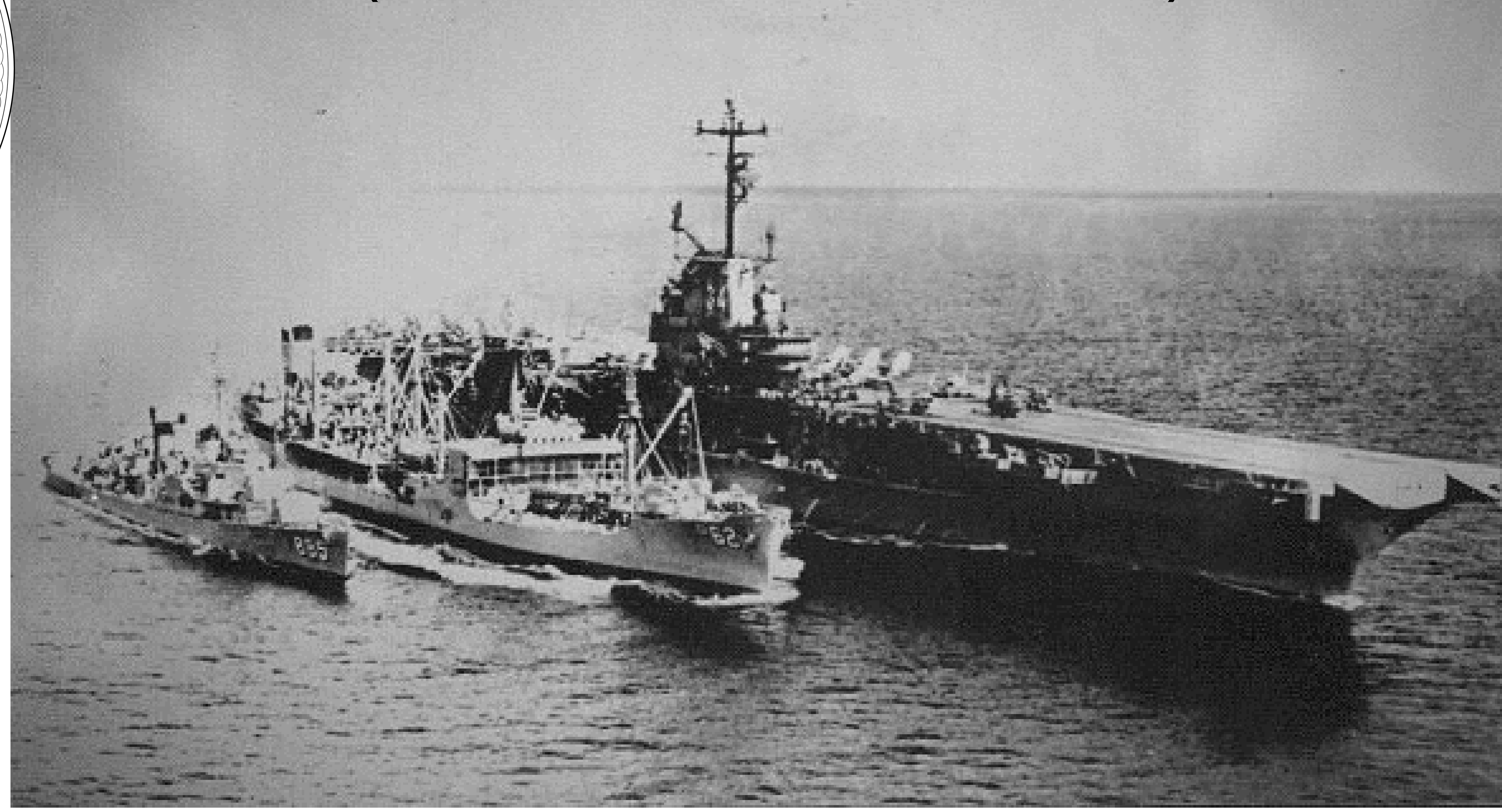
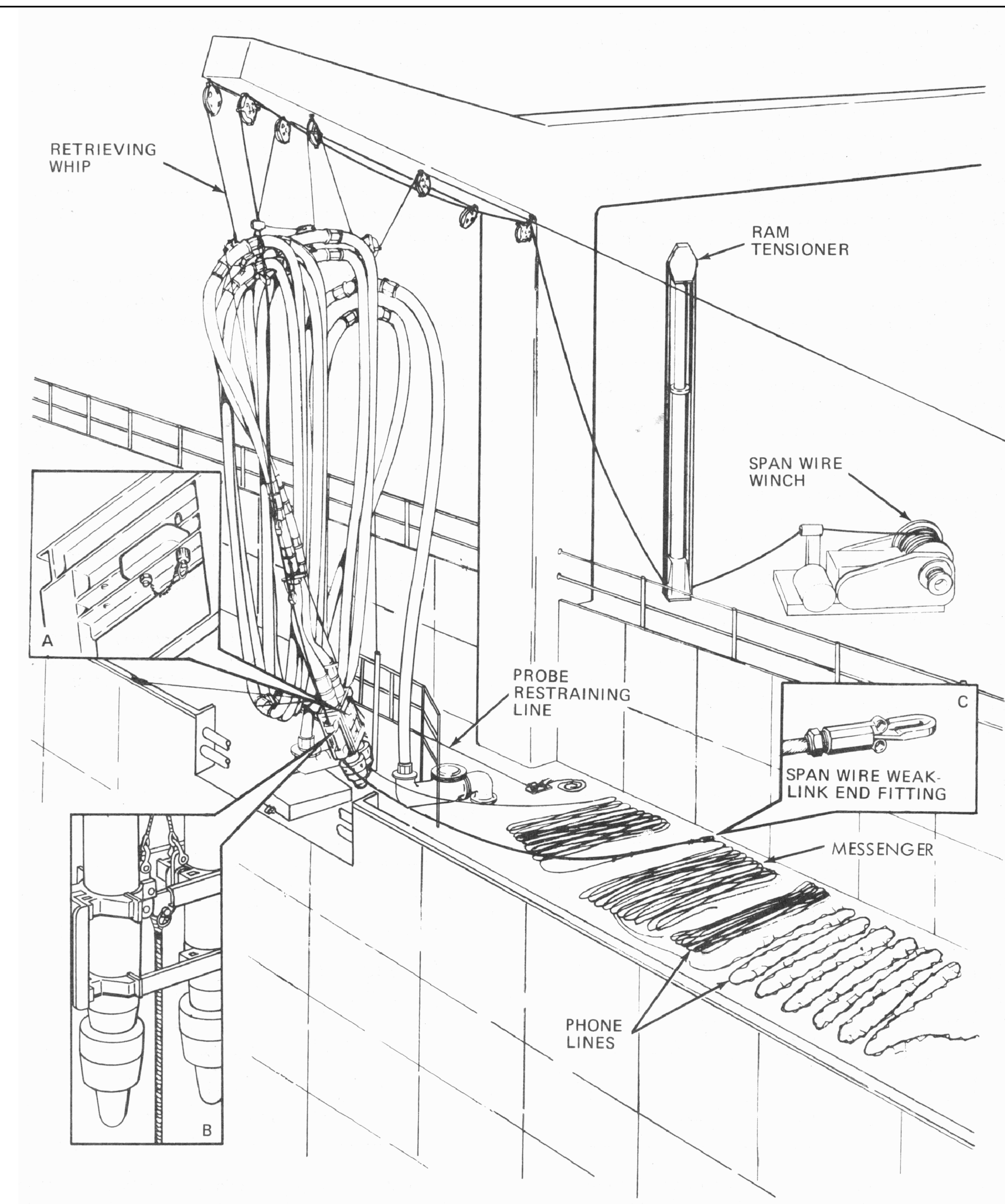
U.S. NAVY OILERS AND TANKERS

UNDERWAY REPLENISHMENT AND FUELING TECHNOLOGIES

(FROM ca. 1916, THROUGH WORLD WAR II, AND INTO MODERN IDEAS)



Logistical support is critical during military operations as it involves obtaining and transporting material, personnel, and services. Without this support in place, conducting battles or major campaigns would be problematic for the U.S. military. In the course of the U.S. Navy's history, there has been a struggle to balance the needs of the fleet with the ability to conduct operations in times of war and peace. As a result, the navy designed specialized ships to carry fuel followed by the development of fueling methods that allowed ships to replenish-at-sea rather than in port. The underway replenishment (UNREP) techniques developed to provide the necessary logistical support have been referred to as a "uniquely American naval tactic." Marvin O. Miller, "UNREP Since 1899," *Surface Warfare Magazine* (March/April 1977), 6. This report will trace the development of both UNREP techniques and the types of vessels involved in UNREP operations.



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US NAVY OILERS AND TANKERS
EVOLUTION OF REFUELING AND UNDERWAY REPLENISHMENT

DISTRICT OF COLUMBIA

SHEET 1 OF 6

HISTORIC AMERICAN ENGINEERING RECORD DC-62

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HISTORIC AMERICAN ENGINEERING RECORD

U.S. NAVY OILERS AND TANKERS

HAER No. DC-62

Location: Various; U.S. Maritime Administration, Washington, DC

Significance: Accompanying the U.S. Navy's warships are logistical vessels, like the oilers and tankers that provide the supplies needed to conduct operations in times of peace and war. The oilers and tankers, as well as the underway replenishment techniques used, have transformed through time to keep a range of battle groups and expeditionary forces supplied while underway for extended periods. In so doing, these vessels add to the security of the United States and its ability to respond to crises anywhere in the world.

Historian: Brian Clayton, HAER Contract Historian, 2009

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For individual tanker and fleet oiler histories, see the following:

Mispillion (Fleet oiler, T3-S2-A3)	HAER No. CA-338
Mission Santa Ynez (Tanker, T2-SE-A2)	HAER No. CA-337
Saugatuck (Tanker, T2-SE-A1)	HAER No. VA-128
Taluga (Fleet oiler, T3-S2-A1)	HAER No. CA-336
Wichita (AOR)	HAER No. CA-356

Introduction

Logistical support is critical during military operations as it involves obtaining and transporting material, personnel, and services. Without this support in place, conducting battles or major campaigns would be problematic for the U.S. military. In the course of the U.S. Navy's history, there has been a struggle to balance the needs of the fleet with the ability to conduct operations in times of war and peace. As a result, the navy designed specialized ships to carry fuel followed by the development of fueling methods that allowed ships to replenish-at-sea rather than in port. The underway replenishment (UNREP) techniques developed to provide the necessary logistical support have been referred to as a "uniquely American naval tactic."[1] This report will trace the development of both UNREP techniques and the types of vessels involved in UNREP operations.

The Quasi-War with France

It was not long after the establishment of the U.S. Navy in 1798 and the start of the Quasi-War with France that the navy began looking for ways to replenish ships at sea. In May 1798, President John Adams authorized the newly-formed navy to provide security for American merchant vessels under attack from French naval units and privateers in the Caribbean, launching the Quasi-War. The USF (United States Frigate) *Constitution* began operating off the coast of Saint-Domingue (Haiti), with Cdre. Silas Talbot in command. An earlier revolt in 1791 in Saint-Domingue had left the area destabilized, and the political situation began to again deteriorate in 1799. Consequently, the American consul in Saint-Domingue advised Commodore Talbot not to enter port for supplies. As a result, the Navy Department contracted the schooner *Elizabeth* to bring supplies from Philadelphia to the *Constitution* in the Caribbean. The schooner made contact with the *Constitution*, and the navy's first replenishment-at-sea commenced by means of ship's tenders as the *Constitution* took the supply vessel in tow and small boats lightered the stores back and forth. Underway replenishment (UNREP) allowed the *Constitution* to remain on station for 347 days out of 366. The ship returned to its homeport of Boston in 1800 after a successful tour that prevented attacks on American shipping.[2]

The Civil War

During the Civil War, there was no equipment to transfer coal-at-sea to supply the navy's coal-powered steamships. Instead, Union steamships participating in the blockade of southern ports had to leave their stations to refuel. Typical steamships during this era were not efficient and held limited amounts of coal in their bunkers. In 1883, Adm. R.S. Lowry of the Royal Navy stated that the Union steamships blockading southern ports had only been about 75 percent effective since at any given time a quarter of the ships were in port refueling. Admiral Lowry also stated that when Union vessels were searching for the CSS *Alabama* they regularly retired from searches due to a lack of fuel, illustrating the need for underway replenishment. Refueling-at-sea did not gain attention until the Spanish-American War, however, when senior naval officers took interest.[3]

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[1] Marvin O. Miller, "UNREP Since 1899," *Surface Warfare Magazine* (March/April 1977), 6.
[2] Tyrone G. Martin, "Underway Replenishment, 1799-1800," *American Neptune* XLVI (summer 1986): 159-163.
[3] Spencer Miller, "Refueling Warships at Sea," *Transactions of the Society of Naval Architects and Marine Engineers* 22 (1914): 157.

The Spanish-American War and Spencer Miller

The war with Spain presented new logistical challenges for the U.S. Navy in 1898. Coal-burning warships had entered service nine years earlier, but coaling stations were only located along the coasts of the United States. Several colliers were constructed to transfer coal to the coaling stations, and they could sail with the fleet, if compelled. However, the colliers hampered the fleet with their slow speeds, their inability to refuel at sea in inclement weather, and their need to use protected ports to take on coal. The problems with coal refueling became even more apparent when Cmdr. Winfield S. Schley blockaded the Spanish fleet at Santiago de Cuba. Fully one-quarter of the fleet had to go as far as 45 miles away for re-coaling, making it difficult to maintain the blockade. Rear Adm. William T. Sampson was forced to secure Guantanamo Bay as a sheltered site for re-coaling operations. This blockade influenced the U.S. Navy to experiment with replenishment-at-sea.[4]

At the conclusion of hostilities with Spain, Adm. George Dewey instructed Spencer Miller to develop a method of coaling-at-sea. Admiral Dewey envisioned a system where battleships could coal-at-sea from any collier because the equipment would be fixed on the battleships. Miller, originally chief engineer with Lidgerwood Manufacturing Company, developed equipment and techniques for the U.S. Navy and other foreign navies over a period of fifteen years. In 1904, he designed a working model to transfer coal-at-sea, which the navy installed on the battleship *Illinois*. The process involved the battleship towing the collier from a distance of 400 yards and passing a highline that was reefed around the collier's mainmast. The highline was then attached to a sea anchor that dragged through the water and tightened the line to 18,000 pounds. Winches on board the battleships hauled a trolley carrying 3,500 pounds of coal, or one load per minute.[5]

While Miller's method of transfer was satisfactory, it was not without controversy. The *Illinois*' captain and other senior naval officers complained that the equipment on the battleship's fantail overloaded the ship and hampered its combat effectiveness. Shortly thereafter, the navy rejected Miller's method for coaling-at-sea. Miller attempted another test using the same technique but interchanged the equipment from battleship to collier. Naval officers deemed the transfer rate of 80 tons per hour slow, especially when compared to the 500 tons per hour rate at the anchor. The navy ceased experiments using Miller's ideas in 1914 when fuel oil took precedence, but Miller's technical work proved invaluable for the future navy and modern underway replenishment by reducing the development time.[6]

World War I

The U.S. Navy's next attempt at UNREP was during World War I. In 1911, the navy began converting its fleet to oil-burning power plants. In addition, the navy started investigating the use of fleet oilers, referring to commercial tankers with such additional features as redundant

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[4] Miller, "Refueling Warships at Sea," 159-60; Marvin O. Miller, "Standby for Shot Line," Naval Institute *Proceedings* (April 1985), 75-76.

[5] Miller, "UNREP since 1899," 6; Miller, "Standby," 75; Marvin O. Miller, John W. Hammett, and Terence P. Murphy, "The Development of the U.S. Navy Underway Replenishment Fleet," SNAME *Transactions* 95 (1987): 124-125.

[6] Miller, "Standby," 75-76; Miller, Hammett, and Murphy, "Development," 125.

twin-screw propulsion and underway replenishment gear. The navy completed its second fleet oiler, the USS *Maumee* (AO-2) in 1916.[7] After sea trials, the *Maumee* headed for the Caribbean and took part in a fleet exercise. Under the existing doctrine, ships refueled in sheltered waters while moored together. During the exercises, the *Maumee*'s crew became proficient users of the equipment. After the United States entered World War I on 6 April 1917, the navy ordered a division of destroyers to Great Britain to assist the Royal Navy in defeating the German U-boats. The succeeding destroyers crossing the Atlantic required refueling due to their small bunkers. As a result, the U.S. Navy ordered the *Maumee* into position 300 miles south of Greenland to refuel the destroyers so they could complete the Atlantic crossing.[8]

Aided by two lieutenants and the chief boatswain's mate, Lt. Chester Nimitz devised a method of refueling destroyers while underway.[9] They decided it was best to tow the destroyers with a large hawser off the oiler's beam, called the "broadside." Two additional breast lines held the destroyers in place. They also concluded that under the most favorable circumstances, two hoses should be used. During the transfer of fuel, the *Maumee*'s crew connected 50' sections of 3" hose to the manifolds and passed the hoses to the destroyers. The hoses were placed directly into the hatches leading to the bunkers. This method doubled the rate of flow and decreased the amount of time needed for refueling. The oiler's booms elevated the hoses and held them in place through a wooden saddle. The broadside method or riding-abeam method, as it was also known, kept the hoses out of the water.[10]

Shortly after the United States entered the war, the *Maumee* sailed to the Mid-Atlantic to serve as a mobile fueling station for destroyers with insufficient fuel capacity to make it across the Atlantic. Using the procedure developed by Nimitz, the *Maumee* was able to refuel the entire Fifth Destroyer Division, consisting of *Drayton*, *Patterson*, *Jenkins*, *Paulding*, *Trippe*, and *Warrington*, in one day in moderate sea conditions and with an inexperienced crew, illustrating the effectiveness of the broadside method.[11]

The Inter-War Years

During the inter-war years, the U.S. Navy operated under severe budget limitations and funds were scarce for maintaining and repairing ships. With tight operating budgets in mind, naval officers seem to have perceived the broadside refueling method as too risky because of the chance of collision. The navy retained its interest in refueling battleships and conducted tests using the over-the-stern method with one hose in the mid-1920s. The navy deemed this operation inadequate, however, because the hose used in the fuel transfer passed a limited amount of oil due to its narrow diameter. As a result, the navy discontinued these experiments in 1931, even though the experiments were successful.[12]

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[7] The first oiler was the *Kanawha* launched on 11 July 1914.
[8] Thomas Wildenberg, "Chester Nimitz and the Development of Fueling at Sea," *Naval War College Review* (Autumn 1933), 52-53; U.S. Department of Transportation, Maritime Administration, Office of Ship Operations, "Historic Assessment of Non-Retention Vessels in the National Defense Reserve Fleet," Programmatic Review and Analysis, Naval Underway Replenishment Vessels, December 2004, 4.
[9] At that time, Nimitz was the executive officer and chief engineer of the *Maumee*.
[10] Wildenberg, "Chester Nimitz," 53-54.
[11] Wildenberg, "Chester Nimitz," 54.
[12] Wildenberg, "Chester Nimitz," 54-55.

By 1938, war planners had begun to recognize the limitations imposed upon them during fleet exercises. The major problem identified by the War Plans Division of the Office of the Chief of Naval Operations was the fuel consumption of carriers. When an aircraft carrier launched and retrieved aircraft, it traveled into the wind at high speeds. When the carrier finished the takeoff or landing evolutions, it moved back into position with the fleet. Both exercises required large amounts of fuel, around 30 tons per hour. This reduced the cruising range to 4,421 miles from 10,000 miles (at 10 knots). Military planners advocated for designs that would enlarge the carrier's fuel tanks to increase the steaming radius, particularly since operations did not generally occur near base. Military planners decided that future carrier designs should have larger fuel tanks, but the temporary solution was to refuel-at-sea.[13]

As a result, Adm. William D. Leahy, Chief of Naval Operations (CNO), sent a memo to Adm. Claude C. Bloch, Chief of the U.S. Fleet, requesting that he begin testing refueling large vessels at sea. Bloch complied, and testing began in October 1938. Admiral Bloch entrusted Rear Adm. Chester Nimitz (Commander of Battleship Division One) with administering the sea trials and ascertaining the results. Admiral Nimitz utilized Task Force 7 as the test platform and conducted trials beginning in spring 1939. Block's decision to assign Nimitz to this task is not surprising since twenty-five years earlier, during World War I, he had developed the plans to refuel destroyers using the broadside method.[14]

Nimitz's prior experience led him to consider alternative approaches to refueling-at-sea. Most officers regarded the over-the-stern method as the ideal refueling location, but Nimitz instead again advocated the broadside method since it allowed more fuel to be transferred in a shorter amount of time. This was an important consideration because during the refueling phase, the two ships were exposed to submarine attack since both had to maintain a parallel course at a reduced speed until the operation had been completed. Tests off the California coast in June 1939 between the oiler *Kanawha* and the carrier *Saratoga* demonstrated the successfulness of the broadside fueling method.[15]

Although the U.S. Navy adopted the broadside method, the inadequate number of fleet oilers prevented refinement of the procedure until 1941. In late spring 1940, Congress passed the "Two Ocean Navy" bill, allowing the navy to acquire five more oilers from the Maritime Commission. With these additional vessels, aptly called the "National Defense" tankers, plus the construction of the *Cimarron* class of fleet oilers, the U.S. Navy was able to refine its refueling techniques. As crews became more proficient, the use of the towline between the two ships disappeared. The introduction of handling lines, fuel hoses, and a communication line further simplified the equipment. The efficiency of this streamlined method saved both time and energy, which would be vital during World War II.[16]

[13] Wildenberg, "Chester Nimitz," 56.
[14] Wildenberg, "Chester Nimitz," 56-57.
[15] Wildenberg, "Chester Nimitz," 57-58.
[16] Wildenberg, "Chester Nimitz," 58-60.

World War II

After the attack on Pearl Harbor on 7 December 1941, the United States entered World War II and began the daunting task of building the forces needed to win the war in both Europe and the Pacific. Although U.S. military planners had settled upon a “Europe First” policy, the U.S. Navy proceeded with an offensive-defensive strategy in the Pacific.[17]

On 16 April 1942, the oiler *Cimarron* refueled the carrier *Hornet* for the raid on the Japanese home islands. Captain Doolittle and a group of B-17s took off from the carrier en route to Tokyo to deliver their payload. The raid was a success, but it triggered a series of offensive raids by the Japanese to the south and east. To the south, when the Japanese attacked, the United States countered at the battle of Coral Sea in May 1942 and successfully defeated them. In the east, when the Japanese attacked Midway in June 1942, the U.S. again countered and triumphed. The result of these two raids put the Japanese on the defensive for the first time, allowing the U.S. military forces to regroup and halt further Japanese expansion. In the end, the U.S. formulated its island-hopping strategy that ultimately won the Pacific.[18]

After the outbreak of World War II, the U.S. Maritime Commission established the Emergency War Production Board to fund the establishment of new shipyards and infused existing shipyards with the necessary cash to expand operations. In the interwar years, there were only five shipyards engaged in large-scale ship construction: Bethlehem Steel at the Fore River Yard (later renamed Bethlehem Quincy) in Massachusetts, Bethlehem Steel’s Union Iron Works in San Francisco, Cramp Shipbuilding south of Philadelphia, and Newport News Shipbuilding in Virginia. In 1937, there were only ten yards in the United States that could construct large ships. Six years later, eighty yards employing over 700,000 people were devoted to major ship construction on the Atlantic and Pacific coasts, the Great Lakes, and the Gulf Coast. By the end of the war, the Maritime Commission had authorized the construction of over 6,000 ships in the United States. Several key factors contributed to successful ship construction. The first one was the development of standard designs, which the commission sent to all shipyards, thereby encouraging consistency. The introduction of welding and prefabricated parts also helped increase production. Overall, these factors led to the construction of 2,718 Liberty ships, 550 Victory ships, 533 T2 tankers, and 1,791 ocean and coastal watercraft by the Maritime Commission.[19]

The U.S. Navy’s fleet of oilers and the modification of World War I UNREP tactics were significant elements in defeating the Japanese military in the Pacific. As Adm. Chester Nimitz stated, “Underway replenishment was the navy’s secret weapon.” The UNREP techniques have been characterized as “jury-rigged,” probably because the navy did not use purpose-built vessels, instead relying on modified commercial tankers. Ultimately, these single-product supply ships

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[17] Ronald Spector, *Eagle Against the Sun: The American War with Japan* (New York, NY: Vintage Books, 1985), 66.

[18] Spector, *Eagle Against the Sun*, 154-163.

[19] L.A. Sawyer and W.H. Mitchell *From America to the United States: The History of the Merchant Ship Types Built in the United States of America under the Long-Range Programme of the Maritime Commission* (Kendal, UK: World Shipping Society, 1979), 15-16; William D. Walters, “American Naval Shipbuilding, 1890-1989,” *Geographical Review* 90 (July 2000): 421.

stocked with ammunition, oil, or food were able to meet the needs of the fleet during World War II. Significant advancements in UNREP would not take place until the 1950s when modern engineering methods were applied to both the equipment and the ships.[20]

The Korean War and its Effect on Underway Replenishment

When the Korean War broke out in June 1950, the U.S. Navy was unprepared. Most of the ships needed for carrier operations in the Sea of Japan were lying in mothballs or scattered around the United States. With the activation of the auxiliary fleet, naval personnel gravitated to using the refueling techniques developed in World War II. There were no refinements or changes to replenishment-at-sea tactics and no specialized ships were built.[21]

When the U.S. Navy began operations off the Korean coast, it recognized the deficiencies in its operations. Three ships supplied the needs of Task Force 77 (comprised of aircraft carriers and escorting destroyers) with ammunition, fuel, and provisions, much like the World War II practice of using single-product supply ships. When two new jet squadrons arrived, their fuel requirements caused additional problems. Originally designed to burn kerosene, these new jets had been modified to burn aviation gas. During operations, the jets burned four times the amount of gas used by the older prop planes, so refueling had to take place regularly. Another problem experienced by Task Force 77 was the transfer of ammunition. Since the merchant ships were understaffed, the crews had to start unpacking the ammunition twenty-four hours before UNREP and store it on the weather deck for transfer to the carriers. These transfers also caused delays for air operations because the ammunition received on the carrier was stored on the hangar deck until the crews could stow it.[22]

Additionally, all the supply ships suffered from boom failures at some point. During moderate weather, the ships would sometimes roll apart, causing the transfer lines to split, known as "tight lining." Not only was this dangerous to personnel, but also it delayed the transfer of supplies. In 1957, Adm. Arleigh Burke, Chief of Naval Operations, called for a conference devoted to developing new UNREP techniques. Burke recalled that during World War II, time spent performing UNREP took away from the combat effectiveness of the task force. As a result, he not only called for the development of new UNREP techniques but also for the development of new ships so that provisioning could occur day or night and in fair or heavy weather. Thus, the major problems encountered by the navy were the direct result of obsolete equipment, and the Korean War became the catalyst for encouraging fresh ideas on accomplishing UNREP.[23]

As a result, in 1954, the U.S. Navy began testing a new span wire system to transfer supplies. The navy developed a counterweight, located in a kingpost, to tension a high line. The 12,000-pound weight could travel up and down 40' to compensate for the ship's relative motion while keeping the line taut up to 6,000 pounds at a maximum distance of 80'. Crews discovered

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[20] Roman Brooks, "Acorns and Ideas: How Today's Multi-Product Replenishment Ships Started," *Naval Engineer's Journal* (December 1968), 850.
[21] Marvin O. Miller, "Mobile Logistics for Aircraft Carriers," *Naval Engineers Journal* (August 1977), 55.
[22] Miller, "Mobile Logistics," 55; Miller, Hammett and Murphy, "Development," 127.
[23] Miller, "Mobile Logistic," 55; Miller, "Standby," 76.

problems with this system, and the safer, more reliable ram-tensioned unit (pneumatic-hydraulic) replaced it in 1960.[24]

At the same time, the U.S. Navy began testing the use of a multi-product ship. Capt. Edward E. Paré had introduced the concept of a one-stop replenishment ship in a September 1947 lecture at the Naval War College in Rhode Island. As described by Paré, single-cargo ships would still be available to bring supplies, but the one-stop types could remain near the battle groups. This concept was based on a German oiler called *Dithmarschen*, which the U.S. Navy had acquired from Germany as a war prize after World War II. The *Dithmarschen* not only carried oil, but also it had specialized holds for ammunition and provisions. The German navy used the ship during the war to replenish submarines operating out of the Norwegian fjords. In 1952, the navy reactivated the *Dithmarschen* and commissioned the vessel as the *Conecuh* (AOR-110). The navy equipped it with basic UNREP equipment, after which the vessel began trials with the fleet. The success of the *Conecuh* ultimately led to the development of an AOE multi-product auxiliary ship, which were fast combat support vessels built from 1965-70 that could carry and transfer fuel, food, and ammunition.[25]

The U.S. Navy's first designed multi-product support ship was the USS *Sacramento* (AOE-1), which was commissioned on 14 March 1964. The *Sacramento* offset the single-product supply ships that had limited speed, range, and capacity. The older replenishment vessels also had reduced capabilities during inclement weather or when the tempo of operations increased for the aircraft carrier. The speed of the AOE was more than 26 knots, which allowed the support ships to remain with the carrier battle group. The AOE class used fewer crew members but carried more cargo, fuel, and sufficient amounts of cargo ammunition and stores. More importantly, the cost of building one ship, in comparison to having to build three single-product ships, was significantly less.[26]

The cargo transfer station on board the *Sacramento* class ships contained state-of-the-art equipment. Engineers designed the cargo handling stations, designated FAST (Fast Automated Shuttle Transfer), with high-speed trolleys and winches to simplify the process of transferring ammunition and other cargo to combatant ships. These complex systems were not thoroughly tested, however, and later developed problems. The specialized personnel needed to maintain this equipment were not always available to make the repairs. Consequently, the FAST system failed due to the system breaking down frequently and its high maintenance costs.[27]

To prevent further interruption in service, naval engineers began developing the next generation of UNREP equipment. The first thing engineers agreed upon was to find the most reliable commercial winch and make it standard on all supply vessels. Engineers also revitalized the use

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[24] Miller, "UNREP since 1899," 9.
[25] Miller, "Standby," 76; Brooks, "Acorns and Ideas," 851; James L. George, *History of Warships: From Ancient Times to the Twenty-First Century* (Annapolis, MD: Naval Institute Press, 1998), 218-221; Thomas Wildenberg, *Gray Steel and Black Oil: Fast Tankers and Replenishment at Sea in the U.S. Navy, 1912-1995* (Annapolis, MD: Naval Institute Press, 1996), 227-28.
[26] Cdr. Wayne Hoof, "Design of Fast Combat Support Ship AOE-1," *BuShips Journal* (August 1961), 13-14.
[27] Miller, Hammett, and Murphy, "Development," 131-132.

of the "sliding block delivery station" and the "sliding pad eye receiving station," which had first been used by the navy in 1910. Engineers advanced the concept in the 1960s and placed it in service in the 1970s. The navy designated the upgraded system STREAM (Standard Tensioned Replenishment Alongside Method). The new technique allowed for the sliding pad eye on the receiving vessel to lower a ram-tensioned line to the deck. Additionally, the same sliding pad eye could pick up cargo and send it back to the supply ship in reverse fashion.[28]

A second development in the 1960s was the creation of a smaller multi-product replenishment ship known as the Auxiliary Replenishment Oiler (AOR), which were built from 1969-1976. The AORs "represented a smaller and more affordable replenishment vessel, albeit somewhat less capable than the AOEs." The AORs had limited speed and smaller ammunition cargo holds in comparison with the AOEs, but they were otherwise similar. These AOR supply vessels, comprising the *Wichita* class, worked in conjunction with the World War II-era *Essex* class carriers that were modified to support anti-submarine warfare.[29]

The Vietnam War and Advances in Underway Replenishment

During the Vietnam War, the U.S. Navy supported carrier groups from the Seventh Fleet in the Sea of Japan. The navy designated the supply area "Yankee Station." The fleet utilized both AOE and AOR multi-product ships to supply the battle fleets operating off the Vietnam coast. The navy did not experience major supply problems, probably because there were nearby bases in Japan and the Philippines. The use of the AOEs meant for the first time in naval history one ship could supply all the logistical needs of a carrier. The new ships also fulfilled the requirements instituted by Admiral Burke of advanced engineering in both UNREP and the new supply ships.[30]

Later in the war, the navy decided to use the smaller AOR replenishment ships as an economical alternative to the AOEs, which led to unsafe working conditions during ammunition transfers. These ships operated like the AOEs except for the ammunition transfers. Crews had to store the ammunition on deck when an ammunition transfer took place onboard an AOR, so the remainder of the re-supply mission had to use the starboard transfer rigs. There were safety concerns onboard because of the resulting loose ammunition on exposed decks and because of the use of transfer rigs from the opposite side of the transfer points, which the designers had not envisioned during the development and construction of the ships.[31]

When Adm. Elmo Zumwalt became Chief of Naval Operations (CNO) in 1970, the U.S. navy faced budgetary restrictions and downsizing even though the aging fleet oilers were in need of replacement. While the navy could have cut the number of warships under construction, Zumwalt instead proposed copying the Soviet system of using merchant tankers and civil service seamen. The aged auxiliary ships manned by civilians would operate through the Military Sealift Command (MSC) and would alleviate some of the navy's operational expenses.[32]

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[28] Miller, "Mobile Logistic," 58; Miller, Hammett, and Murphy, "Development," 131-132.
[29] Miller, "Mobile Logistics," 56-57; Miller, Hammett, and Murphy, "Development," 138-139.
[30] Miller, "UNREP," 10; Miller, "Standby," 78.
[31] Miller, "Standby," 78.
[32] Miller, Hammett, and Murphy, "Development," 135-36.

In 1972, for example, the U.S. Navy decommissioned the fleet oiler *Taluga* (see HAER No. CA-336) and transferred it to the MSC, who placed it in service as USNS *Taluga* (T-AO-62). The ship took part in an underway replenishment pilot program called "Charger Log II" using civilians. The program surpassed all expectations. Over the next three-and-a-half years, the *Taluga* made 875 underway replenishments with the Seventh Fleet using a civilian crew. The ship set the standard for civilian crews working for MSC, which led to the transfer of all navy oilers to MSC for operation in support of the fleet.[33]

The Tanker War

By 1979, the U.S. Navy was patrolling the Indian Ocean near the Persian Gulf with two carrier battle groups. Tensions in the region were running high between the United States and Iran after Iranian revolutionaries took fifty-two American hostages from the U.S. Embassy in Tehran. The following year, the Iran-Iraq war began and engulfed the entire Middle East. As a result of attacks on merchant tankers, the U.S. once again had to expand its replenishment-at-sea capabilities.[34]

Due to the remoteness of the Indian Ocean, the U.S. Navy improvised techniques to sustain the battle group. The only port available was Diego Garcia, but the battle groups were 2,000 miles away. The next closest base was Subic Bay in the Philippines, which was 5,000 miles and a two-week trip. The U.S. Navy recognized that it had to alter the battle group's cycle of operations to accommodate the geography. Normally, the battle group operated on station for thirty days with ten days for port. The navy followed this schedule, developed during the Korean War, in the Vietnam War because the nearest ports were 700 and 800 miles away. For operations in the Indian Ocean, however, the navy kept the battle group at sea for around 100 days before heading to port.[35]

The longer cycle for the battle group imposed new requirements while in the Arabian Sea. Since the navy did not own enough fleet oilers to run fuel from Subic Bay to the Arabian Sea, it contracted merchant tankers to transport fuel from Europe to the oilers near the battle group. Stores and other supplies were flown to Diego Garcia, while contracted merchant vessels also brought in supplies. Ships within the battle group shuttled back and forth to receive supplies.[36]

The U.S. Navy did have some problems during the transfer phase, primarily due to the sea conditions. The monsoon season generated high seas measuring 8' to 12', and strong winds carried desert sand as far as 200 miles offshore. In addition to causing visibility problems, the desert sand wreaked havoc on the carrier's aircraft engines and required frequent replacement by maintenance personnel. Additionally, the head reduced the payload capacity of the VERTREP

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[33] U.S. Navy, *Dictionary of American Naval Fighting Ships*, Vol. VII (Washington, DC: Naval Historical Center, 1991), 27.
[34] Miller, Hammett, and Murphy, "Development," 136.
[35] Miller, Hammett, and Murphy, "Development," 136.
[36] Miller, Hammett, and Murphy, "Development," 137.

(vertical replenishment) helicopters. Overall, the Arabian Sea provide to be a challenging environment for everyone in the area.[37]

Eventually, the war between Iran and Iraq drew the United States into the hostilities. During this "Tanker War," both Iran and Iraq began targeting neutral shipping transiting the Gulf. This eventually prompted the United States to reflag eleven Kuwaiti tankers, which afforded them protection through the U.S. Navy in Operation Earnest Will. These events would later help the United States Armed Forces during Operation Desert Storm and the Second Gulf War by "working out the bugs in the system."[38]

Auxiliaries Today

Today the U.S. Navy is a highly technical fleet. The second generation of AOEs, the *Supply* class, are in service with the carrier battle groups and provide the navy with its needed supplies. The four ships in the class, *Supply*, *Rainier*, *Arctic*, and *Bridge*, are unique and represent the many innovations that have occurred in UNREP. They are fast enough to remain in the battle group and can carry fuel, ordnance, and other stores. They can also supply up to four ships at once. Through modern engineering and wide-ranging automation, the *Supply* class carries a smaller crew to perform the same missions once carried out by the larger *Sacramento* class.[39]

Military Sealift Command (MSC), established in 1972 as the Naval Fleet Auxiliary Force, now provides a majority of the combat logistics for the U.S. Navy. The Secretary of Defense and the Chief of Naval Operations (CNO) designated MSC as the "Single Manager for Ocean Transportation." With this designation, MSC operates around 120 ships around the world and has up to 100 more set aside in reserve status. MSC began running auxiliary ships operated by civilian crews with the *Taluga*.[40]

Conclusion

Accompanying the U.S. Navy's warships are the logistical vessels that provide the supplies needed to conduct operations in times of peace and war. These logistical vessels have transformed through time to keep a range of battle groups and expeditionary forces supplied while underway for extended periods. This dimension adds to the security of the United States and its ability to respond to crises anywhere in the world.

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[37] Miller, Hammett, and Murphy, "Development," 136-37.

[38] Michael A. Palmer, *On Course to Desert Storm: The United States Navy and the Persian Gulf War* (Washington, DC: Naval Historical Center, 1992), 116-17.

[39] United States Navy, Fact File, Fast Combat Support Ships T-AOE, available at http://www.navy.mil/navydata/fact_display.asp?cid=4400&tid=300&ct=4, last updated February 6, 2009, accessed September 2010.

[40] Military Sealift Command overview, available at http://www.msc.navy.mil/N00P/overview.asp?page=history, accessed September 2010.

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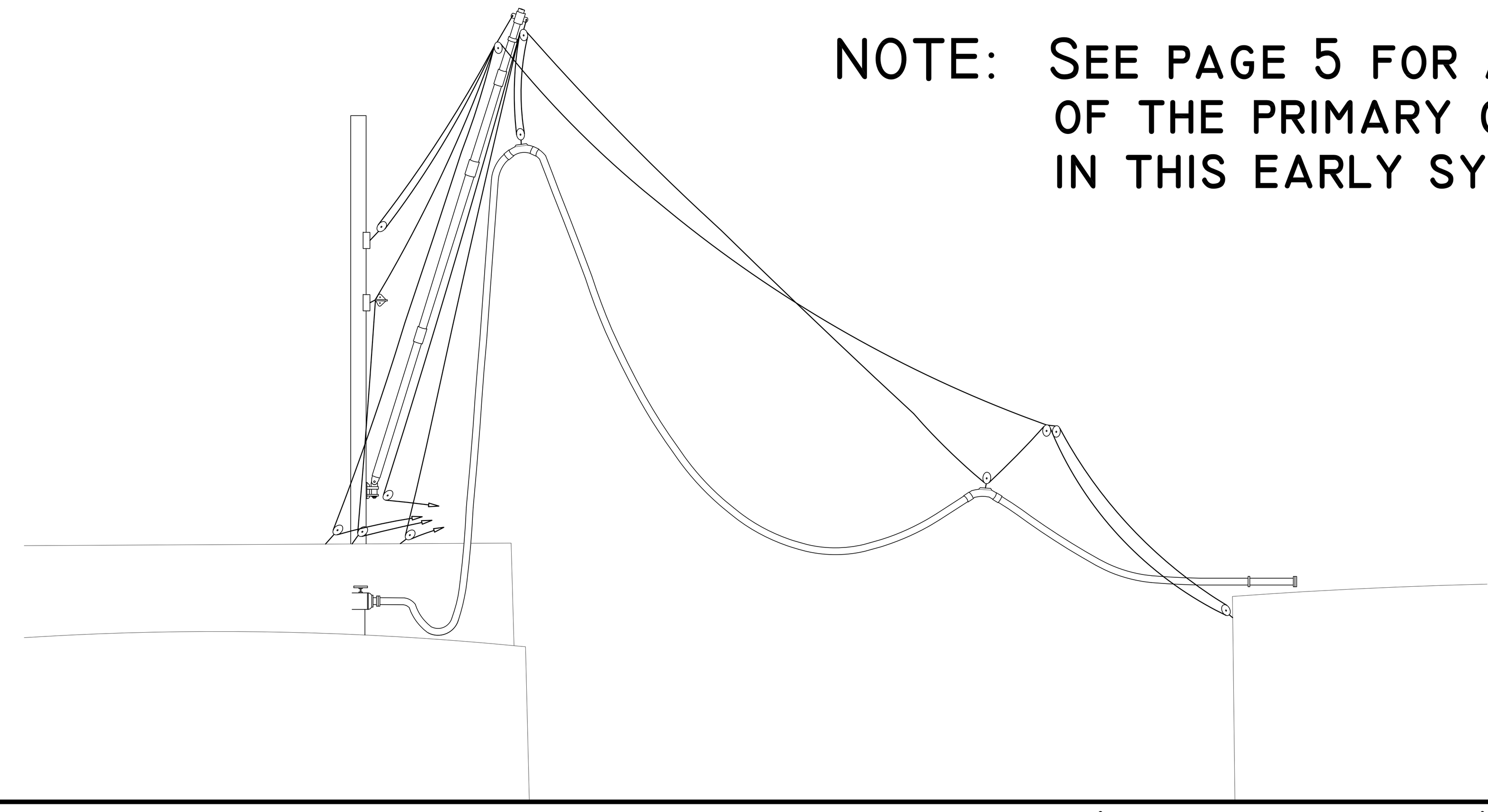
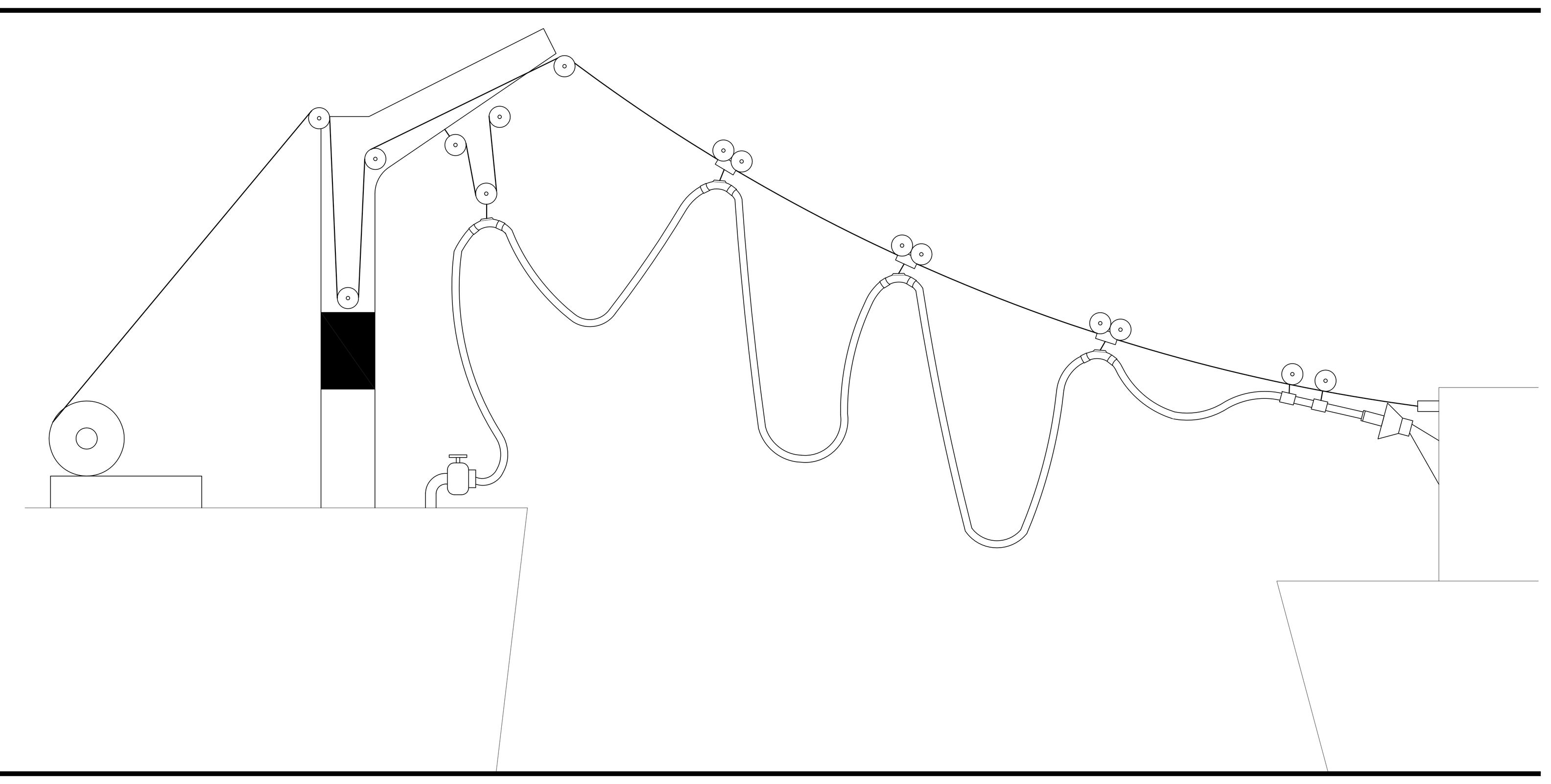
UNDERWAY REPLENISHMENT: EVOLUTION OF FUELING TECHNOLOGY

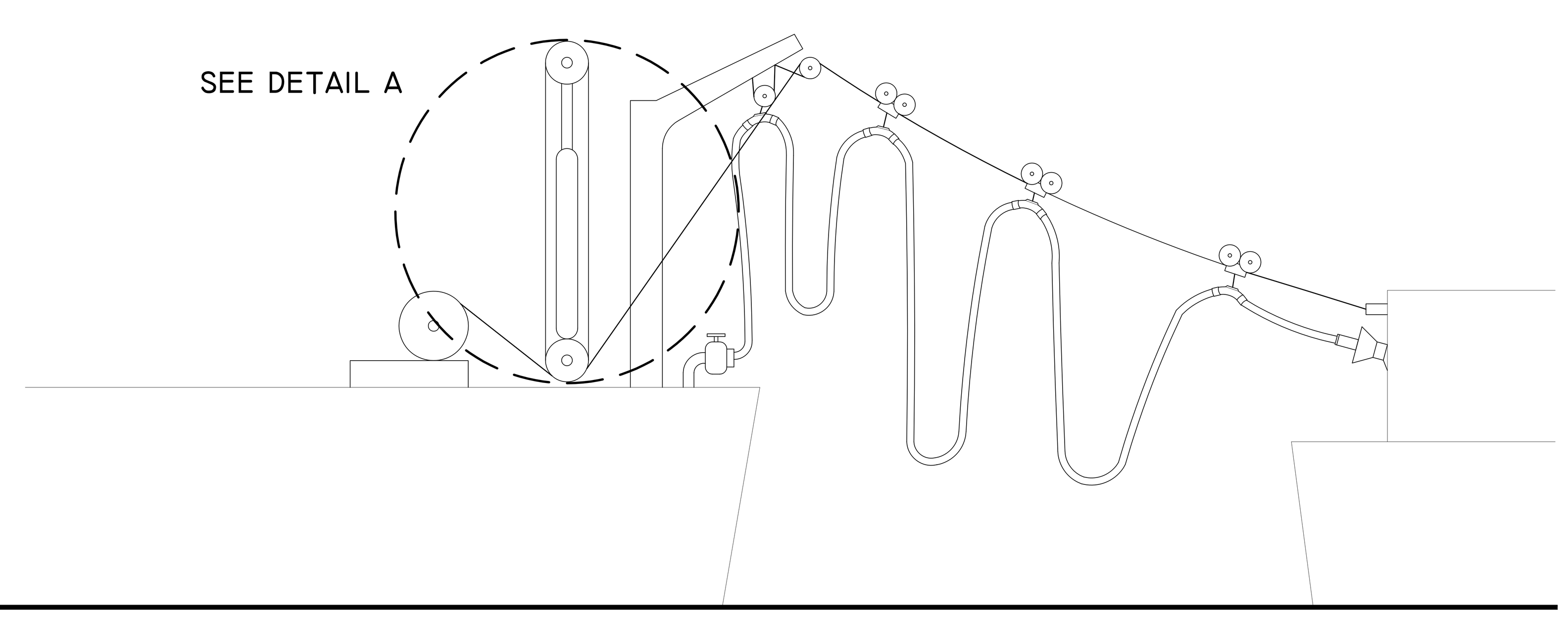
NOTE: SEE PAGE 5 FOR A DETAILED ACCOUNT OF THE PRIMARY COMPONENTS USED IN THIS EARLY SYSTEM OF FUELING.



1916: FIRST REFUELING SYSTEM (JURY RIGGED)



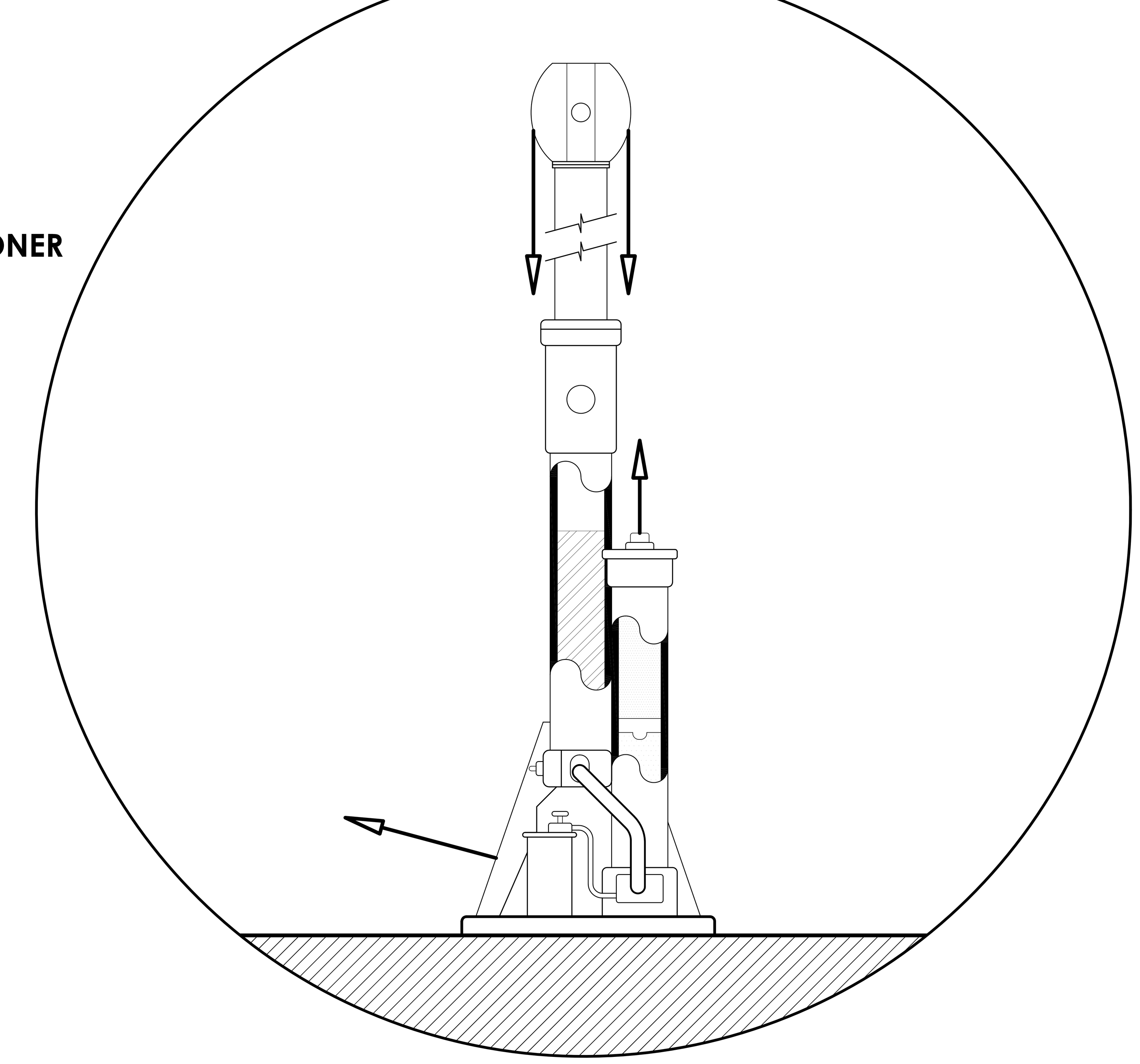
1958: COUNTERWEIGHT REFUELING SYSTEM

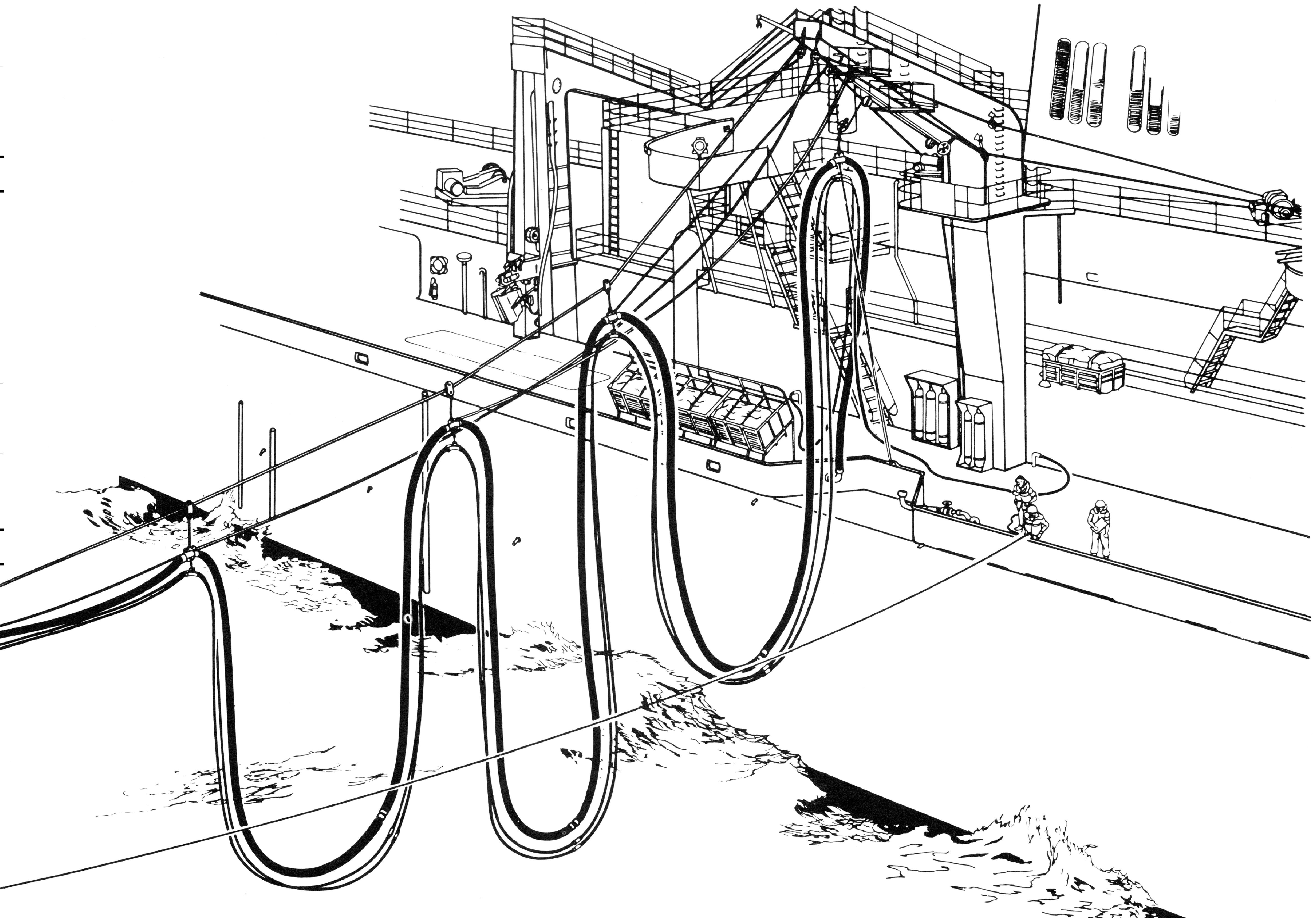
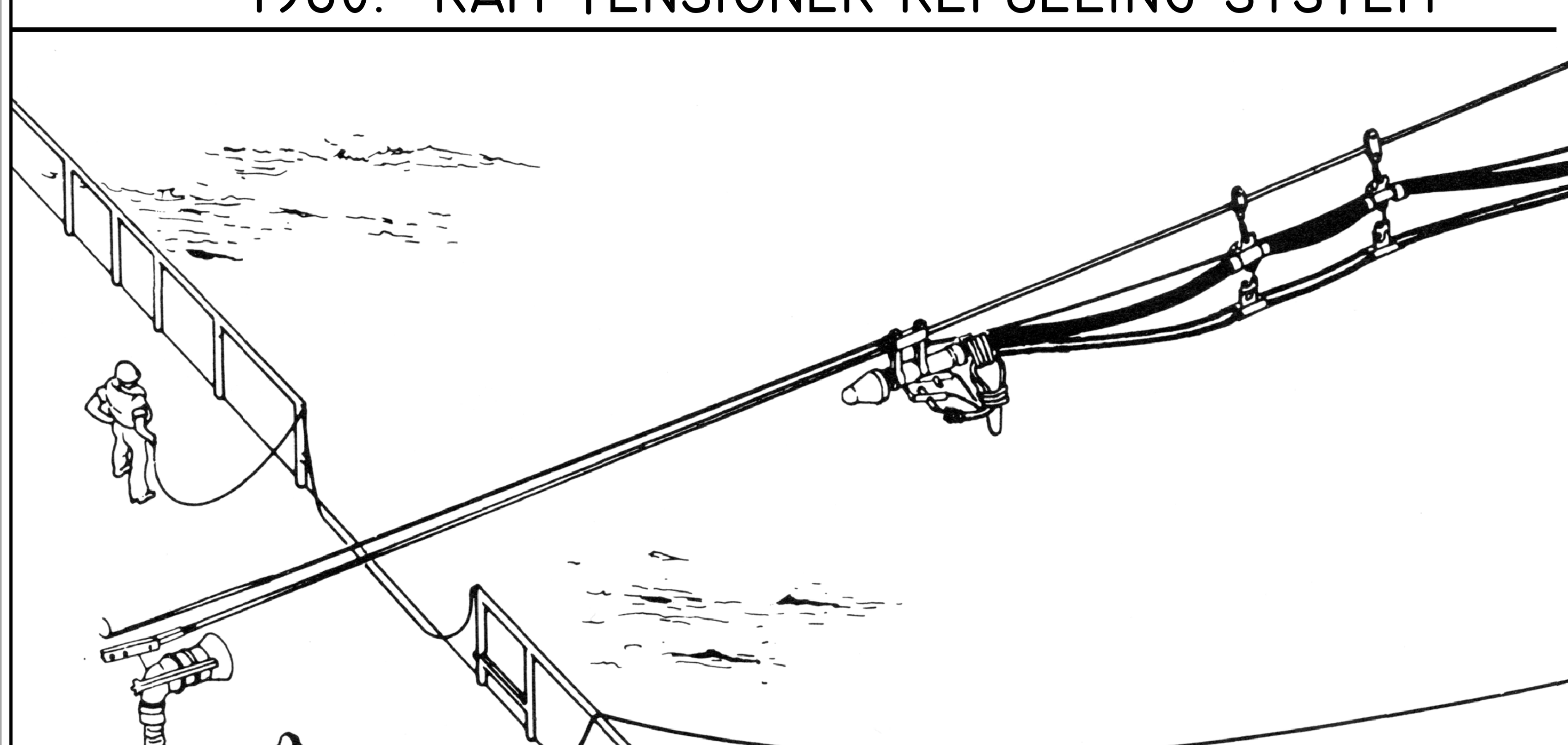


1960: RAM TENSIONER REFUELING SYSTEM

DETAIL A-HYDRAULIC RAM TENSIONER

(The ram tensioner is used to maintain tension on the spanwire, which is fairled from the boom or kingpost mounted on the ram or the ram cylinder, and then to the winch. Air from the flasks maintains pressure on a piston in the accumulator cylinder, and this pressure is hydraulically transmitted to the ram. As the tension in the spanwire is relaxed, the pressure in the system causes the ram to extend, taking up the slack in the spanwire. As tension in the spanwire increases, air is forced back into flasks. A small wire cable transmits ram motion to the indicator dial. One pound of air pressure on the accumulator causes about ten pounds of line pull on the spanwire. Thus, 100 psi in the air flasks maintains a tension of about 1,000 pounds on the spanwire.)



MODERN DAY REFUELING SYSTEM

(NOT TO SCALE)

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SHEET 2 OF 6

DISTRICT OF COLUMBIA

US NAVY OILERS AND TANKERS
EVOLUTION OF REFUELING AND UNDERWAY REPLENISHMENT

WASHINGTON

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NATIONAL PARK SERVICE
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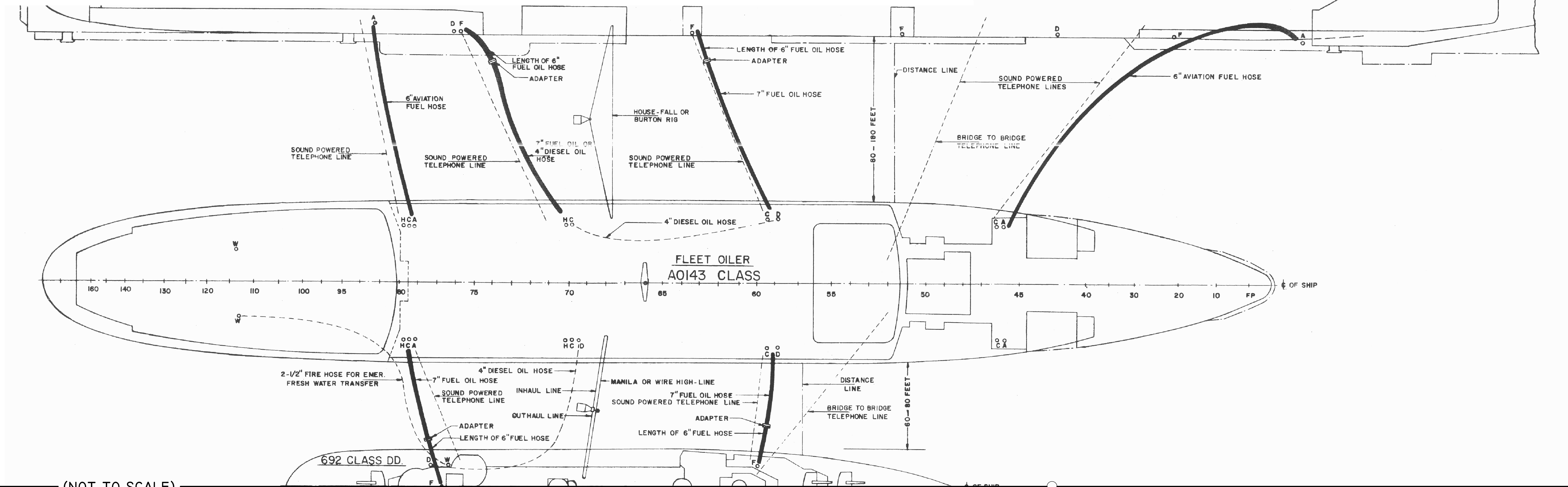
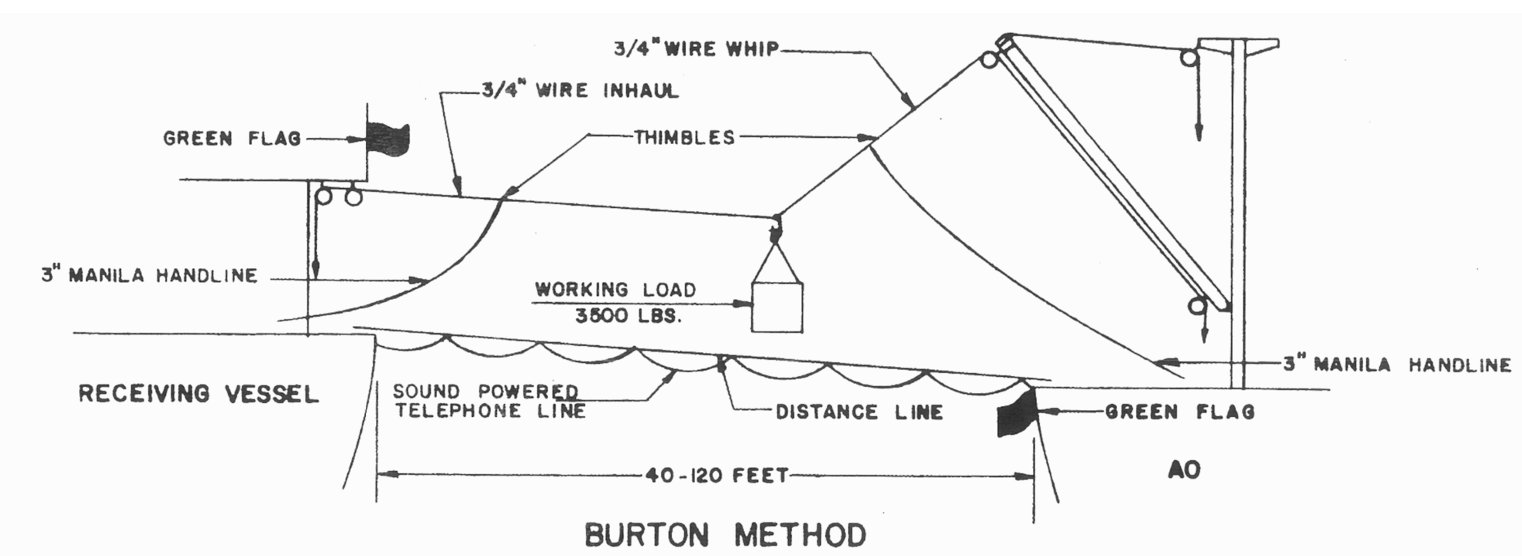
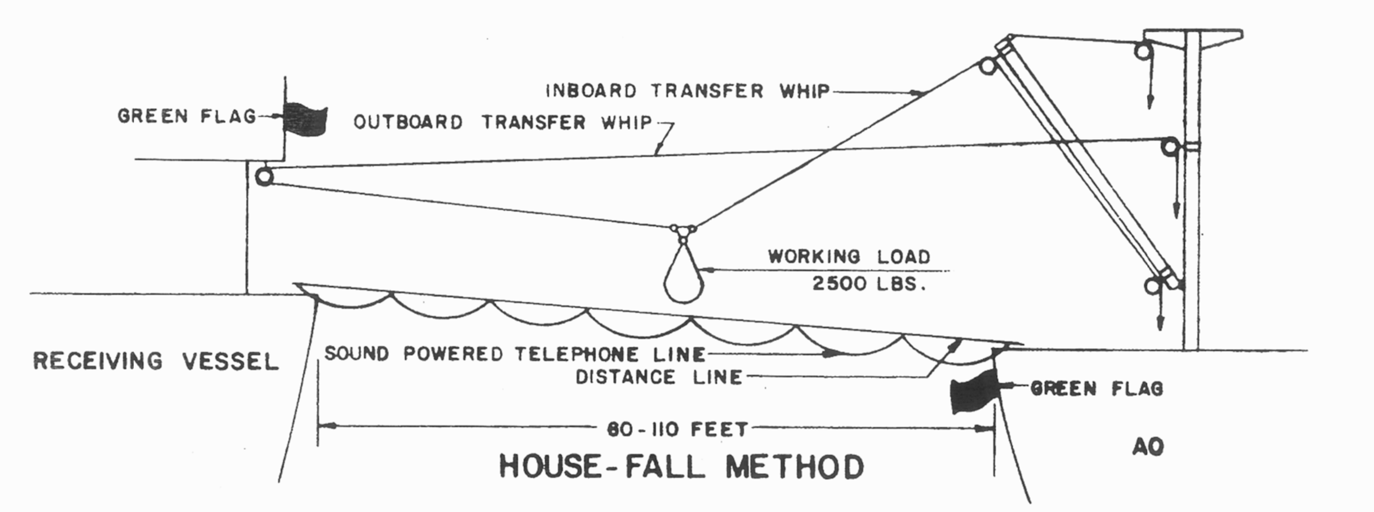
UNDERWAY REPLENISHMENT: ARRANGEMENTS

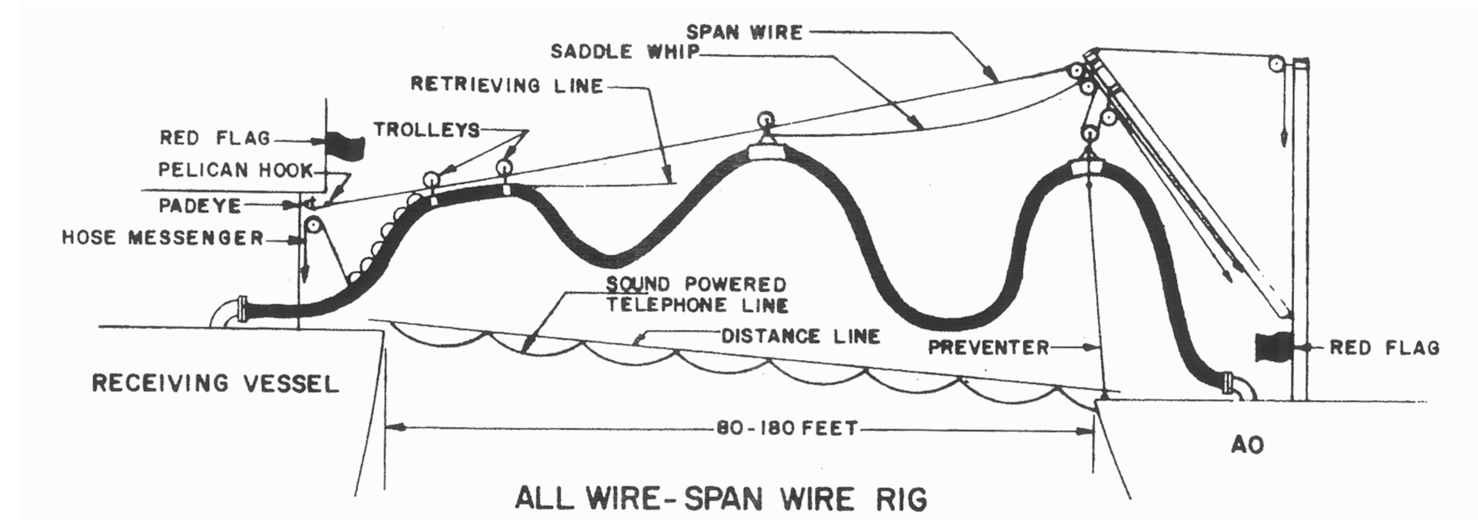




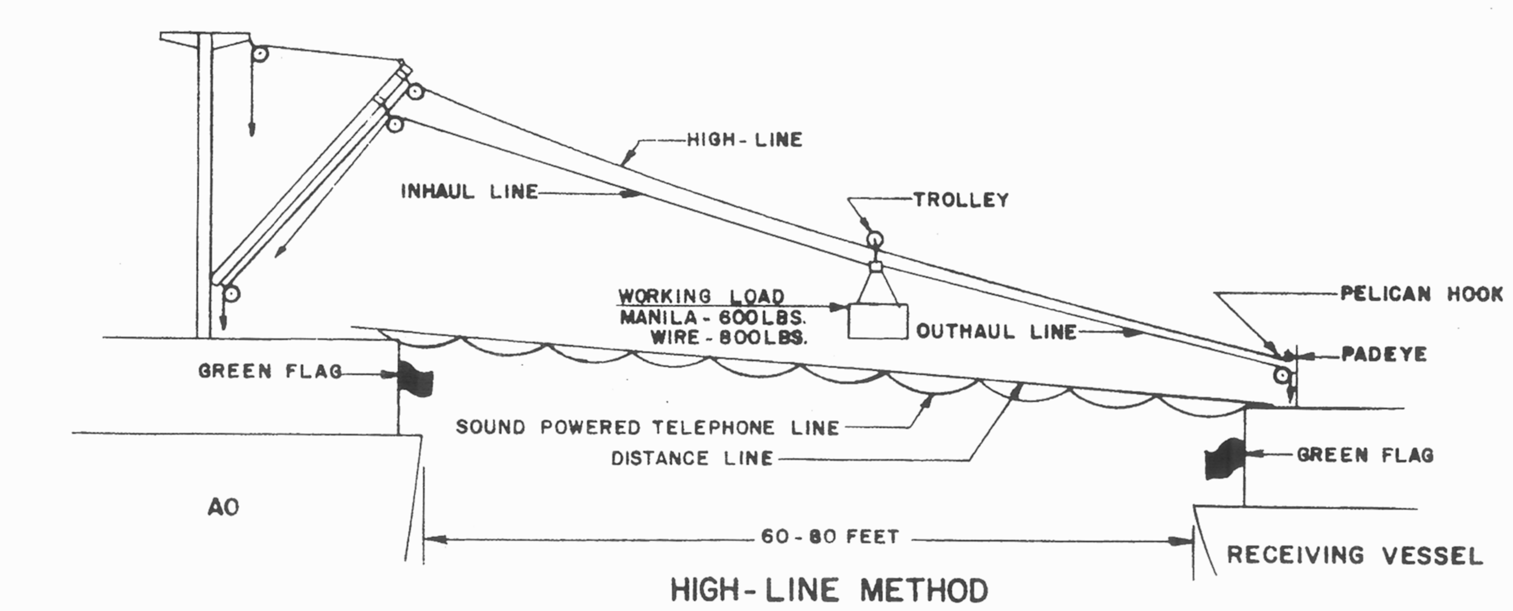
BURTON METHOD



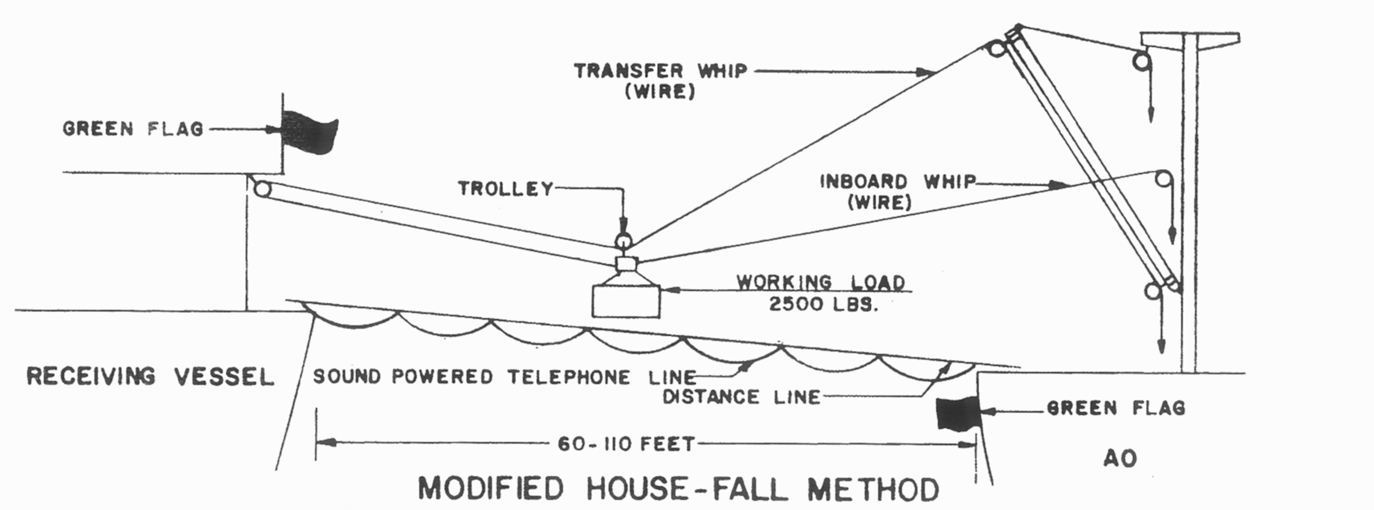
HOUSE-FALL METHOD



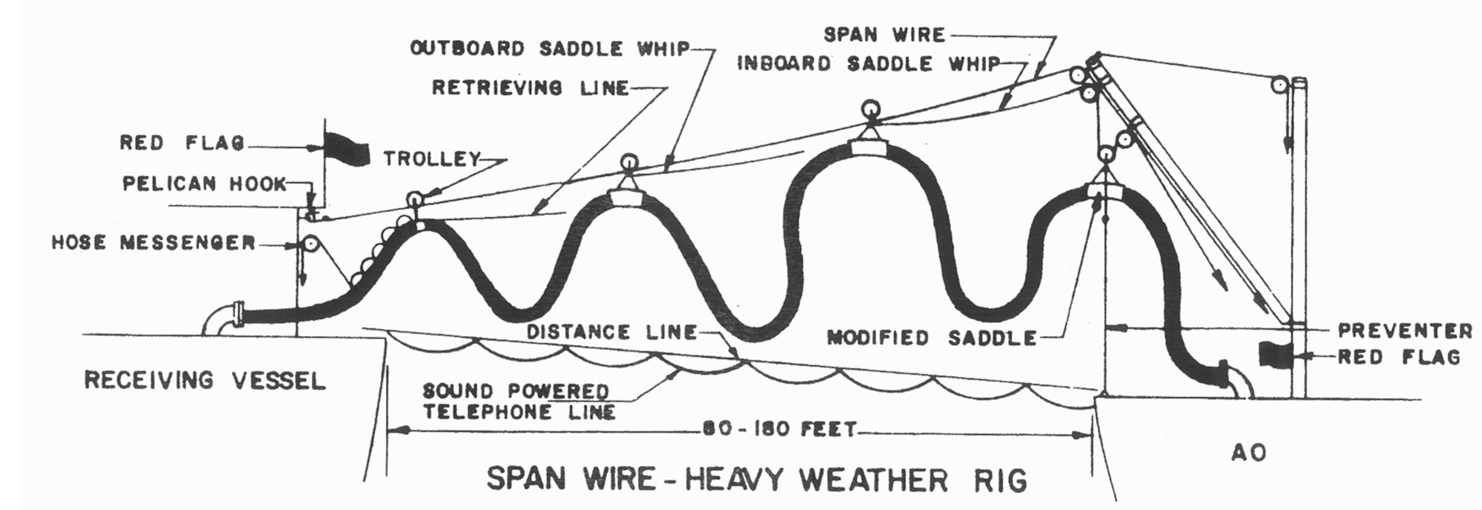
ALL WIRE-SPAN WIRE RIG



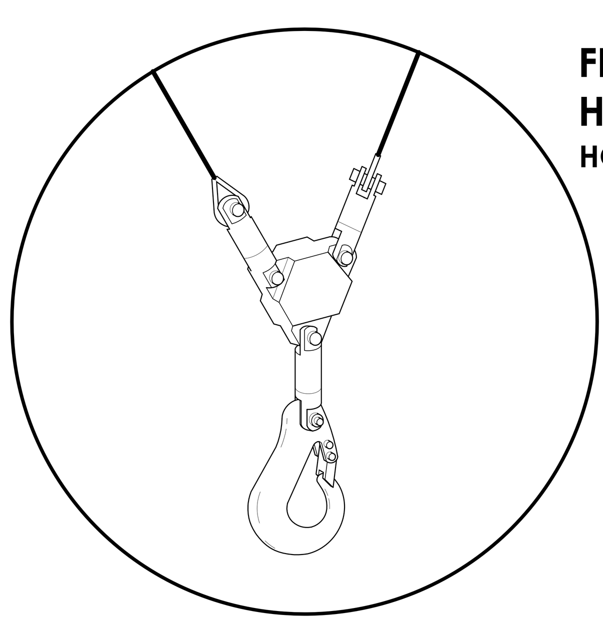
HIGH-LINE METHOD



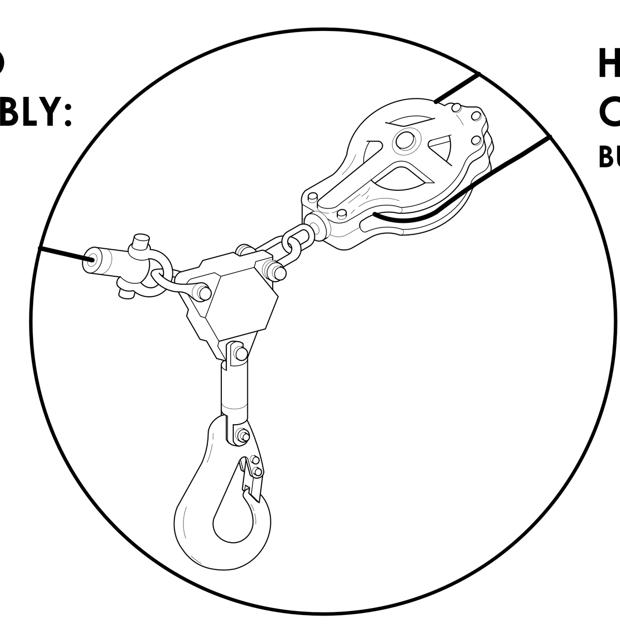
MODIFIED HOUSE-FALL METHOD



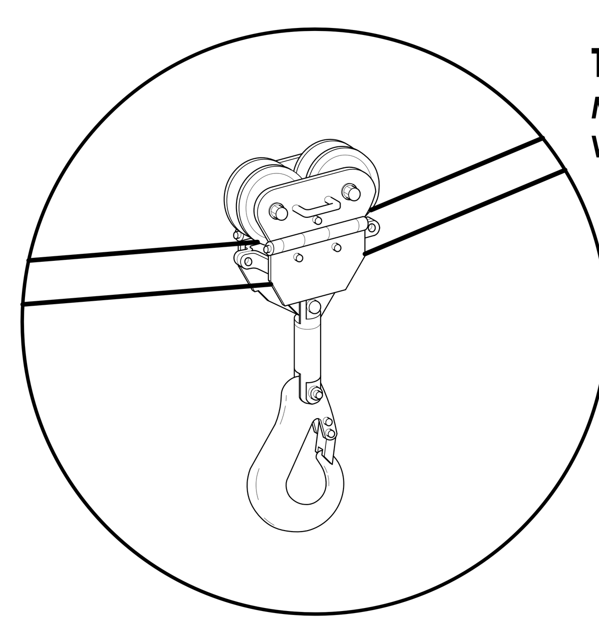
SPAN WIRE-HEAVY WEATHER RIG



FIVE TON CARGO HOISTING ASSEMBLY:
HOUSE-FALL

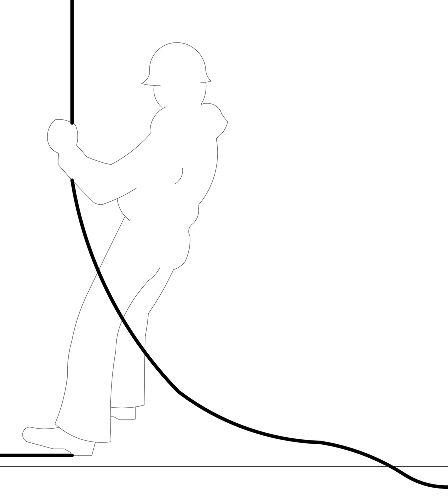


HEAVY BURTON CARGO HOISTER:
BURTON



TROLLEY:
MODIFIED HOUSE-FALL WIRE HIGHLINE

NOTE: Depicted here are a variety of arrangements possible for use in the Underway Replenishment (UNREP) process. Specifically, these arrangements were used with the early boom and mast, span-wire (jury-rigged) method. Consequently, these arrangements were used extensively before and during World War II. Modern UNREP arrangments have evolved with technology and the invent of the M frame and ram tensioner.



REPLENISHMENT (DRY CARGO) AT SEA

FUELING AT SEA

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HISTORIC AMERICAN ENGINEERING RECORD
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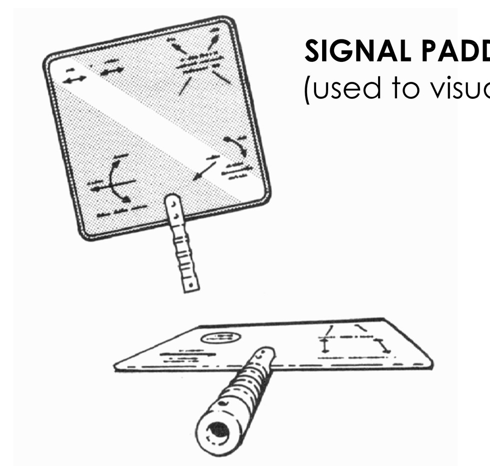
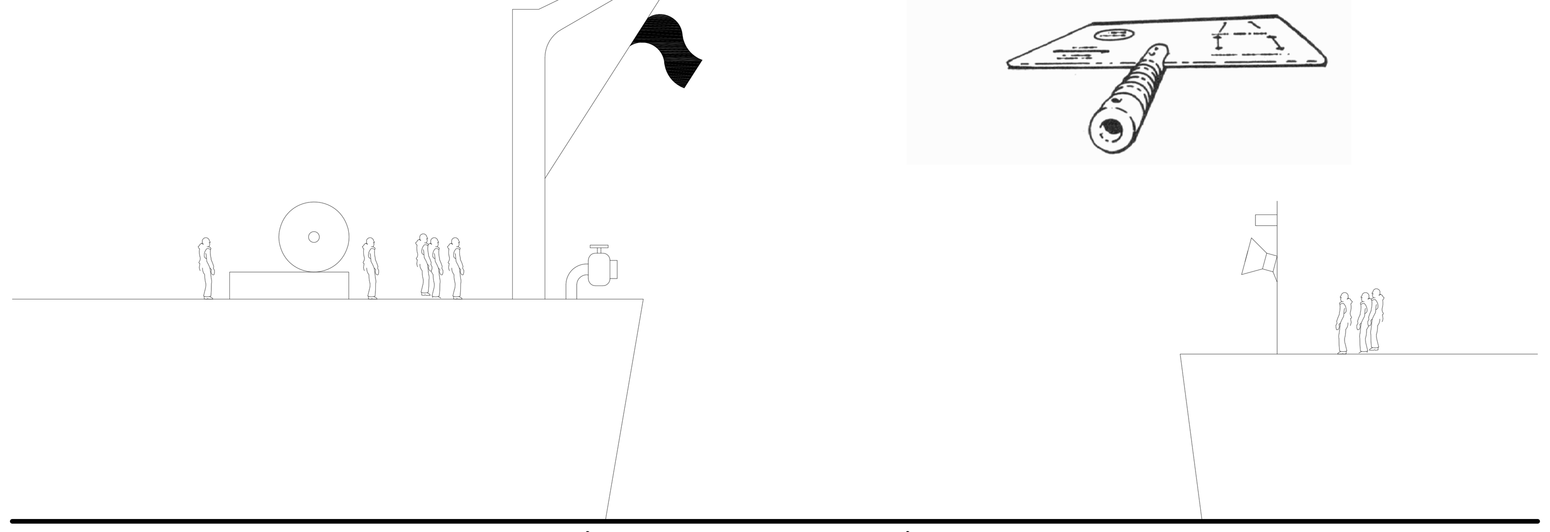
UNDERWAY REPLENISHMENT: FUELING LINE SEQUENCE

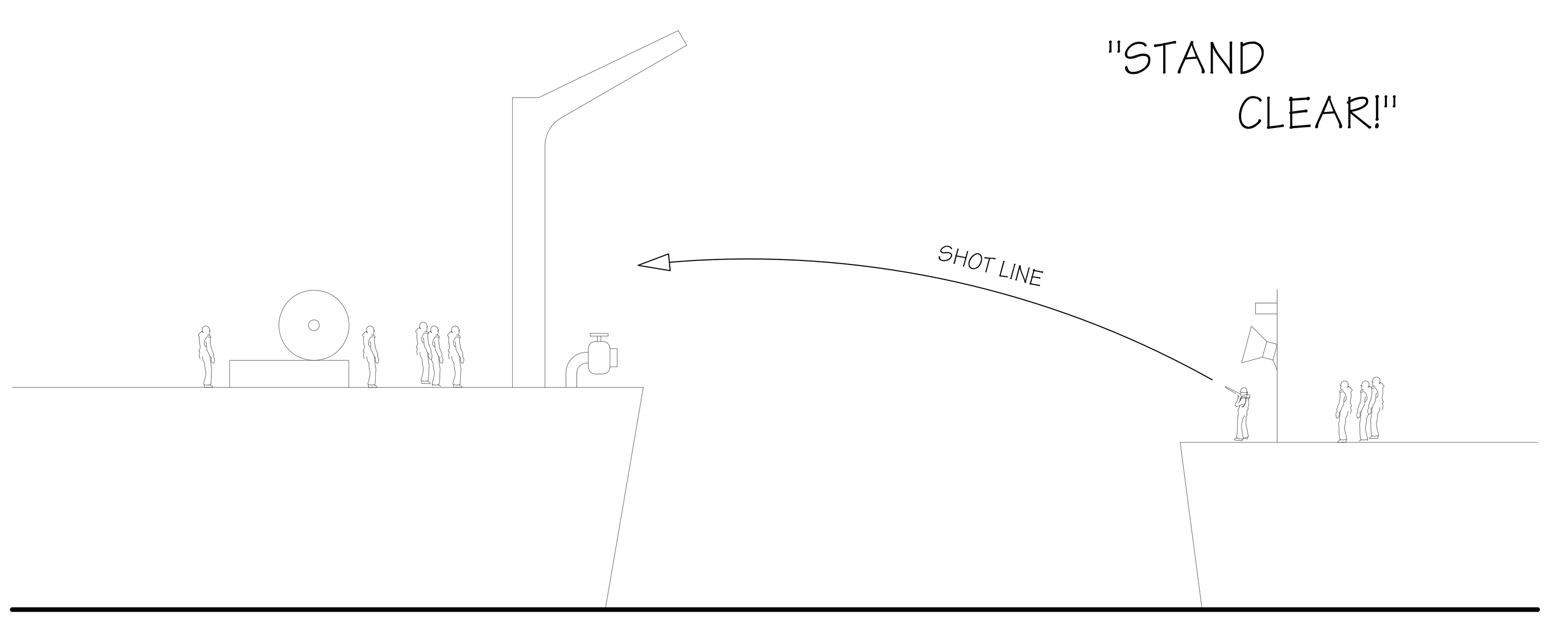
(NOT TO SCALE)



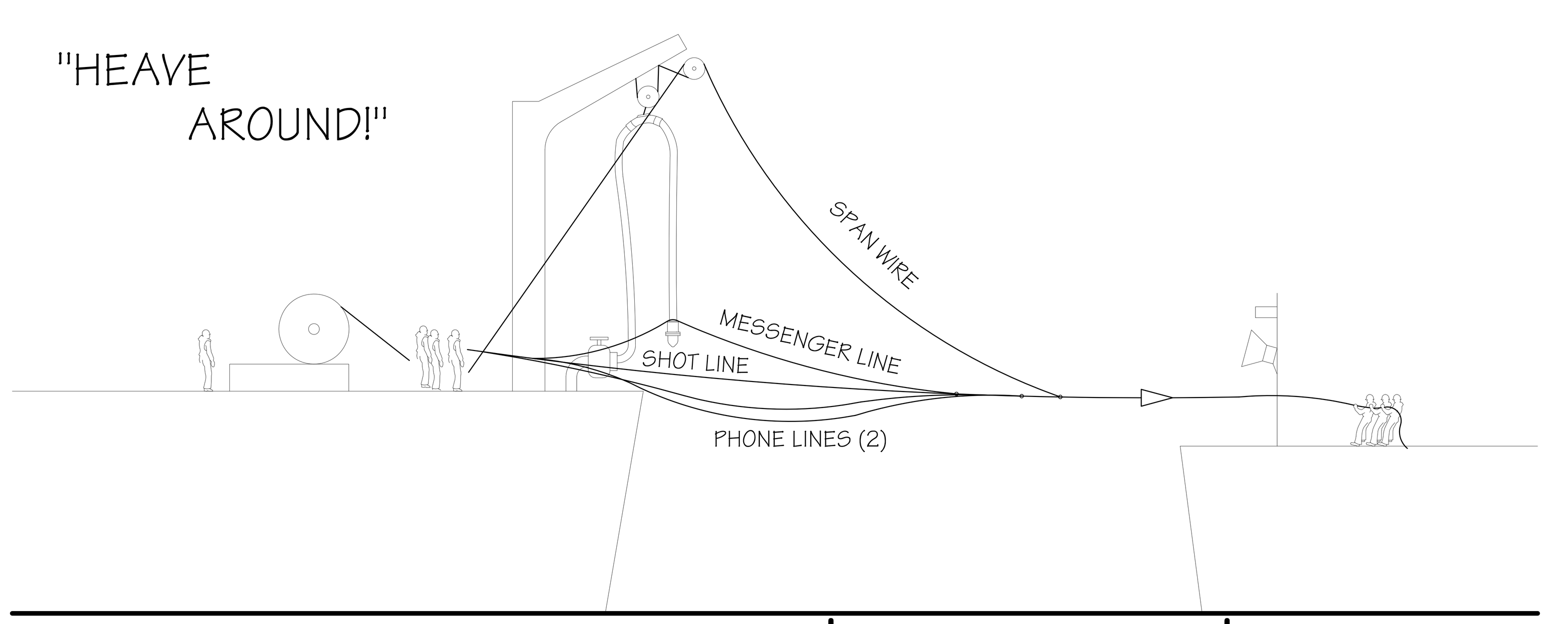
SIGNAL PADDLES
(used to visually signal and direct operations during UNREP)



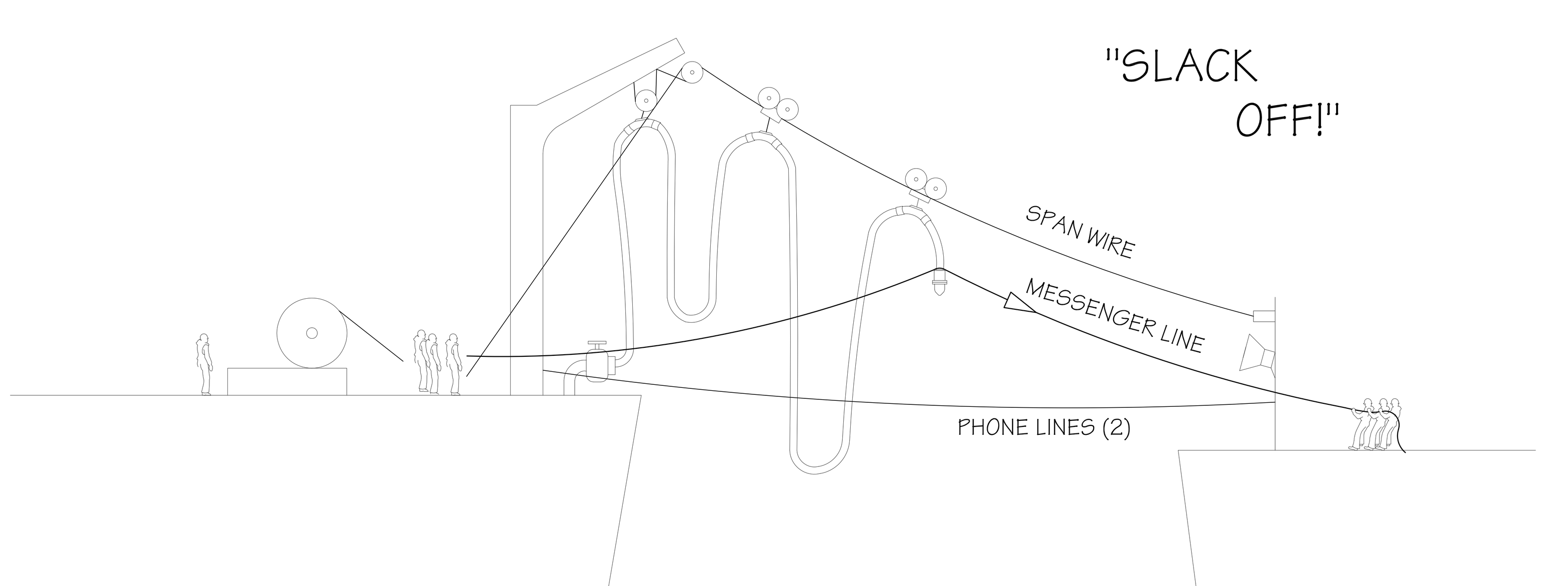
1. SIGNAL FLAG (APPROACH)



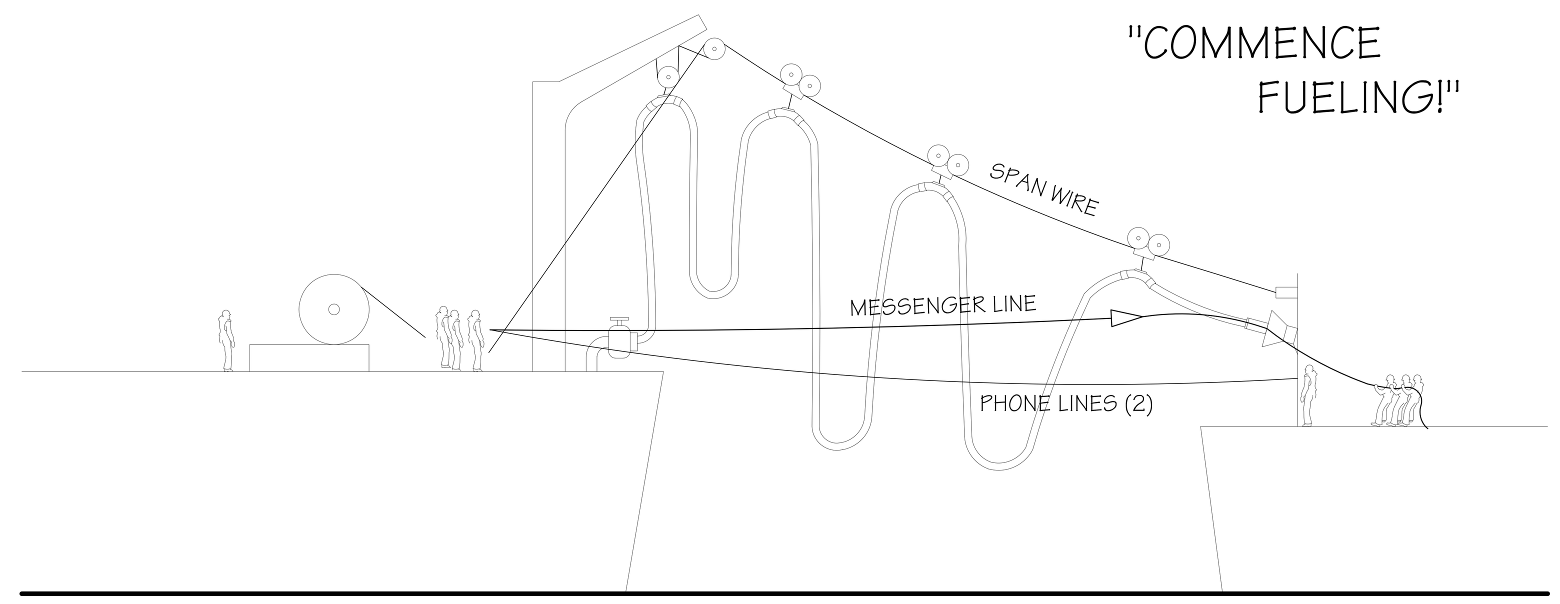
2. SEND SHOT LINE



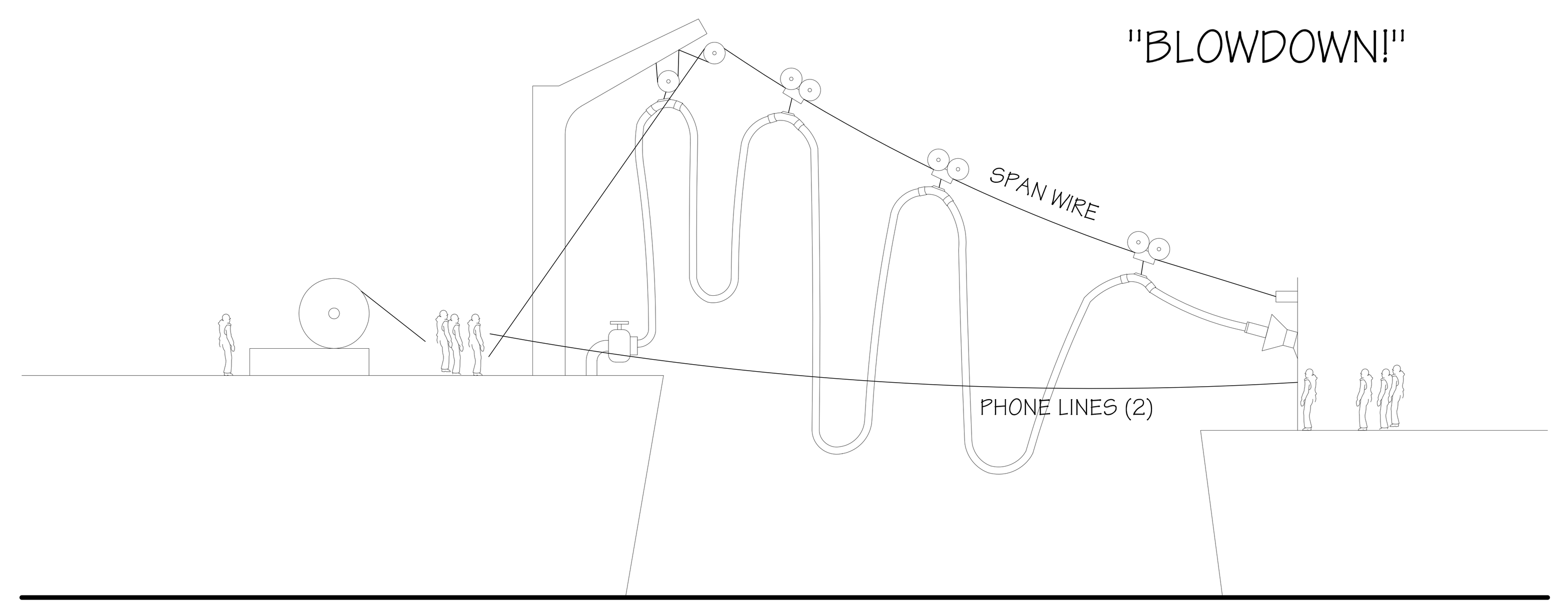
3. HAUL IN SHOT LINE W| MESSENGER|PHONE



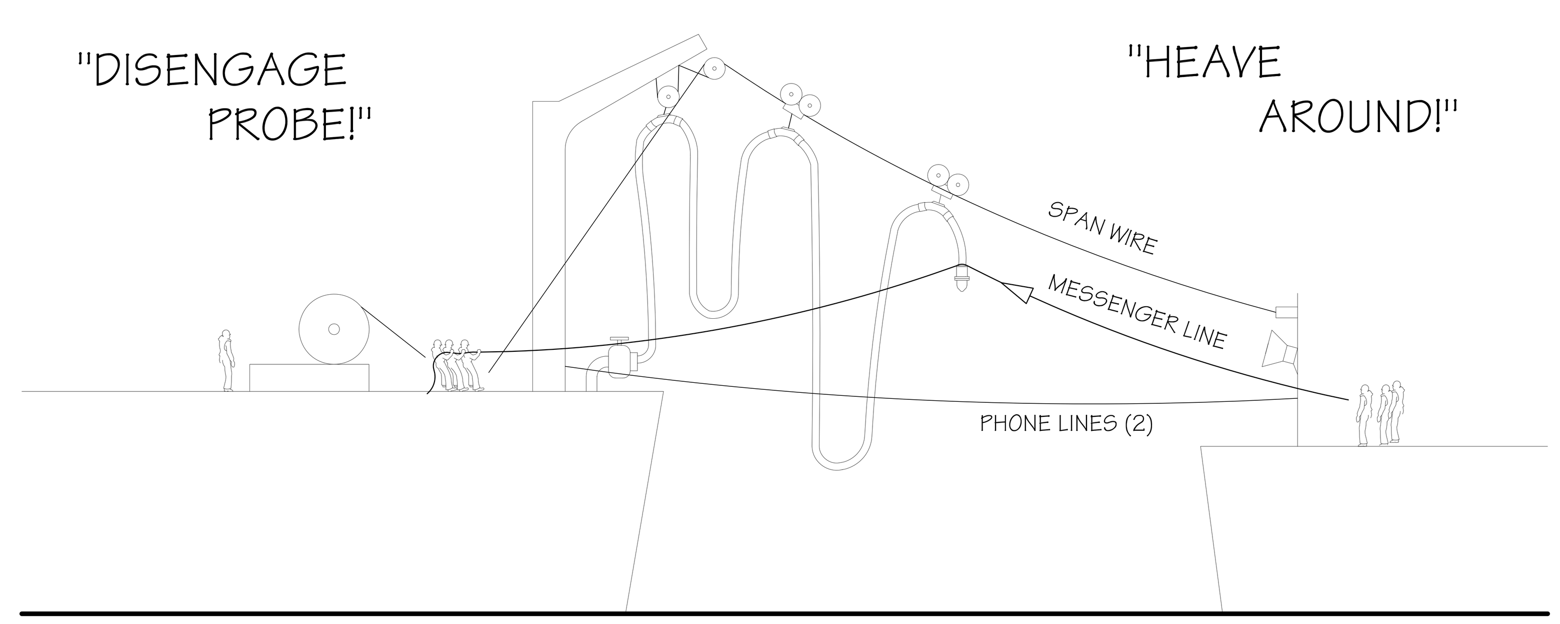
4. HAUL IN MESSENGER W| PROBE



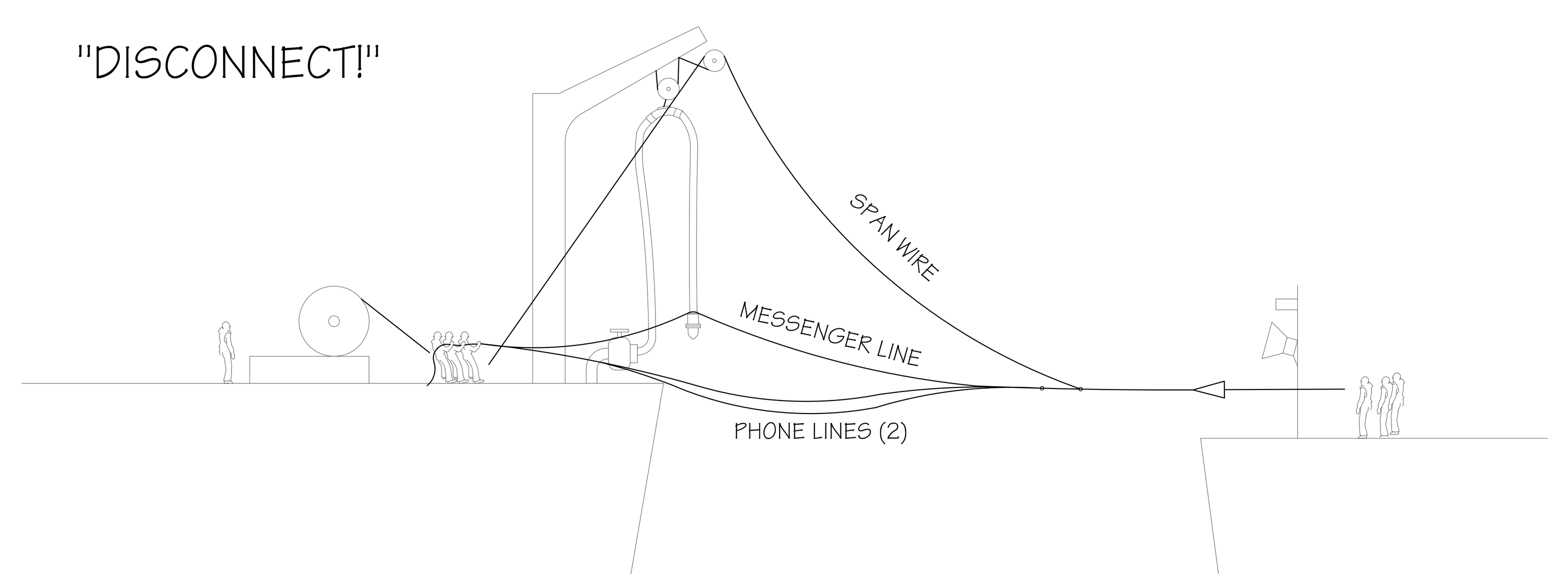
5. ENGAGE PROBE AND COMMENCE FUELING



6. BLOWDOWN



7. DISENGAGE PROBE



8. RETURN LINES

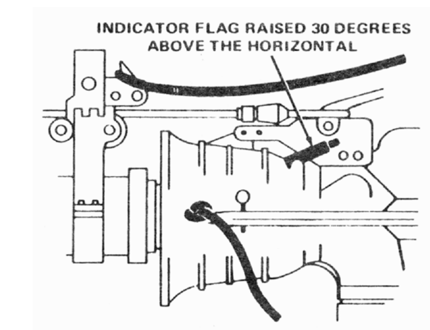
1. SIGNAL FLAG (APPROACH):
Ships signal to each other for their approach and to commence the UNREP process.

2. SEND SHOT LINE:
Delivery ship stands clear to receive the shot line, the first line sent, which serves to connect the ships with a messenger line and two phone lines.

3. HAUL IN SHOT LINE WITH MESSENGER|PHONE:
Receiving ship hauls in the shot line by hand using pulley systems.

4. HAUL IN MESSENGER WITH PROBE:
After the span wire is connected, the receiving ship hauls in the messenger, to which the end of the hose (probe) is attached. Communication is kept orally through use of the phone lines and visually through signal paddles.

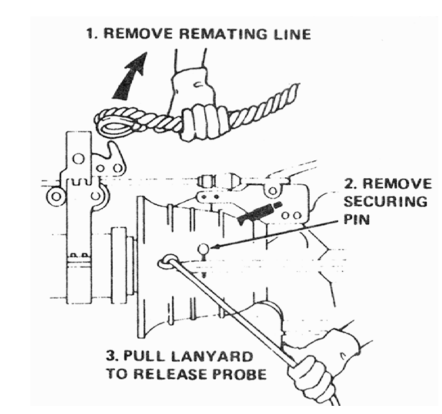
5. ENGAGE PROBE AND COMMENCE FUELING:



Once the probe is properly engaged in the receiving station (and checked), fueling commences. The operating pressure is adjusted to suit receiving ship requirements.

6. BLOWDOWN:

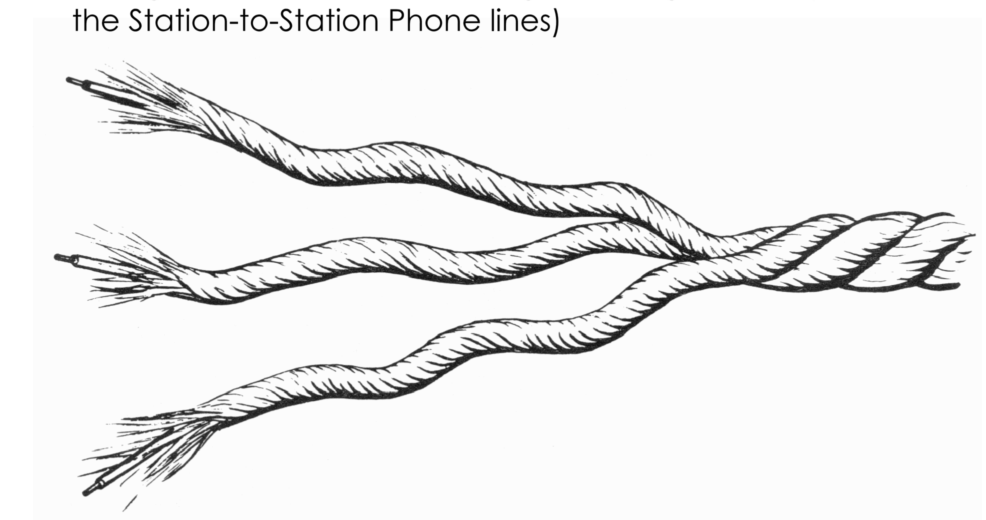
7. DISENGAGE PROBE:



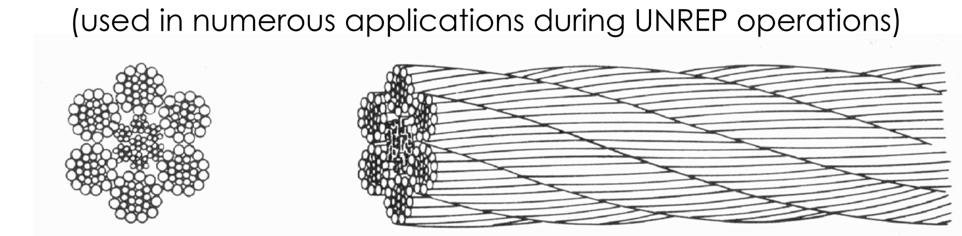
Once the probe is properly disengaged, the delivery ship signals to "disconnect" and the receiving ship eases out the span wire and releases it.

8. RETURN LINES:
All remaining lines are returned to their respective ships.

POLYPROPYLENE ROPE CABLE
(used to provide sound powered phone connections between ships during UNREP, for both the Bridge-to-Bridge Phone|Distance Line and for the Station-to-Station Phone lines)



WIRE ROPE
(used in numerous applications during UNREP operations)



NOTE: The Underway Replenishment (UNREP) process of passing lines back and forth is depicted here using a modern M-frame (instead of a mast and boom). The sequence, however, applies generally to all periods of the fueling process. As technology has advanced, the sequence of these lines has stayed essentially the same. There are current efforts to simplify the process and eliminate extraneous lines, such as passing only a hose (without a wire highline) between ships or by employing tensioned connect-up (using a small stainless steel wire rope in lieu of all the line that is normally needed to connect two ships during UNREP).

DELINEATED BY: C.V. OLIN, 2006

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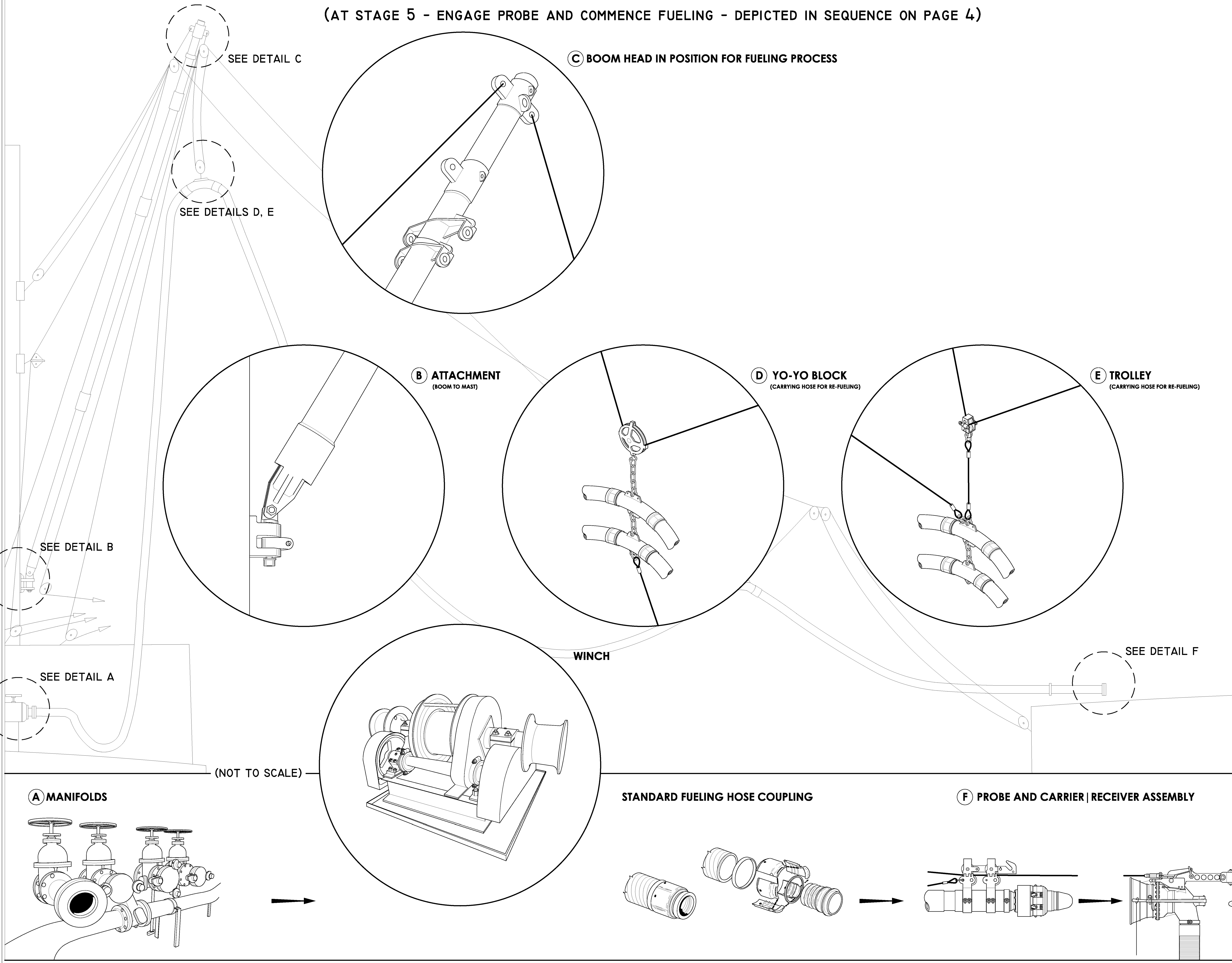
UNDERWAY REPLENISHMENT: FUELING COMPONENT DETAILS

(AT STAGE 5 - ENGAGE PROBE AND COMMENCE FUELING - DEPICTED IN SEQUENCE ON PAGE 4)



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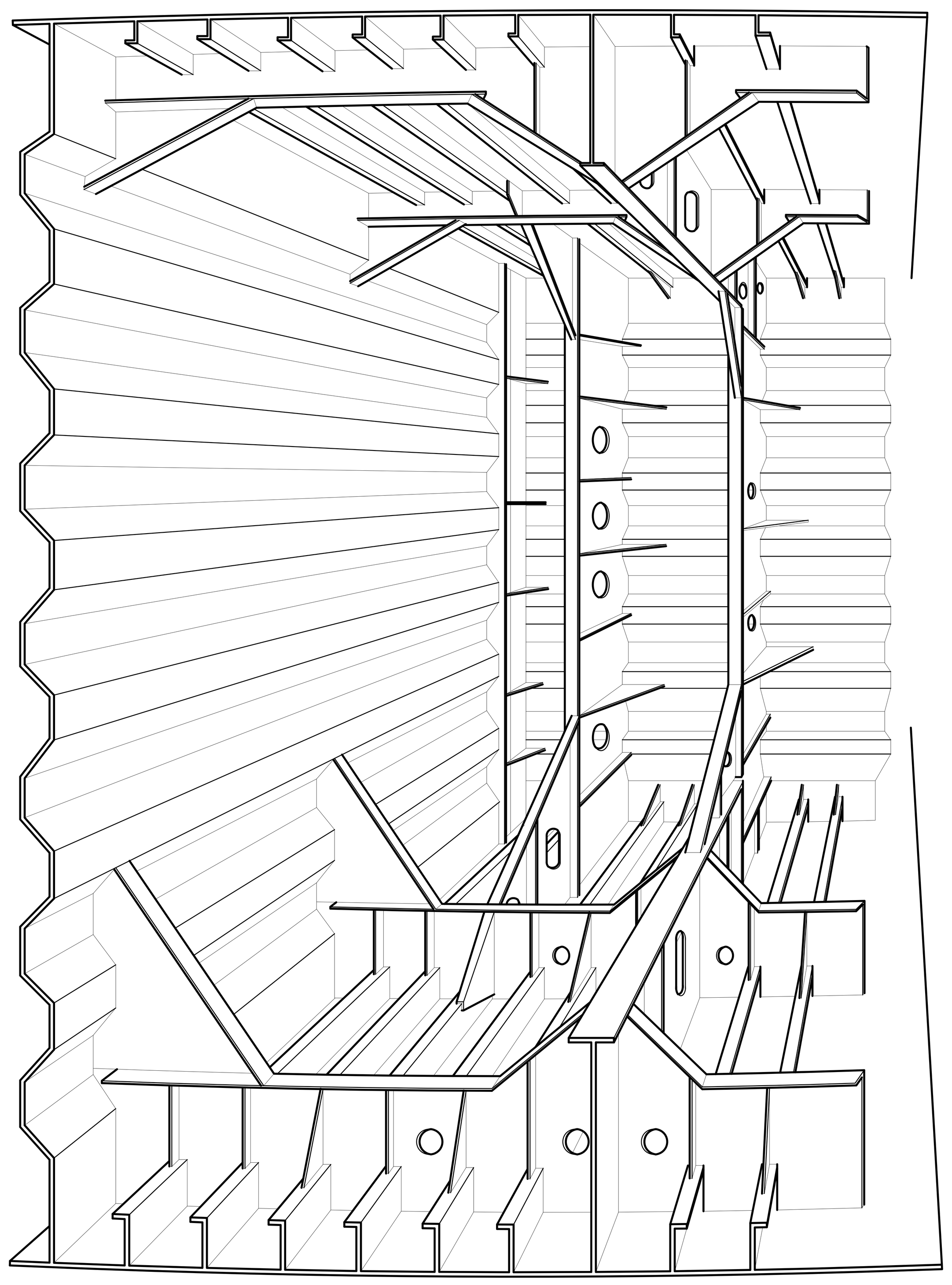
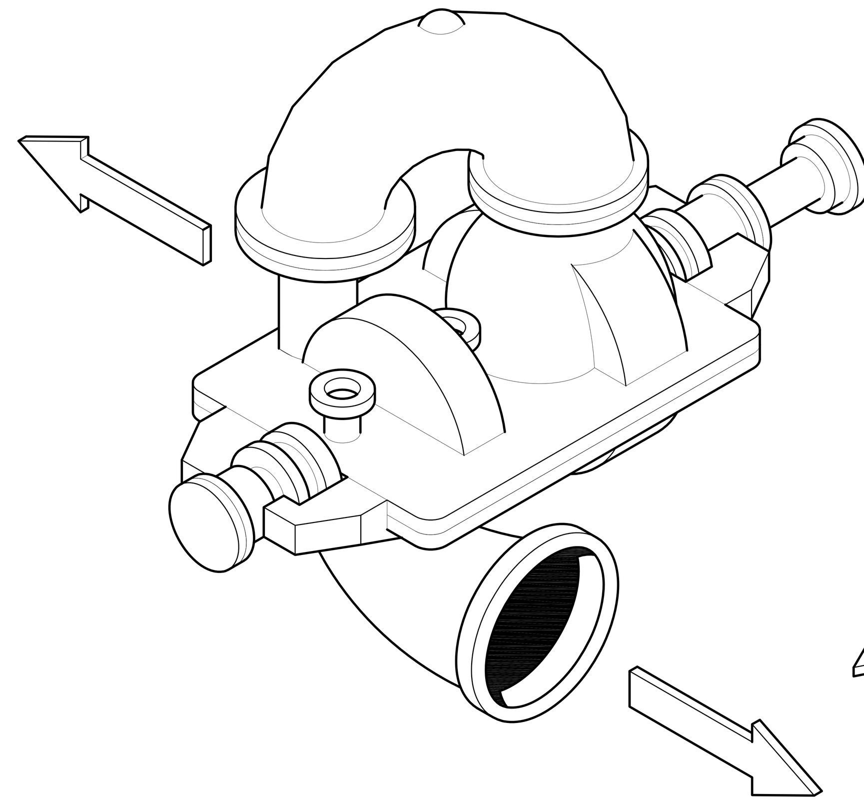
HISTORIC AMERICAN ENGINEERING RECORD
DC-62

LIBRARY OF CONGRESS INDEX NUMBER

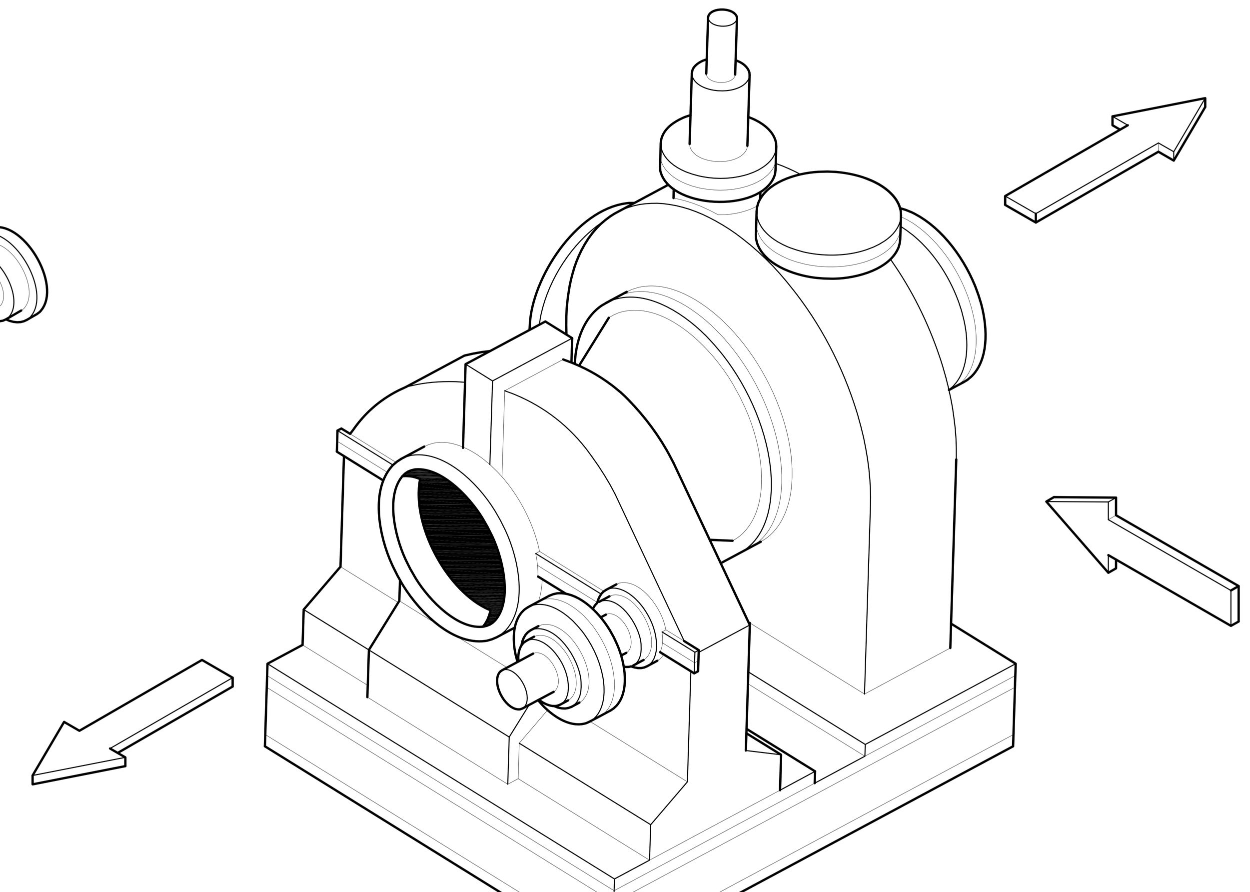
UNDERWAY REPLENISHMENT: FUEL PUMPS AND PIPING



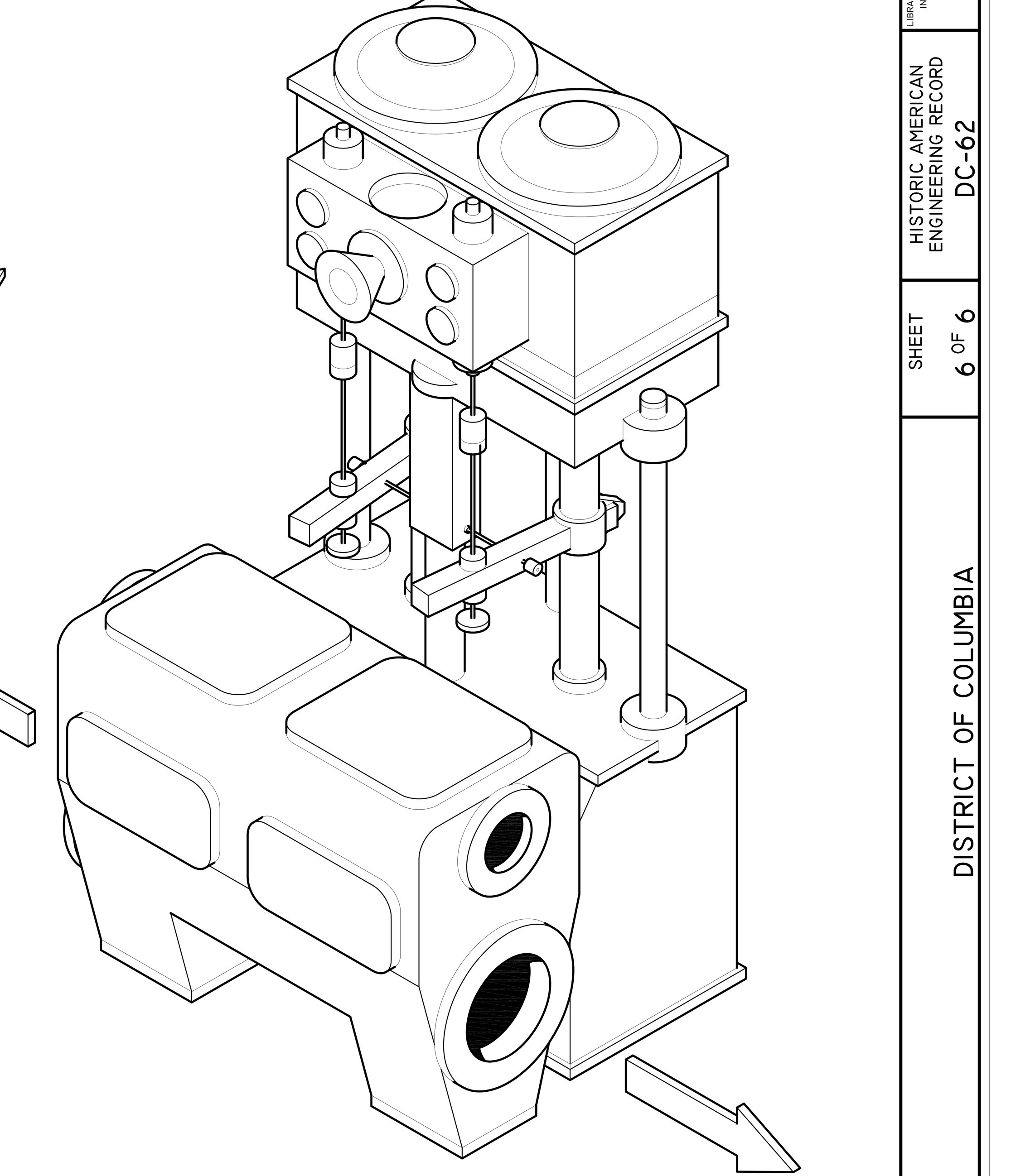
Ⓐ **CORRUGATED CARGO TANK**
(corrugation disperses liquid fuel for gentler movement in and through the tanks)



Ⓑ **MAIN CARGO (CENTRIFUGAL) PUMP**
(steam-powered pump uses centrifugal force to discharge liquid fuel into a pipe)



Ⓒ **CARGO STRIPPER PUMP**
(steam-powered pump discharges liquid fuel into a pipe)



Ⓓ **RECIPROCATING CARGO STRIPPER PUMP**
(steam-powered pump uses high pressure to draw out remaining fuel in tank after the majority has been pumped out by (B) and (C)).

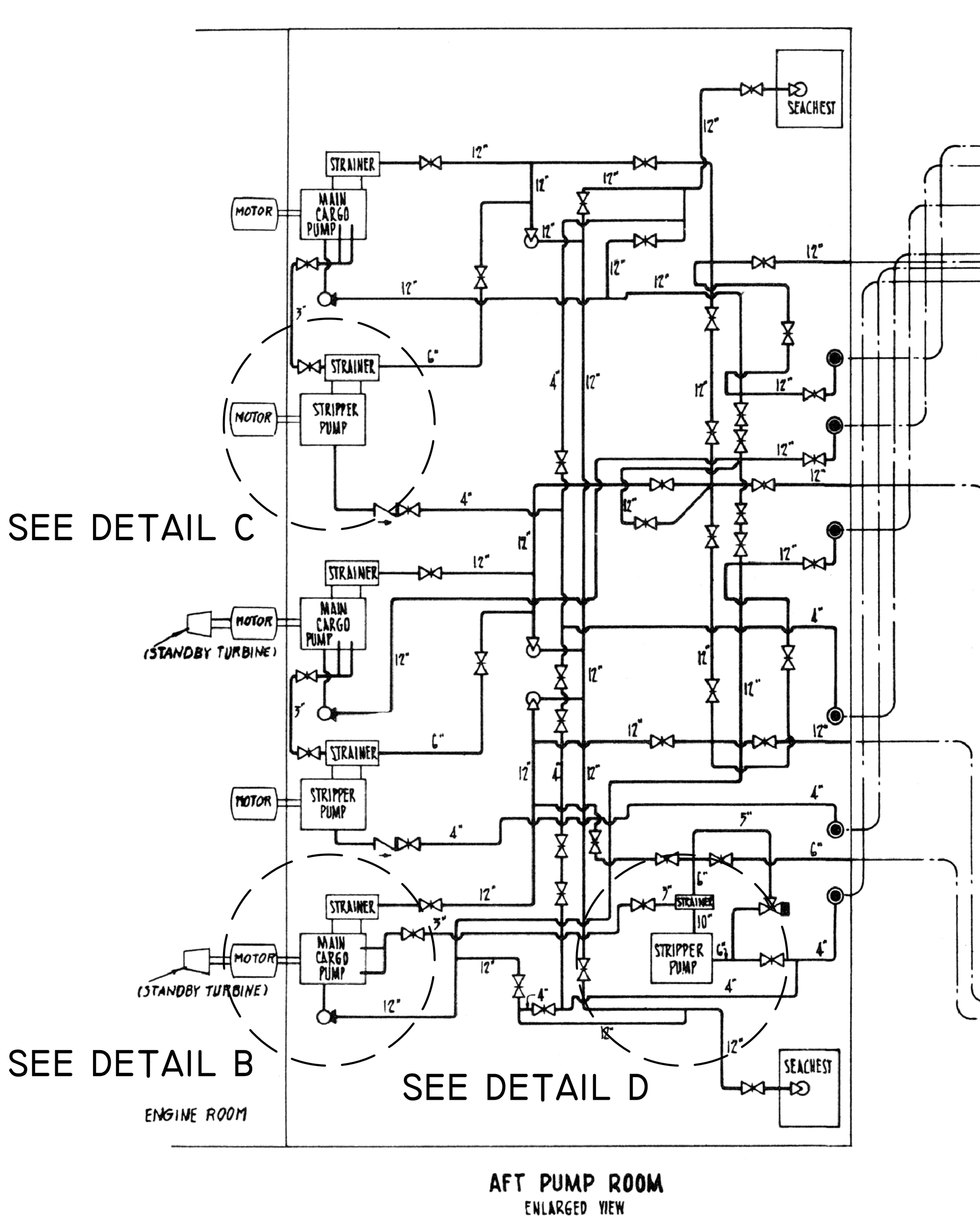
(NOT TO SCALE)

LEGEND

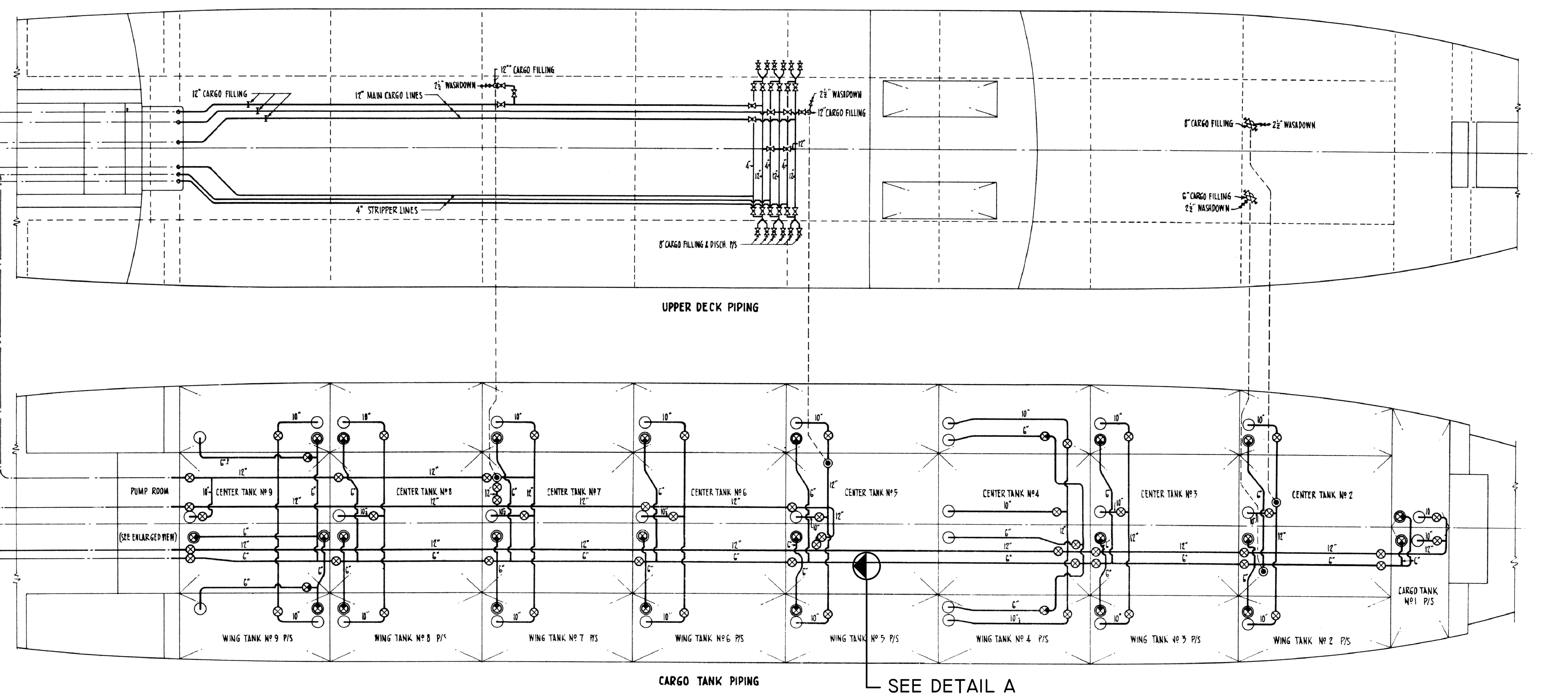
GATE VALVE	STOP LIFT CHECK WITH DECK OPERATING GEAR
HOSE GLOBE VALVE	BELL MOUTH
SWING CHECK VALVE	PIPE TURNING UP
RELIEF VALVE	PIPE TURNING DOWN
CROSS STOP VALVE	PIPE LINES JOINED
ANGLE STOP CHECK VALVE	PIPIE LINES CROSSED
ANGLE VALVE	

TANKER PIPING SCHEMATIC

NOTE: The schematic depicted here is referring specifically to that of a T2 tanker. Generally, this schematic serves to illustrate the internal process of fueling at sea. From large corrugated steel tanks, the cargo (fuel) is pumped through the pipes, up to the manifolds on deck, and through a hose to the recieving ship. (Refer to page 5 for details of the latter portion of this process.) Fuel can also be pumped between tanks to maintain proper ballast ratios.



AFT PUMP ROOM
ENLARGED VIEW



UPPER DECK PIPING

CARGO TANK PIPING

SEE DETAIL A

HISTORIC AMERICAN ENGINEERING RECORD
DC-62

SHEET 6 OF 6

DISTRICT OF COLUMBIA

US NAVY OILERS AND TANKERS
EVOLUTION OF REFUELING AND UNDERWAY REPLENISHMENT

WASHINGTON

HAER MARITIME RECORDING PROGRAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

DELINEATED BY: C.V. OLIN, 2006