mechanics* issue of June, 1936, prominently featured an article about the fog nozzle and its effectiveness on oil and petroleum fires. The article noted Chief Griswold's name and place of employment. *Popular Mechanics*, "Fighting Fires With Fog," vol. 65, No. 6, June 1936, 801-2, 124A. Research to date has not determined if Edward Cochrane of C&R was a subscriber to *Popular Mechanics* in June, 1936, much less if reading this article sparked his interest in the fog nozzle. A copy of this article, however, sent by William Jones of the Fog Nozzle Company to the U.S. Navy Bureau of Engineering in July 1936, is in file S93 [the general fire fighting file], box 1764, RG 19, NARA.
identical, to the World War Two US Navy All Purpose Nozzle. Both are capable of emitting high-velocity fog and a straight stream of water. Operators can attach applicators — pipes with a spray head connected to the straight-stream aperture — to direct fog at low pressure and reduced velocity some feet into the heart of a fire. This latter feature minimized splashing of a burning liquid.\textsuperscript{79}

The Navy had good reason to be interested in this device. It not only offered a superior method of dousing gasoline fires, it used less water than the current-issue nozzles. While the supply of salt water on shipboard was for practical purposes infinite, the ship’s pumping capacity limited the number and size of usable fire hoses. Water conservation in fire fighting was, therefore, attractive.

Cochrane proved a driving force in the Navy investigation of the fog nozzle. In a cover sheet to a letter received from the Fog Nozzle Co., also in July 1936, Cochrane explained that he saw the fog nozzle a substitute for large fixed carbon-dioxide smothering equipment. He also considered that the fog nozzle would prove of “especial interest in carrier hangars and gasoline tank spaces.” Another note on this same cover sheet, by an individual identified

\textsuperscript{79} Fog Nozzle Co., Los Angeles, California, “How to Use Fog Nozzles,” (pamphlet, no date or place of publication given,) located in file S92-(20), box 4307, RG 19, NARA. This is likely to have been misfiled, as the remainder of the documents in S92-(20) discuss welding equipment. S92-(20) is adjacent to S93, in which other material regarding fire fighting and the fog nozzle are found. The picture of Fog Nozzle Type 2A (1.5” diameter) on the fourth page of the pamphlet (no page numbers are given; count begins with title page as page 1) appears identical to the photograph of the fog nozzle in the \textit{Popular Mechanics} article “Fighting Fires with Fog,” 802.
only as Esher, expressed concern regarding the pressure required for the Fog Nozzle to work. The best pressure available at the hose-end aboard ship was from 40 to 90 psi; the documentation noted that the Fog Nozzle required 150 psi.\textsuperscript{80}

Other naval officers explored the fog nozzle option and tried to find some way around the pressure question. J. M. Kiernan of C&R on September 25, 1936 wrote to the Fog Nozzle Co. asking for type “B” and “3A” nozzles for a test. (These two nozzles offered a variety of spray patterns but did not include the solid-stream option nor did they permit the use of an applicator.) He noted that these fog nozzles would function at 65-120 psi. William Jones of the Fog Nozzle Co. called Kiernan on October 17, 1936, reassured him that the type 2A nozzle (mentioned in footnote 79) would function at low water pressures, and suggested that the Navy test the device. Kiernan concurred and asked Jones to send a sample of the 1.5” three-position nozzle.\textsuperscript{81}

In late 1936 and early 1937 the Navy decided to test as well a number of other fog nozzles, some of which also offered the fire fighter a choice between a fog and a solid stream of water. These

\textsuperscript{80.} Cover sheet to Fog Nozzle Co. correspondence, serial number 50659, July 28, 1936, file S93-(17), box 4307, RG 19, NARA. [In this paper, Fog Nozzle has been capitalized when referring to the specific product of the Fog Nozzle Company. It will be lower-case when referring to the generic device.]

other nozzles were the American LaFrance and Foamite Industries "Alfocospray" nozzle (also a three-position — off, fog, and solid-stream) and the Elkhart Brass Manufacturing Co. "Mystery Nozzle."  

While C&R had proposed these tests in the fall of 1936, by early 1937 the Naval Material Laboratory at the New York Navy Yard, responsible for such testing, had not carried them out. Kiernan at C&R pressed them to schedule the tests in the near future.  

In a somewhat anti-climactic result, the Naval Material Laboratory tested the several fog nozzles and deemed them unsatisfactory for fire extinction. In these tests, they had filled several large and shallow pans with gasoline or diesel fuel, ignited them, then attempted to extinguish them with the various nozzles. They used both high velocity fog straight from the nozzles and low velocity fog via the applicators. The devices failed to extinguish the burning liquids. The Naval Material Laboratory noted that the "Alfocospray" nozzle described in a pamphlet by American LaFrance would probably be unsatisfactory for fighting fires in the Navy Yard.  

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82. Harold V. B. Madsen, C&R, letter to American LaFrance and Foamite Industries Inc., Elmira, New York: November 25, 1936, reference S93-(17) (TE), file S93-(17), box 4307, RG 19, NARA. Madsen noted that C&R had located a pamphlet describing the "Alfocospray" and suggested to American La France that it might want to submit the nozzle for tests. In other words, the Navy acted to locate and test other equipment. Harold V. B. Madsen, C&R, letter to Commandant, New York Navy Yard, March 15, 1937, reference S93-(17) (TE), also in file S93-(17), box 4307, RG 19, NARA; Madsen requested that the Commandant include the Elkhart "Mystery Nozzle" in the upcoming tests.  

83. Joseph M. Kiernan, C&R, letter to Commandant, New York Navy Yard, "Test No. 3804 -- Fog Making Fire Hose Nozzle," April 12, 1937, reference S93-(17) (TE), file S93-(17), box 4307, RG 19, NARA. In the cover sheet to this document, in a marginal note dated 4/12 (April 12), JMK (presumably J. M. Kiernan) stated that this test had been pending since January 1, 1937.
Laboratory also judged these devices useless in any kind of wind and stated that the equipment, especially with the applicator attached, was too unwieldy for shipboard use.\textsuperscript{84}

Despite this apparently damning judgment, some officers at C&R continued to press for additional tests to determine if the Navy could find some use for these nozzles. In August 1937, a C&R officer asked if the Commandant of the Philadelphia Navy Yard could test these nozzles in a confined space to determine if they had any virtue in quenching paint fires.\textsuperscript{85}

In any event, the Navy conducted not one but several other tests on fog nozzles from 1936 to 1940. Perhaps the most detailed was the test by the Boiler Laboratory at the Philadelphia Navy Yard in December 1937. In this test on the USS \textit{ex-Rowan}, a decommissioned First World War vintage destroyer, the Boiler Laboratory used several Fog Nozzles to quench both bonfires of oil- and paint-soaked debris and pools of diesel fuel floating on water. In contrast to the results obtained from the Naval Material


\textsuperscript{85} Homer N. Wallin, C&R, letter to the Commandant, Philadelphia Navy Yard, “Spray Type Hose Nozzles, Proposed Test Of,” August 16, 1937, reference S93-(17) [S], file S93-(17), box 4307, RG 19, NARA. The cover sheet to this letter had a note on it from JMK (presumably J. M. Kiernan,) stating that he wished to re-test these devices at the Philadelphia Navy Yard, as he believed there to be “merit in these nozzles.” It is of interest that the proposed test avoided the problem areas identified in the New York tests, i.e., use on open gasoline fires and in windy conditions.
Laboratory tests in New York earlier in the year, on this occasion the Fog Nozzles performed well. The type 4A three-position (off, high-velocity fog, and solid stream) was quite effective: the solid stream broke apart the bonfire pile in tests and the high-velocity spray quenched the oil fires. The 4A tested at Philadelphia was a 2.5” nozzle; the 2A that failed at New York was a 1.5” nozzle, which would project considerably less water.) The model 4A also offered the operator a water “curtain” of laterally-projected sprays of water. This protected the operator from heat, and to a limited degree, from fumes, permitting him to approach the fire more closely.

The test, however, also revealed a number of deficiencies in the Fog Nozzles. Their functioning was dependent on the emission of water from small holes. Any particles or debris present in the water delivered to them would clog them. The Boiler Laboratory, furthermore, also tested the standard Navy 1.5” solid stream or “suicide” nozzle, and determined that it could be effective against oil fires if properly used. “[A]ll that is necessary to extinguish an oil fire in a nearly closed compartment is to spray against the hot bulkheads sufficient water to form enough steam to smother the fire, to cool the oil below its flash point, and to cool the bulkheads before the steam blows away from the oil surface.”

Even prior to the Naval Material Laboratory tests in New York in April 1937, the Naval Air Station in San Diego conducted its own tests of the fog nozzle. The station tested the Fog Nozzle Co.'s Model "B" which produced only high-velocity fog, on two condemned aircraft. The first aircraft was saturated with ten gallons of aircraft dope (used at that time to make taut and airtight the fabric that then covered many aircraft; it is highly flammable) and five gallons of gasoline. The 2.5" type B nozzle quenched the fire in two and one-half minutes. The second test involved a similar aircraft soaked with five gallons of crankcase oil and fifteen gallons of dope. The fog nozzle put it out in one hundred seconds.

The station also used the fog nozzle on burning liquids in open pits eighteen feet across. In all cases it quenched these fires in less than two minutes. The station considered the fog nozzle to be more effective in fighting aircraft fires than either carbon dioxide or foam.

It is important to note that the Naval Air Station at San Diego undertook these tests at the behest of local fire departments. The station concluded that these nozzles were of value for both shore stations and aircraft carriers.87

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87. Arthur L. Bristol, Commanding Officer, U.S. Naval Air Station at San Diego, memorandum to the Chief of the Bureau of Aeronautics, “Fire Fighting Equipment of the Fog Nozzle Company, 1520 East Slauson Avenue, Los Angeles, Calif. — Report
Captain Newton H. White, the prospective commanding officer of the USS Enterprise (CV 6), witnessed a demonstration of the Fog Nozzle (model and maker unspecified) in the summer of 1937. He contended that the Fog Nozzle would atomize salt water, emitted water at double the pressure, and needed only half as much water to quench a fire as the standard nozzle.\(^{88}\)

In July of 1939 a different captain of the USS Enterprise, Charles Pownall, conducted a shipboard test of a fog nozzle (type and vendor not mentioned in document). The crew lit a fire in a simulacrum of a burning engine, created by winding oil-soaked rags on an armature, on the flight deck. An aircraft propellor produced a wind in which to fight the fire. This test noted that 80 psi nozzle pressure was insufficient to produce an effective fog spray. At 125 psi the fog nozzle quenched the fire in less than two minutes.

Despite this performance, Pownall expressed reservations about the fog nozzle. He was concerned about the ability of the crew to use the relatively unwieldy device. He also believed that the fog nozzle was inappropriate for fire fighting use in

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On," January 4, 1937, reference N27, file S93-(17), box 4307, RG 19, NARA. The date of the tests was not given in this document, but a letter by R. B. Larter, Vice President in Charge of Sales, the Fog Nozzle Co., to the Bureaus of Construction and Repair and Engineering on June 15, 1940, stated that this San Diego Naval Air Station test occurred on December 10, 1936. Letter located in file S93-(8)-vol. 1, box 1646, RG 19, NARA.

\(^{88}\) Newton H. White, Prospective Commanding Officer, USS Enterprise, memorandum to the Chief of C&R, "Improvement of Appliances for Combating Fires on Aircraft Carriers . . . ," July 13, 1937; file reference CV 6/S 93 (95 MI) (380), located in CV/S93, vol. 2, box 1577, RG 19, NARA.
engineering spaces. "[S]altwater spray striking the many units of machinery in confined spaces would cause more damage than that incident to the fire. . . . It is therefore recommended that fog nozzles be supplied for use on the flight and hangar decks only." He did add that the Enterprise had in August 1939 four fog nozzles on the flight deck and four more on the hangar deck.89

Research has not to date located documents in which a firm decision was made to procure fog nozzles for US Navy aviation vessels or any document explaining the reasoning for such procurement. Someone, however, made this decision. On July 21, 1938, the Bureau of Construction and Repair approved requisitions from the commanding officers of the Lexington and the Ranger for eight fog nozzles for each ship. The approved equipment was to be equivalent to the type "B" nozzle of the Fog Nozzle Co. This nozzle, however, was not identical to the three position (off, fog, and solid stream) nozzle. It was a spray nozzle attached to a 1.5" hose. On the end of the nozzle was a one-inch diameter applicator about four feet long. While the author of this memorandum considered this equipment especially useful on the flight and hangar decks of the carriers, he did say that the nozzles with the

89. Charles A. Pownall, Commanding Officer, USS Enterprise, Memorandum to the Chief of the Bureau of Construction and Repair, "Fog Nozzles," August 14, 1939, reference CV6/S93 (95-My), serial number 1073, in file S93-Fire Fighting (Ship)-1939, box 460, RG 313, Naval Operations Forces Records to 1944, NARA.
short applicators may be used below decks. They were, he added, effective on gasoline and oil fires.  

Another document of the following year noted that these nozzles were present on at least two carriers, eight on the *Lexington* and two on the *Saratoga*. This letter recommended a doubling of the fog nozzle allowance from the then-current eight to sixteen.  

A later letter, however, indicated that this augmentation did not take place. In October, 1940, the Bureau of Ships (BuShips; formed by the union of C&R and the Bureau of Engineering in June, 1940) allowed eight fog nozzles per carrier. Other vessels were allowed from two to four fog nozzles, depending on the number of aircraft aboard. BuShips, apparently,

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90. Edwin G., Kintner, C&R, memorandum to Commanding Officers of USS *Lexington* and *Ranger*, "*Lexington* Requisition 12-38 and *Ranger* Requisition 540-38 — Both for Spray Type Fire Fighting Equipment," July 21, 1938, reference nos. (R) 12-38/CV2 (TE) and (R) 540-38/CV4 (both numbers attached to a single document, probably referring to the original carrier requisitions), file number S93 - Fire Fighting (Ship), in box 460, RG 313, NARA.

91. John H. Hoover, Chief of Staff for Aircraft, Battle Force, U.S. Fleet, first endorsement (dated November 21, 1939), to a letter of Ralph Wood, commanding officer, USS *Ranger*, to the Chief of C&R, "Spray Type Fire Fighting Equipment — Fog Nozzles," October 27, 1939, reference S93/23-Rh/FF 2-3, file S93 - Fire Fighting (Ship), 1939, box 460, RG 313, NARA. Hoover reported that as of November 21, 1939, 8 fog nozzles were present on the *Lexington* and 2 on the *Saratoga*. He recommended that the allowance be increased to sixteen fog nozzles — eight on the flight deck and eight on the hangar deck — for *Lexington*, *Saratoga*, *Ranger*, *Yorktown*, and *Enterprise*. The second endorsement to the Wood letter, by Marc Mitscher, Assistant Chief of the Bureau of Aeronautics, reference Aer-E-342-DVD of December 1, 1939, same subject and file location, concurred with Hoover's recommendations.
still saw this device as a specialty item for “protection of airplanes.”

Another reference to fog nozzle availability (albeit in limited numbers) aboard ship was in an August, 1941 letter from the Commander of Battle Force Battleships to BuShips. It mentioned that BuShips had available a stock of type “B” nozzles and was procuring a limited number of type “A” 2.5” nozzles. Perhaps more to the point, however, this letter mentions that the type “A” nozzle in particular was well adapted to fighting general shipboard fires in closed compartments, not just to dealing with aircraft fires. The type “B” were not as flexible: “... although adapted to fighting fires of restricted source, such as an oil tank fire or airplane fire on deck, are not as flexible in their application as the Type “A” fog nozzles...” This important command considered the fog nozzle to be a general purpose device for fighting fire, and asked BuShips to approve an allotment of fifteen per battleship. In his endorsement, William S. Pye, the Battle Force commander, also called for increasing the fog nozzle allowance for both aircraft carriers (from eight to twelve) and cruisers (to nine per ship.)

92. Alexander H. Van Keuren, Assistant Chief, BuShips, letter to fleet commanders, type commanders, force commanders, and commanding officers of aviation ships, battleships, and cruisers, “Fire Protection of Aircraft Aboard Ship,” pilot letter of October 5, 1940, (handwritten notation indicates that it was mailed on October 9, 1940), reference S93-(5), DN28/A2-11 (Dv), in file S93-(5) vol. 1, box 1642, RG 19, NARA.

This review of the Navy's gradual acquisition of the fog nozzle illustrates a number of points.

- A small number of officers in the Navy noticed the fog nozzle (a device developed for the civilian sector), recognized its potential value, and took the initiative to have it tested. In the case of the San Diego Naval Air Station tests, it appears that a number of individuals were thinking along the same lines independently.

- Despite poor results on one early test, these officers did not abandon the fog nozzle. They continued to see that there were some areas of fire fighting in which the Navy could use this device.

- The Bureau of Construction and Repair tended to be rigid in its thinking. Pownall's evaluation that the fog nozzle was unsuitable for use in engineering spaces seems to have deterred C&R from approving it for use below decks, and as late as 1942 the crew of *Lexington* did not use the fog nozzle below the hangar deck.94

- The view that Morison and others have fostered that the adoption of the fog nozzle took place as a result of the experiences of the Navy in 1942 is erroneous. The fog nozzle was available as early as 1938, albeit in limited

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quantities. The Navy had determined a need for this device, tested it and approved it well before the US Navy's entry into the war.

The US Navy, obviously, had fog nozzles in service in 1941. However, the devices in service with the Navy at that time were not the late-war All Purpose Nozzle, and they were not yet available in quantity. The lessons of the early actions of the war caused the Navy to increase nozzle allowances for fighting vessels. As early as February 1942 BuShips had declared that it intended to increase these allowances and that additional fog nozzles were under procurement.95

A very significant step in the evolution of the fog nozzle into the All Purpose Nozzle was a visit paid by Lieutenant Commander Harold J. Burke of BuShips to the Fog Nozzle Co. in Los Angeles. Burke had been the Deputy Fire Commissioner of New York City and the head of that fire department's Marine Division.96 During several days of demonstrations in late March 1942, fire fighters equipped with the Fog Nozzle Company's 2.5" three-position nozzle quenched several large simulated fires. In the

95. F. M. Avery, section 851 of BuShips, marginal note of February 10, 1942 on cover sheet 302947 of a memorandum by Herbert F. Leary, Commander of Cruisers, Battle Force. The original memorandum, to the Chief of BuShips, subject "Fire Protection Aboard Ship — Use of Fog Nozzles," October 20, 1941, reference L7-1/EN28/S93/(2898), is in file S93-(5), vol. 1, box 1642, RG 19, NARA.

96. Bryson Bruce, BuShips, confidential memorandum to the Bureau of Navigation, "Fire Protection of Naval Ships," October 21, 1941, reference C-S93-(1) (3688), in file C-S93-(1) vol. 1, box 1635, RG 19, NARA. Burke's history is in paragraph 2.
first test, this nozzle extinguished a fire of 150 gallons of mixed crude oil and gasoline in a fifteen-foot diameter tank in ten seconds; in the ensuing three tests smaller three-position nozzles put out identical fires in less than eighteen seconds. Burke stressed in his report that the nozzle pressure during these tests was between 50 and 60 psi, thus addressing a major Navy concern regarding the suitability of fog nozzles for fire fighting aboard ship. The nozzles in this 1942 test functioned at pressures well below the 125 psi required for the 1936-vintage fog nozzles.

Other tests used a "Christmas Tree," an assembly of pipes which forced oil under pressure into a fire. The 2.5" three-position nozzle put out the fire in ten seconds, the 1.5" nozzle in fourteen. Burke concluded:

"These [three-position] nozzles appeared highly efficient and in view of their all purpose utility; [punctuation original] i.e., their ability to produce either fog, solid stream, or shut off instantaneously, it is [sic] considered to be the best type for use in connection with shipboard fire fighting on combatant ships."

A marginal note, by "J," on page two of this report indicated that BuShips was drawing up specifications for a three-position nozzle.97

97. Lt. Comdr. Harold J. Burke, USNR, [division] 688 of BuShips, memorandum to the Head of the Design Division (300), BuShips, "Temporary Additional Duty at Los Angeles District, Navy Yard Mare Island, Calif., Navy Yard Puget Sound, Washington, and Navy Yard New York: New York," April 10, 1942, no reference number on document, in file S93-(1) vol. 1, box 1630, RG 19, NARA. According to paragraph 2 the tests observed by Lt. Commander Burke were conducted at the Santa Fe Springs fire station with the cooperation of Chief Griswold (sic); given the
Successful use of a new technology will do more to promote its adoption than even the most thorough tests, and the fog nozzle had begun to prove itself even before Lt. Cmdr. Burke's visit to Santa Fe Springs. A February 1942 letter by the Commander of Battleships, Battle Force, which commented on the fires at Pearl Harbor, noted the value of the fog nozzle and announced his intent to procure more of them.  

The loss of the Lexington at the Coral Sea on May 7, 1942, added impetus to fire fighting development in the Navy, including the procurement of a superior fog nozzle. The Bureau of Ships referred to this loss in a memorandum regarding fire fighting in July 1942.

"The Bureau has made a study of the difficulties encountered in the Lexington combatting [sic] the many fires which broke out in that ship prior to its ultimate loss. As a result of this study, and in view of the many potential fire hazards which are inherent in aircraft carriers and tenders which normally carry large quantities of bulk gasoline, the Bureau considers that immediate steps must be taken to improve the fire fighting facilities in such vessels."

BuShips, therefore, recommended that the Navy provide portable fog nozzles for all existing fire plugs. It had already authorized the issue of 1" type "B" and 2" type "3A" fog nozzles

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location, name of participant, and nature of test this is likely to be the same Glenn Griswold who had invented the nozzle at Santa Fe Springs in 1925 and had corresponded with Edward Cochrane of BuShips in June, 1936.


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(apparently from the Fog Nozzle Co., as these are the same item designations which that company gave its products of the 1930s.) The type “B” fog nozzles (which did not have a solid stream feature) were for use below decks. The fog nozzle equipment “is considered considerably more effective in fighting all classes of fires than the present standard 2-1/2” solid hose stream. Fog nozzles afford excellent protection to personnel advancing with fire hoses so equipped, produce a desired cooling effect on the fire being fought and give a much better distribution of water in the fire area." 99

The standard civilian-sector fog nozzles, however, were not ideal for Navy use. Admiral Nimitz himself noted their vulnerability to marine growth, debris and particles in the water supply. The commercial fog nozzles tended to clog under these conditions. These nozzles were, furthermore, somewhat more complex than was desirable, given that they would be maintained and used by sailors who were not full time fire fighters. 100


Research has not yet found the internal documentation regarding BuShips consideration of this problem. The outcome, however, was that in late May 1942 the Bureau summoned representatives of the firms which made fog or water spray nozzles to Washington to discuss a Bureau offering of a "standard operational specification . . . the results of these conversations will be the basis of all immediate purchases of [fog nozzles] for the Navy." By coincidence, the June 4 meeting was in progress as Japanese carriers launched their strike on Midway Island.\(^{101}\)

As a result of this meeting BuShips authorized tests of the various companies' fog nozzles to take place in late June 1942 at the newly-established Fire Fighter's School at Norfolk. The tests were to be similar to those which Lt. Cmdr. Burke observed in March 1942 in California. One added requirement, however, was that the tested nozzle had to function after being completely clogged with marine growth and quickly cleared by the operator. Ten companies, including the Fog Nozzle Co., American LaFrance Foamite, and the Elkhart Brass Manufacturing Co. were to take part.\(^{102}\)

\(^{101}\) (signature illegible), BuShips, letter to manufacturers of "portable spray fire fighting equipment," May 25, 1942, reference S93-(2)(350)(3648), in file C-S93-(1)-vol. 1, box 1635, RG 19, NARA.

\(^{102}\) (completion of June 4, 1942 conference and decision to conduct competitive testing at the Fire Fighter's School at Norfolk) Elmer V. Iverson, U.S.N. (Ret.), division 688, BuShips, memorandum to division 350, BuShips, "Nozzles, hose, water-fog, — Request for authorization for test of," June 8, 1942, no reference number, file S93-(1) vol. 1, box 1630, RG 19, NARA; (dates of tests and list of companies participating) Elmer V. Iverson, by direction of the Chief of BuShips, memorandum to the Officer in Charge, Atlantic Fleet Schools, "Tests of Fire Fighting
Research for this thesis, unfortunately, did not locate the report of these tests nor the decisions made by BuShips as a result. Certain other documents, however, give some indication that the product of the tests was a composite design that became the late-war All Purpose Nozzle. R. V. Iverson of BuShips stated in a letter to the Fire Appliance Co. in mid-July 1942 that as a result of tests at the Fire Fighting School at Norfolk, the US Navy would standardize a nozzle which will incorporate the best features of all nozzles tested. He added that contracts were being let for this equipment.\footnote{A letter from the Rockwood Sprinkler Company to BuShips dated July 16, 1942, some two weeks after the tests, stated that Rockwood had delivered the engineering drawings of its nozzles to the Fog Nozzle Company in California. The letter added that this was done to maintain US Navy standards of interchangability.} A letter from the Rockwood Sprinkler Company to BuShips dated July 16, 1942, some two weeks after the tests, stated that Rockwood had delivered the engineering drawings of its nozzles to the Fog Nozzle Company in California. The letter added that this was done to maintain US Navy standards of interchangability.\footnote{On August 1, 1942, about five weeks after the completion of the tests, BuShips informed Nimitz that it had completed its investigation of all types of fog nozzles and had initiated a contract for the manufacture of 10,000. The Bureau

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\textsuperscript{103} Elmer V. Iverson, BuShips, letter to Hurst, Gordon F., Fire Appliance Co., July 14, 1942, reference S93-(1)-(8688), file S93-(8) vol. 1, box 1647, RG 19, NARA.

\textsuperscript{104} Howard G. Freeman, Head of Research and Development, Rockwood Sprinkler Company, Worcester, Massachusetts, letter to John Walsh, Damage and Control division (688), BuShips, July 16, 1942, no reference number, file S93-(8) vol. 1, box 1647, RG 19, NARA.
had chosen a three-position nozzle, which meant that it could produce a solid stream, a high-velocity fog spray or be shut-off. It also could use an applicator inserted in the solid-stream aperture which would provide low-velocity fog for application on oil fires. Later that month, a BuShips memorandum noted that a recently developed three-position fog nozzle was in production by Rockwood Sprinkler Company of Worcester, Massachusetts, and the Fog Nozzle Company of Los Angeles, California. These nozzles, the memorandum confirmed, should be available for Navy use by October 1, 1942. Finally, the BuShips fire fighting manual of 1943 points out that the All Position Nozzle (APN) was then being manufactured by Rockwood Sprinkler Co. and the Fog Nozzle Co.

After mid-1942, fog nozzle allowances rose dramatically. In late 1941, for example, the Commander of Battleships, Battle Force, had proposed an allowance of fifteen fog nozzles per battleship. By November 1942, the allowance for each battleship (including many of the same battleships which would have been the subject of the 1941 memorandum) was from eighty-three to

105. Alexander H. Van Keuren, Chief of the Bureau of Ships, confidential memorandum to Chester Nimitz, Commander in Chief, U.S. Pacific Fleet, reference C-S93-(1)(8688), in file C-S93-(1)-vol. 1, box 1635, NARA.


one hundred and eighty-eight 1.5" fog nozzles alone. By February 1943, the allowance was for one 2.5" or 1.5" fog nozzle for every fire plug aboard, plus an additional ten percent for spares.108

This review of the Navy’s experience with the fog nozzle illustrates the following:

- In 1938, the Navy began to use commercially designed and produced fog nozzles. They were available in limited quantities and were intended to fight fires in aircraft and flight and hangar decks. The Navy did not then consider the fog nozzle as a general-purpose fire fighting device.

- Because of early-war experience of fire, and because of a successful demonstration of the fog nozzle in March, 1942, the Navy chose to improve the fog nozzle and to increase allowances aboard its vessels. The Navy decided that the commercial fog nozzle designs then available were not wholly suitable for shipboard use.

- As a result of the June 4, 1942 conference and the ensuing competitive tests of fog nozzles, the Navy adopted a nozzle that incorporated the best features of all commercial nozzles tested and would address the fleet’s concerns

regarding reliability. The product of this synthesis was the late-war all-purpose nozzle (APN.)

Two points are worth remembering.

- While the APN was a product of the course of the first year of the war, the Navy had deployed fog nozzles before the war started.

- Progress toward adoption of the fog nozzle into service depended on the efforts of a few individuals. Cochrane, Kiernan, and Burke pressed for the continued testing of the fog nozzle when initial reports were unfavorable or (in 1942) when most of the Navy at first saw this equipment as being of limited utility.

  The APN, despite a tortuous gestation, became a vital element in late-war fire fighting.
CHAPTER 7

ENGINEERING SPACE FIRE PROTECTION

Naval fire fighting was complicated by a division of responsibility between the Bureau of Engineering and C&R over equipment for their various domains aboard ship. The problem of fire fighting equipment in the engineering spaces was (naturally) the province of the Bureau of Engineering. Protection against fire in these spaces was somewhat problematical. These spaces were essential, providing not only motive power for the ship but power for operating the ship's equipment. Furthermore, a ship's firerooms, by definition, had abundant sources of fuel available.

The US Navy, therefore, devoted considerable effort to improve and increase the amount of the fire fighting equipment available in ship's engineering spaces. Such efforts began early with the provision of an elementary steam smothering system in 1911.\textsuperscript{109} Many of these systems were “fixed.” Rather than relying on a crew to direct cooling or smothering substances on a fire by hoses, these had fixed pipes and spigots which could flood an area

with such substances when activated manually or by some form of automatic system. A present-day building sprinkler system is such a fixed unit.

The post-World War One era, however, posed an additional problem for fire fighting in engineering spaces in the introduction of turbo-electric drives. Conventional methods of fire fighting used on such large electric devices would produce a lethal combination of salt water and high voltage. It would also knock out any electrical equipment which had not already failed. The Navy clearly needed to discover alternatives.

An early proposal was to use fresh-water alone as the hose supply. While fresh water would conduct electricity and so create a shock hazard, it would offer less injury to the electrical equipment. The construction of the *Lexington*-class carriers, which would have the largest turbo-electric drives in the Navy called attention to this issue. The private sector shipbuilder originally proposed such fresh water use; it was adopted by the Navy late in 1924.\(^\text{110}\)

The quest for better fire gear did not stop at this point. For a while the Navy favored carbon dioxide (CO\(_2\)) fire-smothering systems for engineering spaces. In 1924, Walter Kidde & Co.

suggested the installation of a fixed CO₂ smothering system in ships' engineering spaces, asserting that such gear would cool and smother fires without harm to electrical equipment. A slightly later document gives more detail of their equipment and their argument. A bank of CO₂ cylinders, under pressure, would provide the smothering gas either automatically, activated by a thermostat when the air temperature in the compartment reached 150 degrees F. or upon manual initiation. Such gear, Kidde's pamphlet continued, left no residue, required no maintenance, and was non-conductive.¹¹¹

The Navy decided to consult expert civilian opinion on this subject. That same month, it instructed its representative in Schenectady, New York, to obtain comments from General Electric regarding the suitability of CO₂ installations for extinguishing fires in the main generators and motors of the "airplane carriers." About a year later General Electric responded; they had studied information regarding various CO₂ systems and had concluded that the "Lux" system, produced by Walter Kidde & Co., was one of the best for fire protection of large electrical machinery. Such a system, they concluded, would work on a warship as it was relatively easy to close the ventilating system and so ensure an

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¹¹¹. Spruance, Raymond A., Bureau of Engineering, memorandum to C&R, "Fire Extinguishing Apparatus," April 15, 1924, file S93, box 1764, RG 19, NARA. Spruance included excerpts from an April 9, 1924 letter of engineer Walter H. Freygang of the Walter Kidde & Co. regarding proposed installation of CO₂ extinguishers aboard ship. Spruance saw these extinguishers as useful for putting out battery fires aboard submarines.
adequate concentration of CO₂. Despite this favorable evaluation, General Electric saw CO₂ systems as an adjunct to steam smothering systems of fire fighting in electrical machinery spaces.⁹¹²

By the middle 1930s the Navy had resumed exploration of steam and fine-water-particle smothering systems for engineering spaces. In 1934, the Navy installed steam smothering systems in the USS Saratoga.⁹¹³ In 1936, the Bureau of Engineering conducted tests of a number of fire fighting systems, including the “Mulsifyre” water mist fixed fire fighting system aboard the discarded World War One vintage destroyer USS ex-Rowan in the Philadelphia Navy Yard.

The Bureaus of Engineering and Construction and Repair appear to have been convinced of the utility of the fixed spray system. In May, 1938, they authorized the installation of a water

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⁹¹³ Claude Bonvillian, Bureau of Engineering, letter to Commanding Officer, USS Saratoga, "USS Saratoga, Alteration, Bureau of Engineering Serial No. Yb 83 B," reference CV3/S48 (3-133Yb), in file CV3/Alt, box 3255, RG 19, NARA; a notation on the back of this letter stated that the steam smothering system had been installed by December 13, 1934.
mist fire extinguishing system in boiler operating spaces for the USS Wasp in lieu of foam fire extinguishing equipment.\textsuperscript{114}

The information about naval combat damage that emerged from the early years of World War Two pushed the Navy into re-assessing its engineering spaces’ fire fighting technology. Until this information became available, the Navy considered the main fire threat in engineering spaces to be oil burning in the bilges, and designed their steam smothering systems to quench such fires. The British wartime experience, however, indicated that such protection was insufficient. In September, 1941, BuShips called for steam smothering in all boiler and engine room spaces in all new construction of steam powered ships. By early 1942, however, BuShips had noted that the Navy had to install smothering systems in all ships, including those, powered by diesel and diesel-electric systems, which did not have a supply of steam available. These latter vessels had to rely on CO\textsubscript{2} smothering systems.\textsuperscript{115}

\textsuperscript{114}. Henry Williams, Assistant Chief of C&R, and James M. Irish, Acting Chief of the Bureau of Engineering, joint letter to Superintending Constructor, Quincy (Massachusetts), “USS Wasp (CV 7) Fire Protection in Boiler Operating Stations and Boiler Rooms,” reference CV7/S93 (TE), in file CV7/S93, box 3381, RG 19, NARA.

\textsuperscript{115}. Herbert S. Howard, Chief of BuShips, letter to all supervisors of shipbuilding and all navy yard commandants, “Fire Protection in Machinery Spaces — Steam Driven Vessels,” September 30, 1941, reference S93(503) EN28/A2-11, file S93-(1)-vol. 1, box 1630, RG 19, NARA; see also Joseph J. Broshek, Office of the Chief of BuShips, letter to all supervisors of shipbuilding, all navy yard commandants, and all commanding officers of ships in commission, “Fire Protection in Machinery Spaces,” April 10, 1942, reference S93(807-640-648) EN28/A2-11, same file.
Steam and carbon dioxide were not the only options the Navy considered for protection of engineering spaces against fire. As noted, one of the first uses of foam aboard ship was in the engineering spaces of the battleship *Colorado* and the *Lexington*-class aircraft carriers in the 1920s. Then in 1933, the Navy decided to install foam fire fighting systems in the boiler rooms of the USS *Ranger* (CV 4).\(^{116}\)

Possible reasons for such a shift of emphasis from CO\(_2\) to other fire fighting systems were noted in a letter (admittedly of 1942, a late date.) A senior official of then BuShips noted that the CO\(_2\) system had serious disadvantages in the engineering spaces. If the system were activated, it would smother the fire, but also would smother the operating crew. He added that the CO\(_2\) gear had been installed originally because at that time no other method of controlling oil fires in machinery spaces was available. The fog nozzle, foam generators, and steam smothering were effective in fighting engineering space fires and were less hazardous to the continued operation of the vessel.

The CO\(_2\) system had also the disadvantage of a limited supply of fire fighting material; once the contents of the gas cylinders were exhausted, the ship could not continue to fight the

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fire. BuShips, accordingly, had decided to discontinue use of CO₂
smothering in steam engineering spaces and remove the
smothering equipment.¹¹⁷

¹¹⁷ C. A. Jones, Assistant Chief of BuShips, letter to the Vice Chief of Naval
S93-(1)(3648), file S93-(1), vol. 2, box 1630, RG 19, NARA. A notation on the
cover sheet to this letter stated that this decision was precipitated by the loss of life
among the engineering crew in a fire on USS Vixen in the Philadelphia Navy Yard.
CHAPTER 8

GASOLINE STORAGE PROTECTION

Previous chapters have reviewed the dangers of shipboard gasoline. As early as 1924 the Navy recognized the extreme danger posed by gasoline fumes and acted to address this danger. In the interwar years the Navy chose to use CO₂ to flood compartments surrounding gasoline storage spaces. In addition, the service devised a system to pump water into partially-empty gasoline tanks to ensure that there was no void space in those tanks in which gasoline fumes might accumulate (a protective measure called “hydraulic stowage.”)₁¹⁸

As early as 1926 the Bureau of Engineering authorized the installation of CO₂ smothering systems for gasoline control rooms and the compartments around gasoline storage spaces in the not-yet completed carriers Lexington and Saratoga. In 1929, reliance on the use of salt-water fire mains in paint, oil, and aircraft fuel tank spaces on these carriers was noted and deemed

₁¹⁸. Navy Department, Manual of the Bureau of Construction and Repair, Washington, D.C., U.S. Government Printing Office, 1924, chapter 14, 17, para 1432. This manual also noted that “hydraulic stowage” -- using water to fill voids in gasoline storage spaces (the gasoline floating on top) was standard in U.S. naval vessels; chapter 14, 20-1, para 1441.
unsatisfactory; a senior aviation officer requested installation of CO₂ gear therein as well.¹¹⁹ In 1928, the gasoline stowage space on USS Langley (CV1) was protected by salt-water flooding, CO₂ and steam smothering systems.¹²⁰

These forms of protection covered the gasoline tanks (through hydraulic stowage) and the compartments surrounding the gasoline stowage spaces. They did not protect the gasoline lines. Several who have written about the US Navy in the Second World War presumed that in early 1942 the American carriers could flood the aviation gasoline delivery lines with carbon dioxide or another inert gas.¹²¹ Navy records indicate that this

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¹²⁰. George H. Rock, Assistant Chief, C&R, memorandum to Commandant, Mare Island Navy Yard, June 11, 1928, “USS Langley (CV1) — Gasoline Stowage Space — Fire Extinguishing System,” reference CV1/S30-2 (DB) NK, in file CV3/S93, box 3288, RG 19, NARA. At least aboard USS Langley in 1930 the crew inspected the gasoline stowage daily. USS Langley Ship’s Log, RG 24, Stack 1 SW 4, row 21, compartment 13, Shelf C., NARA; various entries, but note April 29, 1930, 0800 entry, etc.

was unlikely. A BuShips circular letter as late as August 28, 1942, authorized the installation of equipment for CO\textsubscript{2} flooding of gasoline lines as an interim measure. Inert gas (internal combustion engine exhaust fumes) systems would be installed as available.\textsuperscript{122}

The Navy considered inert gas a better substance than carbon dioxide for flooding gasoline voids and compartments surrounding gasoline stowage spaces. This gas was provided in unlimited quantity by the exhaust from an internal-combustion engine, and did not rely on a limited supply of bottled CO\textsubscript{2}. The first ship to receive this system was USS Saratoga, early in 1942. By June 1942 BuShips authorized the installation of a similar system on all other carriers. The Navy, however, was unlikely to have installed these systems by late summer of 1942. In a note on July 21, 1942, a BuShips officer noted that USS Enterprise and Hornet had not yet submitted plans for such an installation. A letter of November 24, 1942 of BuShips authorized installation of “inert gas producing plants” on all carriers.\textsuperscript{123}

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\textsuperscript{122}. Chief BuShips to Commandants of the Norfolk, Puget Sound, and Pearl Harbor Navy yards; to the commanding officers of aircraft carriers, “Aircraft Carriers and Seaplane Tenders -- Inert Gas Filling of Gasoline Discharge Piping,” August 28, 1942, reference C-CV/S93(812), file C-CV/S93, box 680, RG 19, NARA.

\textsuperscript{123}. Chief BuShips memorandum to Commandant, Puget Sound Navy Yard, “USS Saratoga (CV3) — Installation of Inert Gas Plant,” February 6, 1942, reference CV3/S93 (6648), file CV/S93, box 680, RG 19, NARA; BuShips, ship alteration form CV/S93 (812), same file, dated June 6, 1942; Chief of BuShips letter to all commandants of navy yards and supervisors of shipbuilding, “... installation of
Apparently, save for USS Saratoga and Yorktown, inert gas or CO₂ systems for displacement of gasoline fumes in voids and lines did not exist on US carriers during several of the crucial battles of 1942. These included Coral Sea, Midway, and the Battle of the Eastern Solomons.

Inert Gas Producing Plants on all . . . carriers . . .” November 24, 1942, reference CV/S93, in the same file as previous references of this footnote.
CHAPTER 9

THE PORTABLE SELF-POWERED PUMP

While these fire fighting systems were useful and effective, many of them depended on the continued functioning of the ship’s systems to work. If the ship’s electrical power or steam pressure was cut off, or if the water lines were fractured, these systems would be inoperable.

Until the late 1930s, the only fire fighting pump aboard that was fully independent of the ship’s systems was the “handy-billy.” In the 1930s, this term referred to a hand-operated pump of high weight and low capacity. The large handy-billy weighed 222 pounds; the small one some 150. 124 Of limited effectiveness, they were issued in small numbers — three to a battleship, two to a carrier. 125


125. (Battleship allotment) George A. Alexander, Commanding Officer, USS Arizona, memorandum to the Chief of C&R; [no subject title available], December 8, 1936, file reference BB 39/ S15-(1) (820), located in file S47-8, box 4142, RG 19; see also Fred F. Rogers, Commanding Officer, USS Texas, memorandum to C&R, [no subject title available], December 11, 1936, file reference BB 35/S47/(1562); located in file S47-8, box 4142, RG 19; (Carrier) William F.
C&R had considered portable gasoline-powered pumps as early as 1927, but rejected them because the gasoline would pose a fire hazard and the exhaust fumes would asphyxiate the crew.\textsuperscript{126} C&R also believed that the Navy's existing submersible pumps were adequate for de-watering and fire fighting. While these had superior gallons-per-minute capacity and pressure as opposed to the self-powered pumps proposed in 1927, they remained dependent on ship's power.\textsuperscript{127}

In 1936 a private firm, the Pacific Marine Supply Co., contacted acting CNO Admiral Joseph K. Taussig directly and suggested that the Navy buy their portable gasoline-powered pumps. Taussig approved of the idea and, with the Commander of the Battle Force, pushed C&R to examine the question. He said, "As is well known, the [manual] handy-billy at present issued to ships is heavy and of very little value for fire fighting due to the low pressure and volume of water it will [pump] through [sic.] If the Pacific Pumper is anywhere near as good as the descriptive

\textsuperscript{126} George H. Rock, Assistant Chief, C&R, letter to the Homelite Corporation, "Portable Gasoline Motor-Drive Pumps," October 18, 1927, file S 47-(4), box 4142, RG 19, NARA.

\textsuperscript{127} Isaac I. Yates, C&R; memorandum to Commander Battle Force, U.S. Fleet, "'K' and 'H' Type Pacific Pumpers," July 5, 1935; file S 47-(8), box 4142, RG 19, NARA. Marginal notes on the cover sheet for this document point out that the electric submersible pump was not intended for fire fighting, but for de-watering compartments. Kelly, \textit{Damage Control}, 92, considered submersible pumps of value in fire fighting for providing water to the intake of a portable gasoline-powered pump.
circulars indicate, it is vastly superior to the handy-billy. The matter seems to be worthy of investigation."

Battle Force conducted its own tests, issuing a single pump to a battleship (USS California) and a destroyer (USS Dewey) in 1936. The Engineering Laboratory at the Mare Island Navy Yard also examined the pumps for their suitability for naval use.\textsuperscript{129}

Favorable results convinced C&R to purchase 272 pumps for naval use. Budgetary restrictions of the mid-1930s, however, delayed their deployment aboard ship. Although the pumps had been purchased, and were US Navy property, C&R could not distribute them to the ships of the fleet until the ships transferred $400 per pump to reimburse the C&R account. Despite their obvious virtues, these pumps remained in the C&R storage.


\textsuperscript{129} Roscoe C. MacFall, Commanding Officer, USS California, memorandum to C&R, "Portable Gasoline Driven Pump, Experimental Service Tests; Supplementary Reports," August 14, 1936, file reference BB 44/S47/1086, located in file S47-(8), box 4142, RG 19, NARA; see also Alexander R. Early, Commanding Officer, USS Dewey, memorandum to the Chief of C&R, "Portable Gasoline Driven Pump Experimental Service Test," February 19, 1936, file reference DD 349/S47 (120); located in file S47-(8), box 4142, RG 19, NARA; see also [no author listed] Engineering Laboratory, Mare Island Navy Yard, "Report of Test of Portable, Gasoline Motor-Driven Pumps," Report No. 6172-37, April 27, 1937, file S47-(8), box 4142, RG 19, NARA.
facilities until Forces Afloat had the funds available or the inadequate "Handy-Billies" wore out.\textsuperscript{130}

In 1939, the allotment of the gasoline powered portable pumps remained one per ship, even on a vessel the size of a battleship or carrier. Apparently, as late as 1942, this state of affairs prevailed; the cruisers in the battle of Savo Island had one apiece.\textsuperscript{131}

This examination of US Navy investigation of new fire fighting equipment in the last three chapters indicates the following:

- In some instances, the US Navy took the initiative to develop (if not invent) new technologies (fixed salt water sprays and steam smothering in engineering spaces);
- In other cases, the US Navy responded to outside initiatives and was willing to explore ways to use "off the shelf" materials (the portable pump, the mechanical foam generator, and the fog nozzle.)

\textsuperscript{130}. (quantity of pumps) Joseph M. Kiernan, C&R, memorandum to Commandant, Norfolk [Naval Station?], "Pumps, Portable, Gasoline Motor-Driven," September 7, 1937; file S47-(8) (TE), box 4142, RG 19, NARA; see also (budget problem) Melville W. Powers, C&R, memorandum to Commanding Officer Cruisers, Battle Force, on "Pumps, Portable, Gasoline Motor-Driven . . .," November 16, 1937, file S47-(8) (NE), box 4142, RG 19, NARA; see also Guy Clark, C&R, memorandum to Kintner, [first initial(s) omitted], "Gasoline Motor-Driven Pumper to Replace Handy Billy," December 11, 1938, file S47-(8), (361211), Box 4142, RG 19, NARA.

\textsuperscript{131}. Osmundsen, "Damage Control . . .", page 51, quoting the privately printed document "The Damagecontrolman," (printed for the USS Raby, destroyer), page 79.
The Navy's deployment of this equipment was inadequate, but it was not wholly a free actor. In the 1930s, the Navy was operating under severe budget constraints and had to make difficult choices about allocating its limited resources. One may contend that in the field of developing fire fighting equipment it did rather well.
CHAPTER 10

MISSING: THE HUMAN FACTOR

This paper has shown that the US Navy spent considerable time and effort between the wars examining and developing fire fighting equipment. The Navy was not, however, as effective in developing the human element of fire fighting technology — doctrine, organization, and training.

One should note that, according to a noted military historian, technology includes the application of knowledge to achieve a physical effect by means of an artifact, object or thing and the knowledge needed to design, manufacture, operate, sustain and logistically support the artifact or thing and its user(s). By this definition, training and doctrine, as instilling the knowledge for operating the equipment, is part of technology.

Part of the problem with naval fire fighting training in the interwar era was the general lack of specialized shore training; the Navy was still very much a “learn by doing” organization. Incoming recruits in the 1920s were first dispatched to a shore base to learn basic military information and simultaneously

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132 John Guilmartin, European Warfare from the Renaissance through 1870, (private workbook; Columbus, Ohio: distributed at Ohio State University, 1994), 1
undergo three weeks quarantine to ensure they would not transmit contagious disease to the rest of the station. The five other weeks of the shoreside course included military infantry drill, basic seamanship, boat handling, and obedience to orders. The purpose of this eight-week course was to ensure that the ship would easily assimilate the recruit.\textsuperscript{133} Fire fighting was not part of this basic curriculum.

This pattern of training continued through 1941. Except for those who attended the skilled trades schools of the interwar era, recruits received most training in their duties aboard ship. Division officers were to be responsible for their instruction.\textsuperscript{134} Training at training stations was elementary, devoted to teaching the recruit how to take care of himself and his outfit, personal cleanliness, and regular habits.\textsuperscript{135}

"The logical place to train a seaman is at sea . . . . the major part of all training must be conducted at sea."\textsuperscript{136}

\begin{footnotesize}
\begin{enumerate}
\item \textsuperscript{133} Joseph K. Taussig, "A Study of Our Naval Personnel Situation," \textit{Proceedings}, vol. 47, (August 1921,) 1191. No later than immediately after World War Two basic firefighting was part of the recruit training curriculum. Department of the Navy, Bureau of Naval Personnel, \textit{All Hands}, no. 364, (June 1947,) 5.
\item \textsuperscript{135} William L. Rodgers, Senior Member Present, General Board, memorandum to the Secretary of the Navy, Dec. 4, 1923, document number 57365-278, file 57365, box 909, RG 24, NARA.
\end{enumerate}
\end{footnotesize}
This concentration on training afloat may have been born of necessity. In 1929, one author noted that the Navy could not spare experienced men from the Fleet to act as instructors ashore. He also noted that some 28 percent of shipboard complements in that year were in training.\textsuperscript{137}

As late as 1940, this focus on shipboard training continued. The major part of all training was conducted at sea. Recruits received elementary instruction at training stations for 12 weeks then completed their training in cruising ships.\textsuperscript{138}

A 1941 reference to naval training demonstrated that the shoreside recruits continued to learn infantry drill, basic seamanship, and swimming, but the basics of chemical warfare defense and signalling had been added to the curriculum. The skilled trades schools, now designated Naval Service Schools, then included instruction in the ratings of Electrician, Fire-Controlman (for gunfire, not fire fighting), Gunner's Mate, Torpedoman, Aviation Ordnanceman, Radioman, Signalman,


\textsuperscript{138} U.S. Navy Department, Bureau of Navigation, \textit{Bureau of Navigation Manual}, (Washington D.C., U.S. Government Printing Office, 1940,) article E-1001, paragraph 4, page 240. This manual is the edition of 1925 with changes inserted through July, 1940. Research for this paper did not discover why the basic course was extended from eight to twelve weeks, nor what was done in the extra time.
Quartermaster, Yeoman, Storekeeper, and the arts of mathematics, metalworking, and woodworking.\textsuperscript{139}

Recruit education aboard ship, however, was not left solely to the mercies of the ship's officers and veteran complement. The Navy offered a set of correspondence courses designed to enhance the recruit's skills. In 1922, the Bureau of Navigation offered ten courses "of a technical nature bearing directly on naval duties. . . ." These courses included navigation, seamanship, and ordnance/gunnery, but nothing on fire fighting.\textsuperscript{140}

By 1929, the Navy was using the then-novel technology of slide-shows to instruct its men at sea. A roster of such shows for that year included one designed to enhance the sailor's knowledge of maintaining the ship's stability and watertight integrity, demonstrating that some aspects of damage control were deemed worthy of the US Navy's continuing education; fire fighting was not in the list of such courses.\textsuperscript{141}

Instruction of new sailors in fire fighting was then a factor of shipboard drills and instruction. An examination of the logs of two US aviation vessels in 1930 indicated that this training was unlikely to be detailed. USS Saratoga, one of the largest ships in

\textsuperscript{139} John T. Tuthill, \textit{He's In the Navy Now}, (New York: Robert M. McBride & Co., 1941,) 93-4, 104, 107-8. The first reference in Tuthill's work to exposure of the recruit to fire drills is that which occurs aboard ship (148). He gives no details.

\textsuperscript{140} US Navy Department, Bureau of Navigation, "U.S. Navy Education Study Courses," (no place of publication nor publishing house listed, 1922,) file reference 1024-1165, box 36, RG 24, NARA.

\textsuperscript{141} Cummings, "Enlisted Training in the Navy," 885.
the Navy and carrying thousands of gallons of volatile aviation fuel, held drills approximately every two weeks from March through August 1930. Each drill lasted from eight to twenty minutes. While this duration of drill might be sufficient to exercise the crew in attaching and running out the fire hoses, it is less likely to permit detailed instruction of the crew in coordinated fire fighting.¹⁴² USS Langley also held fire drills at roughly monthly intervals from May to October, 1930, each of which lasted some eight to ten minutes.¹⁴³

This information is no more than indicative. Further research is necessary to examine the intervals and durations of fire drills for several carriers and other major vessels for 1941 to determine whether training intensified during the time of crisis immediately before American entry into war.

Fleet exercises offer other clues as to the standards demanded of fire fighting practice in the Navy in the interwar years. In the evaluation of USS Colorado in the exercises of 1935 the official exercise observers commented on errors the Colorado's crew made in fire fighting, but made no

¹⁴². USS Saratoga, Ship's Log, 1930, RG 24, Stack 1 SW 4, Row 24, Compartment 22, shelf B., Old Army and Navy Branch, NARA, log entries January 24, January 29, February 17, March 19, April 2, May 2, May 28, June 4, June 10, June 21, July 7, July 30, and August 6.

¹⁴³. USS Langley, Ship's Log, RG 24, Stack 1 SW 4, row 21, compartment 13, Shelf C, Old Army and Navy Branch, NARA, entries of May 26, June 18, July 17, September 10. The log, unlike that of the Saratoga, indicates that the ship's complement inspected the aviation gas spaces daily. Oddly enough, however, no fire drills were logged from October 1 to December 31 of 1930, although numerous other drills, including gunnery and general quarters drills, were so logged.
recommendations for improvement. In contrast, they made numerous recommendations regarding control of flooding and maintenance of ship's stability.\textsuperscript{144}

Perhaps more indicative are the evaluations of the 1936 exercises on the big fleet carriers \textit{Lexington} and \textit{Saratoga}. The observing officers did study the responses of the ships' crews to simulated fires. Aboard both ships the primary responsibility for fire fighting rested with the crew at the site of the damage; there was no mention of specialized fire fighting teams. The observing officers deemed that organization adequate.\textsuperscript{145} The report on the \textit{Saratoga} damage control exercise of April 7, 1936, included similar reliance on personnel on the scene to fight the fire, with one addition, in which the Construction and Repair party reinforced such personnel. The observers of this fire fighting exercise did not describe the fire fighting practice of these elements of the crew.\textsuperscript{146}


\textsuperscript{145.} William F. Halsey, Commanding Officer, USS \textit{Saratoga} and Assistant Chief Observer, USS \textit{Lexington} Damage Control Practice, "USS \textit{Lexington} Damage Control Practice, Long Beach, California, 8 April 1936, USS \textit{Saratoga} Observing Ship," file (SC) A5-15, box 369, RG 38, (Office of Chief of Naval Operations, Fleet Training Division, General Correspondence, 1914-1941), NARA, 25-32 and 49. Although the Assistant Chief Observer, Halsey was listed as transmitting officer for this report in reference CV3/S29 (reference number 753-10) of this same file.

One can draw an erroneous conclusion from these exercises. Certainly an immediate fire fighting response by crew on the scene was of great value in fighting fires. There is, however, no indication in the reports on these exercises of the kind of specialized and what might be called “articulated” fire fighting teamwork later evident in the Navy. By 1944 the Navy had evolved an elaborate division of responsibilities within each fire fighting team for action in the immediate vicinity of the fire. The group leader would assess the fire, determine the optimum means to fight it, and direct the other members of the team. For example, hose men were to handle the hose and direct foam, fog, or water on the fire. Access men operated doors, hatches, and other openings and kept the access routes to the fire clear for both the hose and members of the team. Other members of the team had very specific responsibilities in fighting the fire, although each team member was supposed to be able to do the duties of any other member. This team training was designed to minimize confusion in fire fighting.\footnote{US Navy Department, Naval Training School (Damage Control) Philadelphia, \textit{Digest of the Course of Study} . . . , May, 1944, 122, 124.}

While this approach may seem obvious to the modern reader, it was not common in the 1930s. Civilian fire fighting departments of that decade had very elaborate drills, with similar divisions of responsibility, for handling hose going to the site of the fire. No civilian manual examined, however, suggested such a
specific division of responsibilities for fire fighters in the immediate vicinity of the fire.

Leadership by the petty officers and chief petty officers (CPOs) is a vital element in a crew's ability to fight fire. As this paper will show later their initiative was crucial in saving USS Enterprise in two separate battles in the second half of 1942. The first reference, however, to specialized training for chief petty officers was in 1937. A US Naval Institute Proceedings article suggested a fourteen week training course for such CPOs (already in grade). The proposed curriculum included, under the general topic of seamanship, ship stability and salvage. Fire fighting was absent.148

This suggestion apparently had some effect. In 1938 the Bureau of Navigation issued a handbook for a “General Training Course for Petty Officers 1c [first class] and Chief Petty Officers.” An examination of the general qualifications for both classes of petty officers included detailed training in seamanship, including the ability to handle the duties of the officer of the deck while underway as well as those of a warrant officer of each petty officer's particular branch. Nowhere in the course is any

reference to any detailed training in fire fighting or fire fighting leadership.¹⁴⁹

Senior officers in the Navy themselves noted a lack of expertise in fire fighting aboard ship early in World War Two. Admiral Chester Nimitz, Commander in Chief of the US Pacific Fleet (CincPac) pointed out that while (in his view) the damage control personnel were adequate fire fighters the average crewman had very little training or experience in fire fighting.

"In every ship examined the repair parties appeared to be familiar with the firefighting [sic] equipment and its proper use. But the average man had very little training or experience in the subject and probably could not have used most of the equipment effectively until the repair party arrived..."¹⁵⁰

Not all senior officers were as concerned about fire fighting training. As late as July 1, 1942, Admiral William S. Pye, Senior Officer Present Afloat (SOPA) in the port of San Francisco, issued orders to all US naval vessels in that facility. While he gave numerous orders regarding gunnery training, his only discussion of


¹⁵⁰. Chester Nimitz, Commander in Chief, U.S. Pacific Fleet, Confidential Memorandum 17CM-42, "Firefighting [sic] -- Defects in Equipment and Training of Personnel," April 7, 1942, serial 01045, file no. A2-11/FF12(1), S93/(50), located in file C-S93-(1)-vol. 1, box 1635, RG 19, NARA, page 5, paragraph 7. At this time, the experience of the US Navy in damage control was essentially limited to actions at Pearl Harbor and by the U.S. Asiatic Fleet. Nimitz based his judgment on these actions and did so before the losses of major US Pacific Fleet units to fire at Coral Sea, Midway and Guadalcanal.
fire fighting aboard ship is in reference to guarding against fires spreading aboard ship from nearby docks in event of an attack.\textsuperscript{151}

The entries in the \textit{Bluejacket's Manual} are also indicative of this absence of training regarding fire fighting aboard ship prior to 1942-3. The \textit{Bluejacket's Manual} (BJM) was a standard text for incoming recruits from at least 1929.\textsuperscript{152} This was still the case in 1941.\textsuperscript{153} The Manual was also intended to be a ready reference for sailors regarding their naval service and duties.\textsuperscript{154}

To indicate the relative priorities, the 1940 \textit{Bluejacket's Manual} (the tenth edition) had three pages devoted to both fire drill (without any mention of articulated drill) and use of fire fighting equipment. It had seven on painting. By comparison, the 1943 \textit{Bluejacket's Manual} (the eleventh edition) had seven pages on painting, three on fire drills alone, and fourteen on the use of fire fighting equipment.\textsuperscript{155} By 1944, the \textit{Bluejacket's Manual} noted

\begin{footnotes}
\footnotetext[151]{Admiral William S. Pye, "S.O.P.A. Miscellaneous Orders and Information Concerning San Francisco," July 1, 1942, manuscript, in file S.O.P.A. Misc. Orders & Info, box 2, RG 313, NARA. Pye had been present at the Pearl Harbor attack. This may have influenced his judgment in favor of gunnery drill.}
\footnotetext[152]{Cummings, "Enlisted Training in the Navy," 879.}
\footnotetext[153]{Tuthill, \textit{He's In the Navy Now}, noted that the \textit{Bluejacket's Manual} was regulation issue to incoming sailors, 76.}
\footnotetext[155]{\textit{The Bluejacket's Manual}, 10th Edition, (Annapolis: U.S. Naval Institute, 1940,) 217-220 (fire drill and use of equipment; note that it is three pages, as it runs from the bottom of 217 to the top of page 220) and 286-292 (painting.); see also \textit{The Bluejacket's Manual}, 12th Edition (Annapolis: U.S. Naval Institute, 1943,) 166-8 (fire drill), 168-82 (use of equipment) and 254-60 (painting).}
\end{footnotes}
for the first time the existence of a fire fighting rating and referred the reader to the USN Fire Fighter's Manual for details of the articulated drill.¹⁵⁶

USN officers were little better served in fire fighting training between the wars. Graduates of the US Naval Academy and Reserve schools obtained instruction in fire fighting only through the drills they underwent during their instructional cruises. The Navy did have a program, drawn up in 1919 by a board under the aegis of the Bureau of Navigation and composed of Captain Dudley Knox and Commanders Ernest King and William Pye, for post-graduate education of line officers. This program remained the basis of USN line officer training until 1935 at least and perhaps later. The original curriculum as adopted on the recommendation of the King-Knox-Pye board was quite detailed, including study of subjects such as piloting, shoring, watertight integrity, and mooring board problems. It had no mention of fire fighting. As late as 1940, the Bureau of Navigation Manual described the curriculum of the officers of the line as being that of the King-Knox-Pye board. It also had no comment on fire fighting.¹⁵⁷

¹⁵⁶. Bluejacket's Manual, 13th Edition, (Annapolis: U.S. Naval Institute, 1944,) 83 (existence of fire fighting specialty) and 317 (reference to the USN Fire Fighter's Manual.) Department of the Navy, Bureau of Naval Personnel, “Evolution of Naval Ratings,” All Hands, no. 585, (October 1965,) 34, noted that the rating of Firefighter was introduced in 1942-1943 (no more specific date listed) and existed until subsumed in the rating of Damage Controlman in 1948.

It is difficult to prove a negative, but the information available indicates that the Navy did not carry out vigorous or systematic fire fighting team training until after the beginning of the war. The conflict demonstrated that efficient fire fighting requires teamwork. Each member of the late-war shipboard fire fighting team had an individual and distinct assignment, and must work in concert with all other members to protect each other from the fire and to extinguish it quickly and completely.\textsuperscript{156} A ship's company had to organize such teams long before any fire broke out.\textsuperscript{159}

The civilian municipal fire fighting departments appear to have been more advanced in fire fighting team training than was the Navy in the 1930s. The manuals of the large urban fire departments, government documents, general reference works, and the professional journal \textit{Fire Engineering} show that by the early

\textsuperscript{156} Digest of the Course of Study \ldots , 122-3; see also Kelly, \textit{Damage Control}, 88-9.

\textsuperscript{159} \textit{Damage Controlman 1 and C}, 165.
1930s these departments had regular systems of training and facilities permitting new firemen to simulate work on a fire site.

On closer examination, however, this appearance proves to be misleading. These training sessions, drills, and simulations stressed individual use of fire fighting equipment. Team exercises focused on the speedy deployment of hose, especially up ladders to the higher floors of buildings. None of the standard fire fighting instruction references of the day referred to the kind of elaborate articulated drills for teams confronting a fire that the Navy came to use in the Second World War. While the Navy was inadequately trained for the fires it faced early in the war no one else offered much of an alternative.

Even so, during the 1930s the US Navy did take advantage of the knowledge of civilian fire fighting professionals through a limited set of exchanges. The National Fire Protection

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Association (NFPA) was recognized as the national clearing house for fire-fighting information. At its annual meetings, beginning no later than 1935, US naval officers attended the plenary sessions and sessions on information exchange about marine fires and other topics of special interest to the Navy. Lieutenant Commander H. L. Vickery (who had participated in investigations of fire fighting in shipboard engineering spaces) attended the meetings of the Committee on Construction and Design of the Marine Section of the NFPA. This committee discussed the topic of building fire resistance into ships' structures. In 1936-7, Vickery participated in NFPA-sponsored tests regarding resistance of ships' structures. Two years later, Vickery addressed the plenary session of the NFPA annual meeting, describing recent advances in shipboard fire safety features. He mentioned that he had personally briefed Admiral Emory Land, then Chief of the Bureau of Construction and Repair, about recent civilian innovations regarding fire-resistant ship construction.

This exchange, of course, worked both ways. Tests jointly sponsored by the Navy's Bureau of Aeronautics and an NFPA fact-


finding committee, and conducted by the National Bureau of Standards, regarding means to extinguish fires fueled by aviation gas received prominent place in the NFPA Proceedings of 1930.\textsuperscript{165}

This sort of exchange was frequently informal and decentralized. On a number of occasions, heads of naval shore stations far from Washington and even commanders of individual ships investigated civilian technical developments in fire fighting and passed their observations to senior authority. We have already seen the testing of the fog nozzle conducted by the San Diego Naval Air Station in 1937. That same year, Captain Leigh Noyes of the USS Lexington sent representatives to a Bremerton Fire Department demonstration of a “spray-type hose nozzle.” Noyes stated that such a device appeared to be of value in fighting gasoline fires aboard carriers and “fires of whatever origin in confined spaces belows decks. . ."\textsuperscript{166}

These exchanges, however, focused on innovations in “hardware” in various forms. There is no indication that the Navy saw fit to explore or improve on any civilian fire fighting drill.

\textsuperscript{165}. Proceedings of the Thirty-Fourth Annual Meeting of the NFPA, (Boston: National Fire Protection Association, 1930,) 126 (joint USN-NFPA auspices) and 127-36 (description of tests and conclusions).

\textsuperscript{166}. Captain Leigh Noyes, Commanding Officer, USS Lexington, memorandum to the Bureau of Construction and Repair (via Commander Aircraft, Battle Force,) “Fire Fighting Hose Nozzles -- Spray Type,” Nov. 16, 1937, reference number CV2/S93 (1641), file number S93-- Firefighting (Ship), box 460, RG 313, NARA; Claude S. Gillette, Commandant U.S. Navy Yard at Philadelphia, memorandum to the Bureau of Engineering, “Fire Fighting Equipment - Fog Nozzle - Information and Recommendation for Test,” April 2, 1937, reference number NP 18 (General) (A-715), file number S93/L5, box 1764, RG 19, NARA.
The Navy's relative neglect of the human element in fire fighting is even more notable given the advances it made with that element of the other major component of damage control: flooding and stability.

In the early 1930s, the Navy began to regularize its damage control organization and doctrine, a topic that had, apparently, never before been addressed in a systematic manner. The US Naval Academy Post-Graduate School had presented a series of lectures on flooding and stability from c. 1928 to 1930. When ship commanders began to ask for transcripts of these lectures, C&R decided to collect this information in a single document, "The Stability of Ships and Damage Control," for general distribution.\textsuperscript{167} The Navy followed up this effort and issued a set of "Tentative Damage Control Instructions" in 1933.\textsuperscript{168}

Ship's organizations came to reflect this new interest in damage control. In the summer of 1933, the CNO issued orders establishing some regularity of vessel damage control organization. The ship's First Lieutenant (not the Executive Officer, but the officer in charge of the Deck Division and other matters) was made the designated Damage Control Officer (DCO).

\textsuperscript{167} George H. Rock, Chief of C&R, circular memorandum to all officers of the Navy's Construction Corps, "The Stability of Ships and Damage Control," [date inadvertently omitted by author], file S88-1, vol. 1, box 4290, RG 19, NARA.

\textsuperscript{168} Cyrus W. Cole, office of the CNO, memorandum to Commander in Chief, U.S. Fleet (CinCUS), "Annual and Semi-Annual Inspections. Addition of Damage Control Questions to Forms For," December 21, 1933; file S88-1 (331221), box 1261, RG 80, NARA. An enclosure to this document stated that the "Tentative Damage Control Instructions" were issued in April, 1933.
Damage control was to be his highest priority, and he was to be relieved from other duties that conflicted with this responsibility.\textsuperscript{169}

The CNO began to explore alternate doctrines in 1933. As CNO Admiral William H. Standley stated:

". . . commanding officers should be free to adopt, as a tentative or trial measure, features of organization which appear to them advisable even though they may not accord entirely with existing regulations and instructions. By this means intelligent . . . changes in regulations may be initiated when and as experience shows them to be necessary."\textsuperscript{170}

The Navy instituted regular damage control practices in the summer of 1934. While still on an experimental basis, and having then no weight in battle efficiency competitions,\textsuperscript{171} they were a step towards increasing anti-flooding teamwork and experience.

Part of this doctrine was the creation of a Damage Control Central Station in each large vessel. The Navy would compile for each ship key flooding and stability information into a Damage

\textsuperscript{169}. William H. Standley, CNO, memorandum to Commander in Chief, U.S. Fleet, "Damage Control," September 27, 1933; file FS/S 29-1 (330927), box 2223, RG 80, NARA; see also Albert W. Marshall, Board of Inspection and Survey, Pacific Coast Section, Report to President, Board of Inspection and Survey, "USS Salt Lake City, Material Inspection," September 26, 1933, file CA 25/S3-1 (330926), box 1522, RG 80, NARA. The Salt Lake City's First Lieutenant was replaced by a First Lieutenant/DCO on June 24, 1933.

\textsuperscript{170}. Standley, "Damage Control," September 27, 1933.

\textsuperscript{171}. Joseph K. Taussig, acting CNO, "Practices: Orders for 1934-35," June 1, 1934; file FS/S88, box 2225, RG 80, NARA.
Control Book, kept with other important flooding and stability information and charts in the central station.\textsuperscript{172}

These measures may have proven inadequate to meet the demands of war, but they were in advance of at least one other major service, the Royal Navy.\textsuperscript{173} They certainly indicated that in the 1930s the US Navy was attempting to refine its damage control organization and doctrine and to regularize training in flooding and stability control.

The US Navy did more to improve its firefighting equipment than it did its firefighters. The Navy had the opportunity to do as much with fire fighting doctrine and organization as they had with the problems of flooding and stability, but did not do so. One possible reason might be the US Navy's own history of battle damage; from 1865 until 1941, no US naval vessel was destroyed in action by fire. Underwater attack leading to flooding had sunk several ships in the First World War.

After Pearl Harbor the US Navy established numerous fire fighting schools. Several naval historians have considered these schools to be the most significant factor in the US Navy's mastery

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\textsuperscript{172} Cyrus W. Cole, "Annual and Semi-Annual Inspections . . .," December 21, 1933, page 4 of enclosure, question 33.

\textsuperscript{173} Russell Willson, U.S. Naval Attaché, London; Report, "Damage Control in the British Navy," August 10, 1938; serial 765, register number 22598, file O-5-d, box 1214, RG 38, NARA; paragraph 2. The Royal Navy had made the ship's Executive Officer responsible for damage control — hence, suffering from conflicting responsibilities in combat — until late 1937; Willson also considered the RN's damage control information available aboard ship much inferior to that of the U.S. Navy (paragraph 17, 6-7).
\end{flushleft}
of fire fighting late in World War Two. Their work implies that the Navy established the schools as a response to initial American losses — to put it another way, that the US Navy had been unaware of this problem and did not take this vital step until forceably confronted with its own inadequacies in wartime fire fighting. They imply that the Navy was reactive, not “pro-active.”

This is not so. The Navy was monitoring foreign experience with fire fighting well before Pearl Harbor. On June 7, 1941, Wilson Brown, Commander of the US Pacific Fleet Scouting Force, distributed a memorandum to the Scouting Force noting the severity of British losses to date in the war due to fire, information Brown obtained from a Pacific Fleet Intelligence Bulletin of April 25, 1941, which focused on the loss of HMS Southampton in January of that year. This memorandum was forwarded to the Bureau of Ships. Certain excerpts from the memorandum are of special interest.

“The problem of dealing with fires is the most serious and critical one that has to be contended with. The mere structural damage from hits is generally speaking a comparatively easy one to handle. But fire resulting from oil, gasoline, paint, furniture, etc. does the real damage . . . . The amount of ignorance on how to fight fires of all sorts systematically is appalling and much time must be spent in teaching all hands how to fight fires . . . ”

“It is requested that Commanding Officers study their organization for fighting fires, insure that the personnel particularly officers in charge of repair parties, and leading
petty officers are well informed as to the necessary steps to
be taken to localize fires . . .”

A November 7, 1941 letter of Captain A. R. Early to the
Commander in Chief, US Pacific Fleet noted the frequency with
which fires occurred on British ships in the early part of the war
damaged by shell, bomb, and torpedo hits. He noted that fires
broke out from gunfire damage on eleven British ships and from
bombs or torpedo damage on four more.

As a result of this experience the Navy considered
establishing fire fighting schools before Pearl Harbor. Perhaps
the immediate inspiration for this was a letter from Bryson Bruce
of the Bureau of Ships to the Bureau of Navigation of October 21,
1941. Bruce mentioned an article writted by Lieutenant Harold J.
Burke (USNR) about fire protection aboard ship and commented
that Lt. Burke in civilian life was the head of the Marine Division
of the Fire Department of New York City. According to Bruce,
BuShips saw Burke’s experience in fire fighting as invaluable and
requested that the Bureau of Navigation assign him to BuShips for
consultations on this subject.

174. Wilson Brown, commanding officer, U.S. Pacific Fleet Scouting Force,
confidential memorandum to the Scouting Force, “Fires — Control Of to Stop
Spreading,” June 7, 1941, reference number S93/(0403), file C-S93-(1)-vol.
1, box 1635, RG 19, NARA. The cover sheet for this document notes in the “brief”
section that these extracts are “for in[formation] and serious consideration.”

175. Captain Alexander R. Early, confidential memorandum to the Commander in
number S93 serial 01092, (but located as an attachment to document reference
S93/(5) serial 01572, letter of Commander in Chief U.S. Pacific Fleet to the Chief
of Naval Operations, June 1, 1942) file number C-S93-(1)-vol. 1, box 1635, RG
19, NARA.
This letter also stated that "[t]he Bureau has also received information concerning the establishment by the British Navy of fire fighting schools and is preparing to recommend that such schools be established for the Fleet as soon as the necessary equipment can be assembled."

In the marginal notes on the cover sheet, writer "Co," (from the handwriting and similar notes on other documents likely to be Captain Edward L. Cochrane of BuShips) added that "We shall need at [least] two schools, probably at Norfolk and Pearl Harbor."\(^{176}\)

It is thus evident that, based on British experience, the Navy was moving almost two months before Pearl Harbor to establish fire fighting schools. The Navy was not waiting for its own catastrophes to move in this direction. The Navy, furthermore, was drawing on the expert knowledge of a veteran civilian fire fighter. While the Navy did not physically establish the schools until after Pearl Harbor, it planned to do so before the outbreak of war.

The Navy established the schools in January of 1942. A set of letters from Chief of the Bureau of Navigation Admiral Randall Jacobs, dated on the fifteenth of that month, ordered the commandants of the Navy Yards at Boston, Mare Island, and Philadelphia to furnish enlisted personnel for firefighting schools.

\(^{176}\) Bryson Bruce, (by direction) Bureau of Ships, confidential memorandum to the Bureau of Navigation, "Fire Protection of Naval Ships," October 21, 1941, reference C-S93-(1) (3688), file number C-S93-(1)-vol. 1, box 1635, RG 19, NARA.
Jacobs suggested that they enlist (as USN reservists) local firemen for duty as instructors.\footnote{Randall Jacobs,Chief of the Bureau of Navigation, letter to the Commandant of the Puget Sound Navy Yard, January 15, 1942, "Enlisted allowance, Fire Fighting School, Navy Yard, Puget Sound," document reference number Nav-611-ACS, file NC 120, box 1170, RG 24, NARA. Identical letters, copies of which are found in the same file, were sent to the commandants of the Boston and Mare Island Navy Yards.}

A second letter by Jacobs illuminates the perceived purpose of these schools. He wrote the commandants of the First and Third through Fifteenth Naval Districts, announcing the establishment of the fire fighting schools and urging them to train the personnel of the local defense forces "in the subject of combating shipboard fires. . . . [I]f practicable, the class should observe actual tests of apparatus in the extinguishing of pit fires, and should receive instruction in the technique of fire prevention and extinguishment pertaining to each space or compartment of a ship. . . . The object of the instruction should be to give personnel a clear understanding of the principles of fire fighting and to give them confidence in the equipment provided, particularly to combat shipboard fires, and confidence in their ability to handle such equipment successfully."\footnote{Randall Jacobs, Chief of the Bureau of Navigation, memorandum to the Commandants, First, Third, Fourth, Fifth, Sixth, Seventh, Eight, Ninth, Tenth, Eleventh, Twelfth, Thirteenth, Fourteenth, and Fifteenth Naval Districts, "Instruction in the principles of fire fighting," January 28, 1942, reference number Nav-1646-DD, file NC 120, box 1170, RG 24, NARA. This author must make clear that at this time, not all local defense forces had access to these schools. Jacobs urged the Navy Yard commandants to use the cooperation of local fire departments in teaching naval personnel fire fighting.} On August 1, 1942, the schools at Boston, Norfolk, and Pearl Harbor were in commission, and the
ones at Bremerton and Mare Island expected to be so in a few weeks.\textsuperscript{179}

The schools of 1942, of course, did not achieve immediately the same level in instruction and proficiency which they demonstrated later in the war. The Boston school, as late as November 1942, had no definite curriculum. It did, however, offer enlisted men a one to three day course consisting of lectures, demonstrations of fire fighting, and exercises in which the students themselves fought a fire. The primary function of the school was to familiarize the sailor with fire fighting equipment and reduce their fear of fire.

"Many of the enlisted personnel from lower ratings up to chief and also the officers attached to the school have voluntarily stated that they were somewhat afraid to approach a fire before attending this school. After attending the school and getting the experience of putting out fires, however, they realize that fire, like anything else, can be intelligently handled without a great deal of danger to the personnel. It is this feature of the training that is considered the most valuable function of the school."\textsuperscript{180}

\textsuperscript{179.} Randall Jacobs, Chief of the Bureau of Naval Personnel [the successor organization to the Bureau of Navigation], letter of August 12, 1942 to the Commandant of the U.S. Coast Guard, “Fire Fighting Schools,” reference number Pers-1411-DE, file NC 120, box 1170, RG 24, NARA.

\textsuperscript{180.} Wilson Brown, Commandant of the Boston Navy Yard, letter to the Bureau of Naval Personnel, “Fire Fighter’s School,” November 27, 1942, reference NC 120-5 (Y), file NC 120, box 142, RG 38, Officer of the Chief of Naval Operations, General Correspondence, NARA. Brown did note, however, that the officer who could attend the school for a month or more “learns considerably more”. For comparison, in the middle-1950s these fire fighting schools offered two- and five-day courses. George Baker, “The Enemy [Fire] In Your Ship,” All Hands, Department of the Navy, Bureau of Naval Personnel, No. 478, November 1956, 3.
A letter of September 23, 1942, from Ronan C. Grady of the Boston Navy Yard to Captain Forrest U. Lake of the Bureau of Naval Personnel confirms the “familiarization” nature of the course and its lack of curriculum. According to Grady, at this time the Boston fire fighting school had been operating about two months. Despite its youth and limitations it was much in demand; Grady believed that this was because of the loss of Lexington.\textsuperscript{181}

The Bureau of Ships (which had responsibility for much relating to the schools) stated as early as May, 1942, that it was constructing simulated ship’s compartments at the fire fighting schools. These compartments, constructed of fire-resistant materials, were to be used to familiarize ship’s complements with fire fighting and to permit the trainees to fight fires under conditions closely simulating those aboard ship.\textsuperscript{182}

This archival information demonstrates that the Navy, before the losses at Coral Sea, Midway, and Guadalcanal, began to improve and formalize fire fighting instruction by creating schools. It did not wait for the losses by fire of the first year of the war to push it into such innovation.

\textsuperscript{181.} Ronan C. Grady, Boston Navy Yard, to Forrest Lake, Bureau of Naval Personnel, no subject listed, September 23, 1942, reference (Y), file NC 120, box 1170, RG 24, NARA.

CHAPTER 11

THE EFFECT OF US NAVAL FIRE FIGHTING ON THE WAR AT SEA

The outcome of a war depends on literally innumerable factors. To say that US Navy development of superior fire fighting gear and technique was even a major contributor may overstate the case. In certain cases, however, the success or failure of USN fire fighting did affect important actions, and, possibly, the overall strategic situation in the Pacific in 1943.

For example, the American heavy cruisers destroyed at Savo Island, USS Quincy, Vincennes, and Astoria, would have benefited from more vigorous pre-battle efforts to remove flammable material. The initial Japanese hits caused immediate severe fires from the burning gasoline of the vessels' float planes. These fires drove the crew from superstructure positions (including gunfire control stations), destroyed life jacket stores, and provided excellent aiming points for Japanese gunnery.

While fire clearly played a significant role in the loss of these cruisers, they were, however, unlikely to have profited from enhanced fire fighting training or doctrine (aside from fuel denial efforts). They were overwhelmed in minutes by multiple medium-caliber hits and the impact of the powerful Japanese torpedoes.
Fire may have increased the loss of many skilled engineering room personnel who were trapped below decks by the fires above. At a time when the Navy was rapidly expanding and experienced personnel were at a premium, this lost manpower may have been as important as the loss of the ships themselves.\textsuperscript{183}

In early 1942, much American naval power rested in six ships — the large fleet carriers \textit{Lexington, Saratoga, Yorktown, Enterprise, Wasp}, and \textit{Hornet}. Perhaps the greatest impact of fire fighting skill, therefore, was in its effect on the fortunes of the large American carriers.

USS \textit{Lexington}'s loss at the Battle of the Coral Sea was due to fire. The ship's crew had controlled the initial damage caused by the bomb and torpedo hits. The secondary explosions caused by gasoline fumes over an hour after the attack caused the loss of the ship.\textsuperscript{184}

More effective and rigorous fire fighting training might have saved the \textit{Lexington}. For example, one handicap the \textit{Lexington}'s crew faced was the rupture of the ship's cast iron fire mains by the initial hits and the secondary explosions; without water


pressure fire fighting was difficult.\textsuperscript{185} It is of interest to note that post-1942 fire fighting manuals stressed isolating damaged sections of fire main and rigging "jumper" hoses from one undamaged section of main to the next past the broken length to move water to the burning regions of the ship.\textsuperscript{186} Other sources have indicated that burning paint and plush furniture,\textsuperscript{187} the improper fire fighting gear, such as the solid-stream "suicide" nozzle and an inadequate supply of foam, may have contributed to the loss of \textit{Lexington}.\textsuperscript{188}

Even had the ship been saved by superior fire fighting practice, the \textit{Lexington}, much harder hit than the \textit{Yorktown} at Coral Sea, would not have been present at Midway. She might, however, have been present for the Guadalcanal campaign in the fall of 1942.

As has been noted, the loss of the \textit{Wasp} was due largely to what she was doing — fueling aircraft — when she was hit by

\begin{itemize}
\item \textsuperscript{185} Hoehling, \textit{The Lexington Goes Down}, 7, 121, 123.
\item \textsuperscript{187} Stroop in Wooldridge, \textit{Carrier Warfare in the Pacific}: . . . 43.
\item \textsuperscript{188} Stroop in Wooldridge, \textit{Carrier Warfare in the Pacific}: . . . 43; Osmundsen, "Damage Control, . . . " 38-9. The Navy Department had allotted the \textit{Lexington} and other carriers a certain number of fog nozzles for the flight and hangar decks; as the fires were deeper in the ship such a deployment of equipment may not have been helpful. As has been mentioned, it was perhaps the influence of the Pownall report of 1938 that kept the fog nozzle from the place where it was needed in 1942. See also Belote & Belote, \textit{Titans of the Seas}, 43.
\end{itemize}
Japanese torpedoes. 189 As in the case of USS Princeton off Leyte in October 1944, even advanced fire fighting practice equivalent to that existing late in the war was unlikely to have saved her.

USS Hornet almost certainly would have been saved by superior fire fighting technique and more thorough removal of flammable material since most of her damage was caused by the fires that followed the initial bomb hits. Even after the failure of her water pressure, after some hours the crew was able to extinguish the fires with improvised methods.190 A second factor in her loss was that fire forced the evacuation of her engineering spaces for several hours; this made it impossible for Hornet to move away from where the enemy knew her to be.

Despite the failures of her fuel denial and fire fighting practice, the fires had been extinguished, the engineering rooms reoccupied, and the ship coming under way again when the second Japanese attack arrived. Despite finding Hornet almost dead in the water and without power for her weapons and anti-aircraft gunfire control, Japanese fliers scored only one torpedo hit; it was sufficient to doom the carrier.191

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Given the narrow margin by which she was lost, it is likely that with superior fire fighting practice — either that of late-war standards or even that of her contemporary, the Enterprise — and the presence of less flammable material aboard Hornet would have met the second Japanese attack under way and with weapons in use. The fatal hit in those circumstances would have been improbable. The Hornet almost certainly would have been saved to fight again in early 1943.

A major factor in the battle reputation of the US carrier Enterprise was excellence in fire fighting and thorough removal of flammable material. Before entering the Solomons campaign Enterprise crew had removed substantial quantities of flammables from the ship. At the Battle of the Eastern Solomons (August 24, 1942,) three bombs hit the Enterprise. Rapid response by crewmen close to the impact sites and the speedy arrival of damage control teams contained the fires. The ship's complement used fog nozzles on fires below the hangar deck.¹⁹² While the bomb explosions fractured the ship's fire mains, as in the case of Lexington and Hornet, quick action on the part of petty officers closed off the broken lengths and maintained water pressure elsewhere to fight the fires.¹⁹³ One hour after receiving these


injuries, *Enterprise* was recovering aircraft and maintaining 24 knots.  

Following this battle, the *Enterprise* was under repair for one month. During this time, her crew trained intensively in fire fighting, including drilling blindfolded to simulate work in smoke-filled spaces. They again scoured the ship to locate and remove any remaining unnecessary flammable items.  

At the Battle of Santa Cruz (October 26, 1942) the *Enterprise* took one bomb hit, one near miss, and one bomb that struck but broke up without a full-strength explosion. Dangerous fires broke out in the ship's living areas (fueled by bedding and clothes — fuel denial can only go so far) and, fueled by leaking aviation gasoline, in the forward elevator pit. The ship's crew contained the fires then extinguished them. Aside from a forward elevator stuck (fortunately) in the raised position *Enterprise* was repaired and back in service in two weeks; she was then the only American carrier in the South Pacific.  

Skillful fire fighting played a major role in *Yorktown*'s survival at the Battle of the Coral Sea and contribution to the important battle of Midway. At Coral Sea, one bomb hit *Yorktown*, starting fires on her hangar deck which were quenched quickly. An

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all-out repair effort at Pearl Harbor barely permitted Yorktown to return to service for the battle of Midway. Had the Yorktown's crew failed to limit the damage of these fires her presence in that battle would have been unlikely.\textsuperscript{197}

Had the Yorktown not been in service at the battle of Midway American carrier and shipborne aircraft strength would have been one-third less. The fire fighting ability of the Yorktown's crew had a second impact on the this battle. The first Japanese counterattack found the Yorktown and left her listing, burning, and dead in the water. The second Japanese attack, some hours later, found an American carrier steaming at high speed and betraying no trace of damage. Assuming that it was an untouched second carrier, the Japanese fliers attacked vigorously and scored several more hits. Their target was again the Yorktown. Her crew had quenched the fires and restored the ship's mobility. This damage control success diverted unwanted Japanese attention from the undamaged Enterprise and Hornet. While the Yorktown crew's efficiency at fire fighting may have caused the Japanese to attack their own ship a second time, this may have saved precious undamaged carriers from injury.\textsuperscript{198}

Between the Coral Sea, Midway, and the battles around the Solomons in the fall of 1942, skill in fire fighting, therefore, may


have determined to a large degree the number of carriers the US Navy had in early 1943. Had the Enterprise crew failed to excel in fire fighting, the Navy might have had no more than one carrier, Saratoga, available. Had better fire fighting equipment and training been available, the Navy may have had two other carriers available for operations. This might have made a difference in what the United States could have done in that theater at that time. While this change might be significant, any thought on this matter would remain speculation and should be outside of the limits of this thesis. What can be known for certain is that American failures in fire fighting and fuel denial cost us two valuable warships, the Lexington and Hornet. Success in these practices preserved the Yorktown to serve at Midway and the Enterprise to operate for the rest of the war. As such fire fighting made some difference to the length and course of the conflict.
CHAPTER 12

CONCLUSION

The United States Navy did not neglect fire fighting in the 1930s, as a number of historians have assumed or implied. Much of the equipment used so successfully in the Second World War was developed, not as a result of the experiences of that war, but to address problems perceived by US naval officers in the ten years before that war. By their work, the naval personnel of the 1930s helped to save many ships and hundreds of men in the 1940s. Even if the US Navy could not issues such items of equipment because of bureaucratic delay or budget stringency, at least they existed, had been tested, and the Navy could adopt them quickly once war cut the red tape and loosened the purse strings.

In brief, by 1940 the US Navy was far better equipped to fight fires aboard ship than it had been in 1930. Even if this equipment were not sufficient to meet the demands of war from the beginning, it was an improvement over what had gone before.

This success in developing equipment was not, unfortunately, matched by the development of the human element. The Navy proved itself able to regularize and organize its damage control effort against flooding and stability casualties; it did not
do so for fire fighting. Even though training and organization appear to be the elements the Navy could most easily control, the Navy did not devise the doctrine and conduct the team training necessary to optimize the performance of a ship's crew against a fire.

Several lessons about military organizations in general have been confirmed by this study. First, as the Navy did in this case, the introduction of one new technology (the large fleet carrier) may mandate the development of other support technologies (improved fire fighting material to cope with the threat of hundreds of thousands of burning gallons of aviation gasoline.)

Second, early evaluations of experimental equipment may well be misleading, and repeated testing is desirable. The Naval Research Laboratory deemed the fog nozzle unsatisfactory in 1937. The determination of a small number of officers rescued the fog nozzle from oblivion and showed its value for fighting certain types of fires. The Pownall Report of 1938 indicated that the fog nozzle was unfit for fighting fire below decks. The acceptance of this caveat by the Navy may have contributed to the loss of the Lexington through limiting fire fighting below decks to the “suicide nozzles”.

Third, re-evaluation of accepted technology may be necessary as well. Carbon dioxide systems had definite advantages over the alternatives available for fighting engineering space fires in 1925; the situation had changed by 1938. Fortunately the Navy pursued a number of alternative
technologies (foam, steam smothering, and the fog nozzle) and had them available as replacements.

Finally, and most important, the saga of Navy fire fighting between the wars confirms the value of the human element, training and doctrine. The advances in equipment procurement were not matched by advances in training. Until late 1941 the Navy did not recognize that fire fighting was a specialized skill requiring service-wide doctrine and professional training of crew members. While its performance in regard to establishing fire fighting schools was better than Morison and his followers noted, the Navy might have saved several ships if it had recognized the importance of fire fighting training and established formal training when it began to do so for stability and flotation damage control in the middle 1930s.

Another lesson of the human element is the need for someone in authority to act as a “spark plug” for technical advance. The work of Cochrane, Burke, and Kiernan with the fog nozzle, of Taussig with the portable self-powered pump, and of Van Keuren of C&R and Cooley of the NRL regarding the mechanical foam generator are illustrative. Some one has to call the attention of the organizational hierarchy to the potential of that device, maintain faith in that potential through the probable early setbacks, and simply keep pushing. Until the arrival of Burke and the development of Cochrane’s interest in fire-fighting schools in late 1941, no one focused on the training element. The Navy suffered thereby.
From 1920 to 1942 the Navy clearly did far more than historians admit to anticipate and cope with the problems of wartime fire fighting. In 1942, of all the world's maritime armed services the US Navy was probably the one best equipped to deal with battle damage and the fire that was almost certain to follow.

END
APPENDIX

HISTORIOGRAPHY OF FIRE FIGHTING IN THE US NAVY IN
WORLD WAR TWO

The statement that the majority of historians examining this topic failed to address it correctly is based on a survey of their work. For each work, the index was consulted under "fire," "fire fighting," "damage control," and "training." Then each section of the book dealing with major battles in which fire aboard a US naval vessel affected the outcome was examined. For the purposes of this study these battles included Coral Sea, Midway, Savo Island, Eastern Solomons, Santa Cruz, Leyte Gulf, and Okinawa under the Kamikazes. Each such battle offered the historian an opportunity to discuss fire fighting practice and/or training in context. No book listed in this footnote did so. 199

Samuel Eliot Morison, author of the “semi-official” history of the US Navy, did address fire fighting and recognized its importance. As his work was and remains influential, his treatment of the subject is worth quoting in full:

“Something more than courage — know-how — was required to conquer fires such as those that raged in Franklin. Neither she nor many of the other ships crashed by kamikazes off Okinawa could have been saved but for the fire-fighting schools and improved technique instituted by the Navy in 1942-1943. The initial impulse came from Lieutenant Harold J. Burke USNR, deputy chief of the New York City Fire Department. He interested Rear Admiral Edward L. Cochrane, Chief of the Bureau of Ships, in the new fog nozzle, which atomized water to a fine spray and quenched a blaze much more quickly than a solid stream. Burke and Lieutenant Thomas A. Kilduff, USNR, formerly of the Boston Fire Department, trained over 260 officer instructors and established schools with mock-up ships at every continental naval base, and on several Pacific islands. At one of these, the damage control party of every new warship was trained before going to sea. The major object of this instruction was to ‘get the fear of fire out of the sailor’; to teach him that if properly equipped with fire mask and helmet, handling an all-purpose nozzle and applicator, he could boldly advance to the source of a blaze and not get hurt.

“The big carriers, which already had fourteen fire mains dependent on ship’s power, were now given two more, operated by individual gasoline engines. One of these in Franklin threw fog for eight hours continuously when all other mains were knocked out by power failure. All ships were equipped with 160-pound handy billies, and the destroyers and larger types with 500-pound mobile pumps, each operated by its own gas engine. Hoses and couplings were made standard throughout the Navy. Portable oxyacetylene steel-cutting outfits and rescue breathing

apparatus were provided. A foamite system was placed at every hundred feet of a carrier’s deck. The foam generators in destroyers, formerly located in the engine spaces, were moved topside.\textsuperscript{200}

Morison’s statement creates the impression that US naval fire fighting skill was a response to the losses of the first year of the war. It also implies that the most important items of fire fighting equipment were developed after the war began. As late as 1985, Ronald Spector, in \textit{Eagle Against the Sun}, used Morison as the source for his discussion of US naval fire fighting.\textsuperscript{201}

Morison, however, seemed uninformed of the extensive work the Navy had devoted to fire fighting before the outset of the Second World War. He was also apparently unaware that the US Navy had, before Pearl Harbor, planned to establish fire fighting schools because of its knowledge of the British wartime experience.

The reason why Morison made this error at this point remains conjecture. His footnote to this passage, number 27 on page 99, may, however, offer a clue. Morison apparently drew most of his information on this topic from Thomas Kilduff in postwar interviews. As Kilduff was not mentioned in the source material for the 1930s and early war period, he was not likely to


have been present for this era of fire fighting research and
development. Kilduff may have been unaware of the substantial
time and effort the prewar Navy had devoted to this subject. This
volume, furthermore, was published in 1960 and Morison
interviewed Kilduff in that year. Kilduff may not have
remembered all details correctly.
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