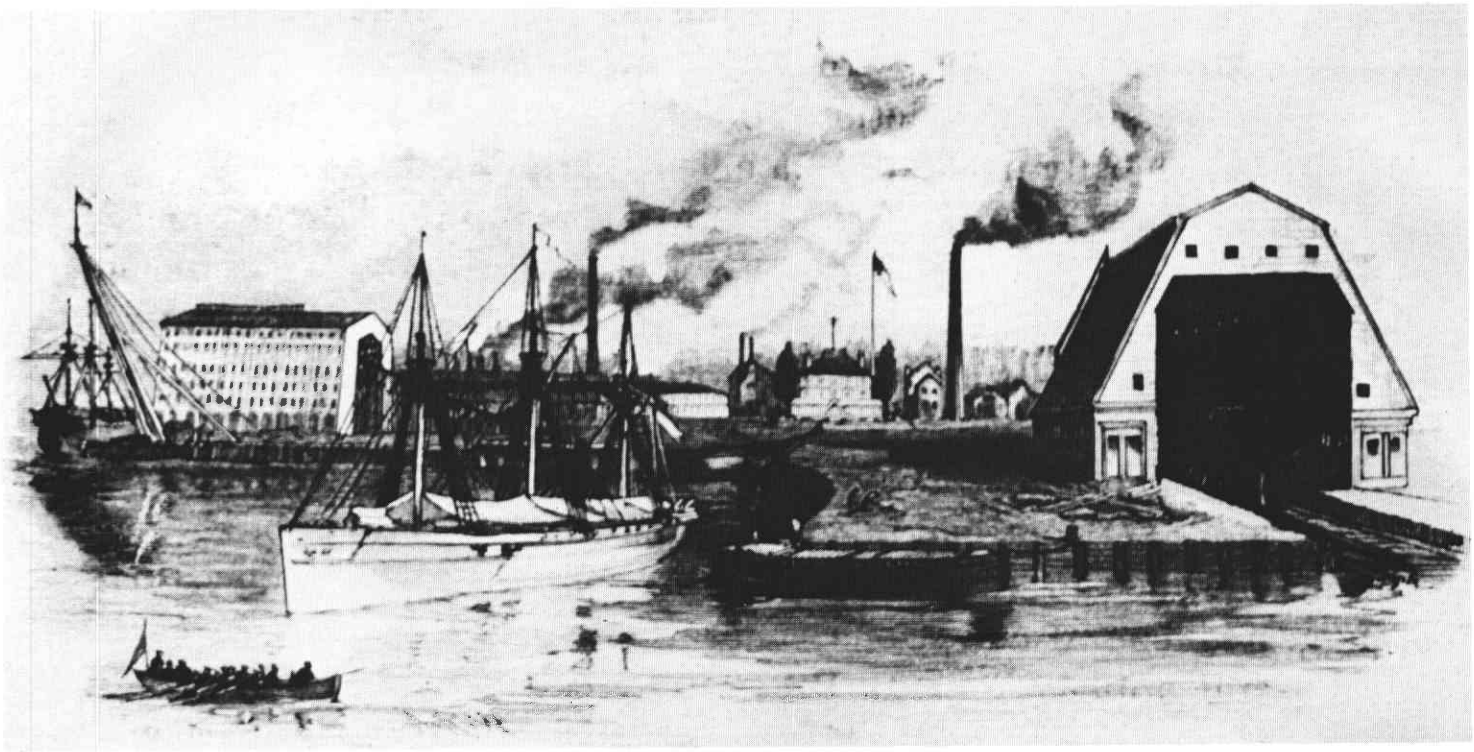
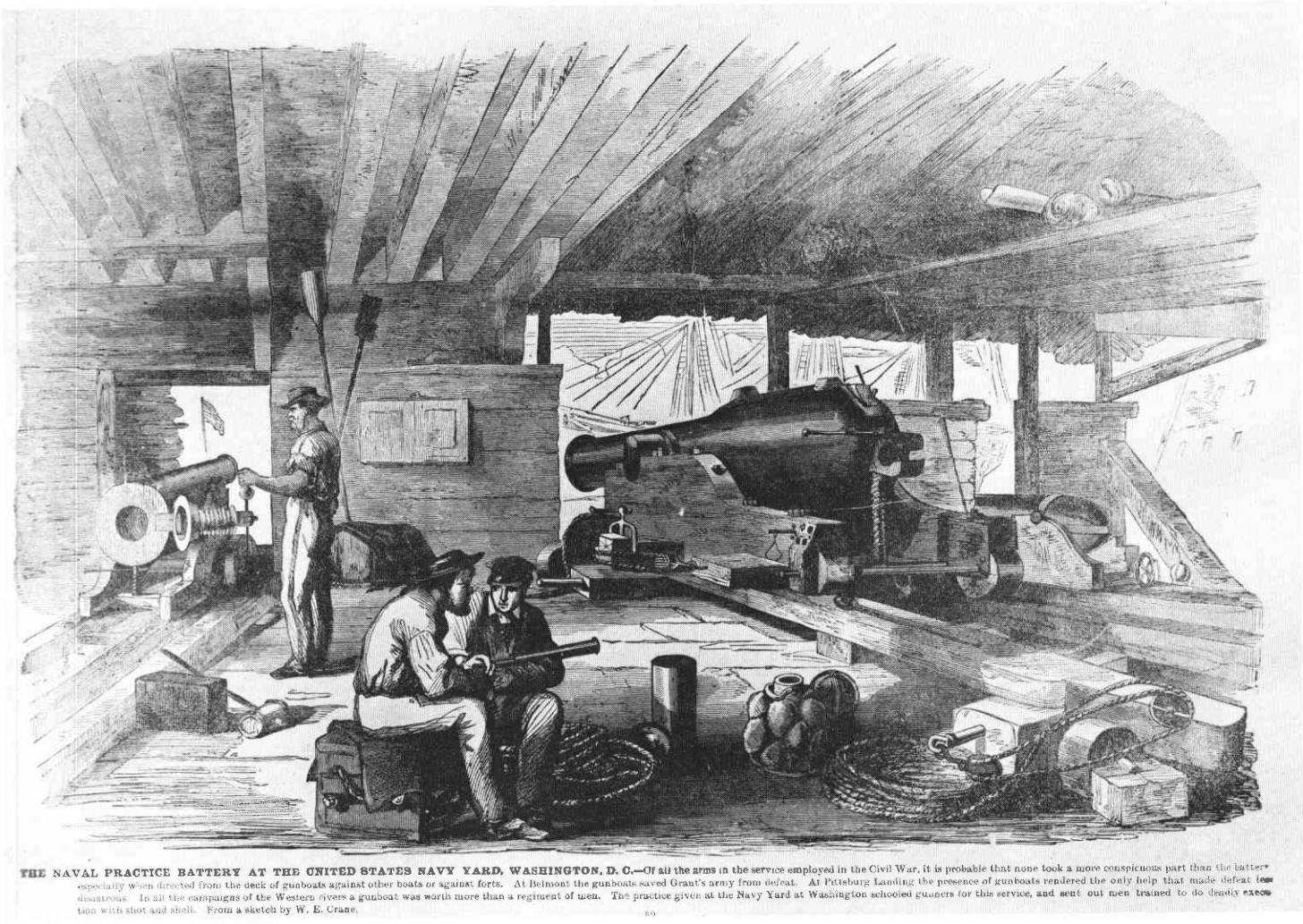


Washington Navy Yard, circa 1850. U.S. Naval Institute photo.



THE NAVAL PRACTICE BATTERY AT THE UNITED STATES NAVY YARD, WASHINGTON, D. C.—Of all the arms in the service employed in the Civil War, it is probable that none took a more conspicuous part than the batter especially when directed from the deck of gunboats against other boats or against forts. At Belmont the gunboats saved Grant's army from defeat. At Pittsburg Landing the presence of gunboats rendered the only help that made defeat les disastrous. In all the campaigns of the Western rivers a gunboat was worth more than a regiment of men. The practice given at the Navy Yard at Washington schooled gunners for this service, and sent out men trained to do deadly execu tion with shot and shell. From a sketch by W. E. Crane.

Naval practice battery at the Washington Navy Yard. National Archives photo.

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The Last Smoothbores

The Development of John A. Dahlgren's Heavy Cast-Iron Ordnance For the United States Navy in an Era of Transition, 1848-1865

Robert J. Schneller, Jr.

On his fortieth birthday, November 13, 1849, Lieutenant John Adolphus Bernard Dahlgren barely escaped death. He was working with a 32-pounder gun when, suddenly, it blew up. He wrote in his journal:

> I said, "Fire." An unusual explosion took place instantly. The battery was filled with smoke, and a great crash of timber was heard. Behind me I heard the ground ploughed up, and of the things that fell, something grazed my heels, which afterwards proved to be a part of the breeching, a piece weighing two thousand pounds. Much stunned by the noise and the concussion, I turned to the battery. Amid the smoke, yet lifting slowly, the first object I saw was the body of the unfortunate gunner, stretched out on the deck and quite dead.

The incident confirmed his doubts about the navy's current ordnance and inspired him to develop a new type of gun.[1]

The task that Dahlgren undertook would earn him the title, "Father of United States Naval Ordnance." Between 1848 and 1865 he developed several different classes of 12- and 24-pounder bronze boat howitzers and rifles, three classes of heavy iron rifled guns, and a number of heavy iron smoothbores ranging in size from a 9-inch gun of 9,000 pounds to a gigantic 20-inch gun of 100,000 pounds. All of his guns were muzzle loaders. Dahlgren is best remembered for his 9-, 11-, and 15-inch models. When the 9- and 11-inchers were first introduced in the 1850s, many naval officers and officials considered them to be the world's most powerful ordnance. The 11-inch guns remained in service until nearly the end of the nineteenth century.[2]

The period in which Dahlgren lived (1809-1870) bore witness to vast transformations in the navies of the world. Shortly before his birth, sailing ships-of-the-line had reached their zenith at the battle of Trafalgar. By the end of his life, forerunners of twentieth-century battleships had emerged. Sails, smoothbores, and wooden hulls gave way to man-made power, big guns, and all-metal ships. Six principal technological developments catalyzed this revolution: steam power, shell guns, rifled guns, iron hulls, screw propellers, and armor plate. Dahlgren lived to see the United States Navy introduce all of these innovations. His heavy, cast-iron muzzle-loaders were the last smoothbores that the navy adopted.[3]

Although Dahlgren perfected his guns in the context of a naval revolution, the United States Navy was slow to adopt them. Time and time again, his ideas, innovations, proposals, and designs met strong resistance from naval officials, who, for reasons that may or may not have been valid, rejected them at first. Only through patient and persistent effort was Dahlgren able to convince the naval bureaucracy that his ordnance and theories were valid. In nearly every case, the process took years. Meanwhile, the Europeans made rapid progress in perfecting the next generation of ordnance: rifled guns. Dahlgren, too, proposed developing rifles, but again, years passed before the navy gave him permission to proceed. During the Civil War, Union ships armed with Dahlgren smoothbores encountered enemy vessels equipped with the newer rifles. When the crisis stemming from the battle of Hampton Roads arose, the navy once again ignored Dahlgren's ordnance expertise. All of this leads to a question: did the naval bureaucracy, in hindering Dahlgren's innovative plans, saddle the navy with ineffective ordnance during the Civil War? This article shall attempt to answer this question by outlining the origin and development of Dahlgren's 9-, 11-, and 15-inch guns, discussing some of the bureaucratic and technological hurdles he encountered, addressing briefly the early

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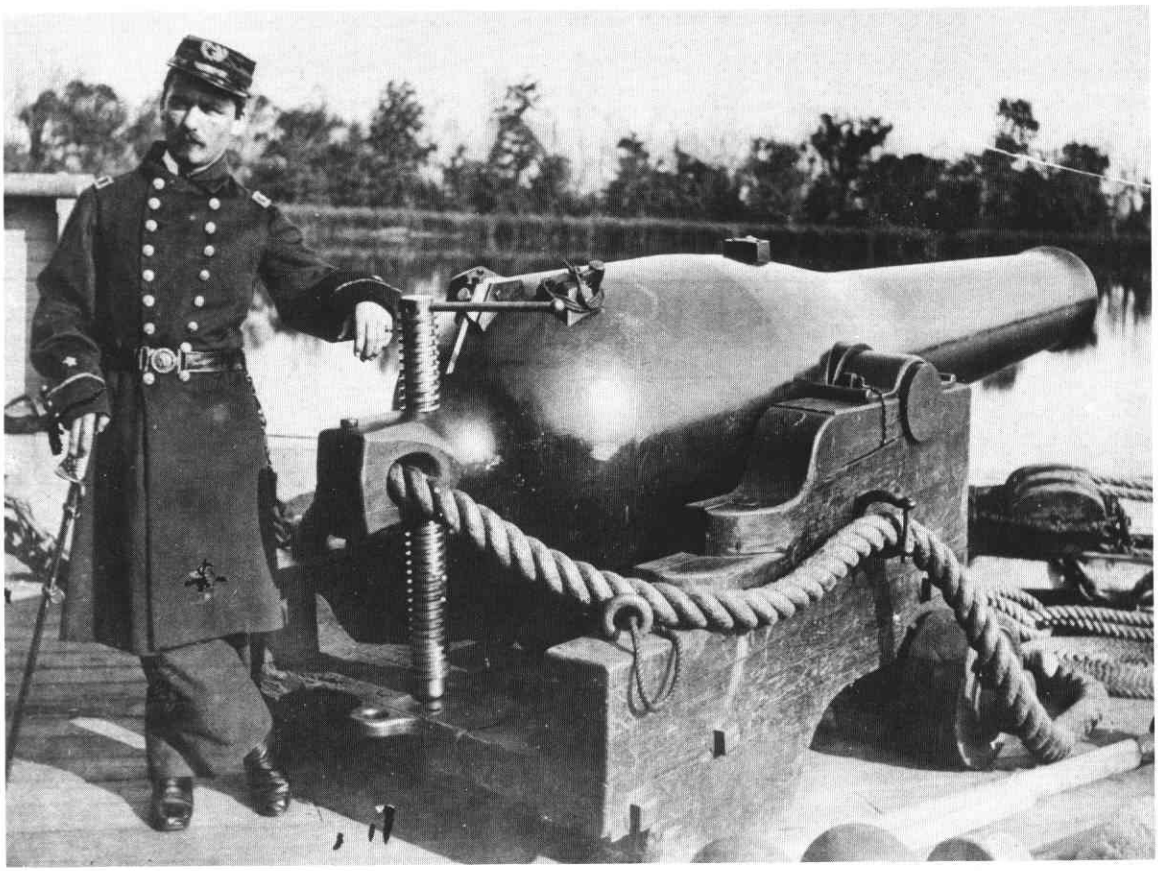
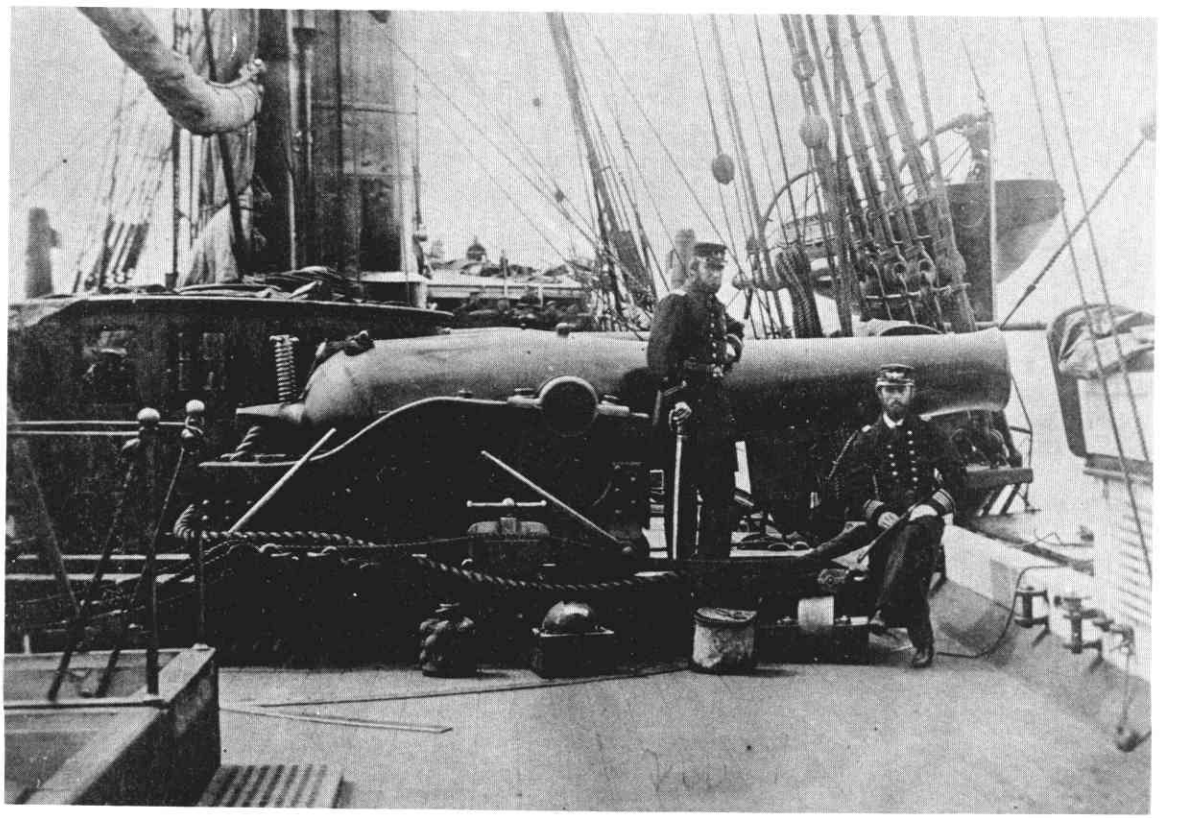


9-inch Dahlgren gun on a Marsilly carriage. Unlike carriages with four trucks, or wheels, the Marsilly carriage had only two. The increased friction helped to reduce recoil. Note the sight masses and the percussion lock and lanyard on the right lock lug. After the death of Charles Morris, Dahlgren guns were cast with two lock lugs for two vents. Only one vent was bored when the gun was delivered to the navy. After five hundred firings, the original vent was sealed with zinc, the second vent bored and the lock shifted. To fire the gun, a percussion primer in the form of a 2.5-inch long quill barrel topped with a wafer or flat head was first inserted in the vent. The lanyard was then steadily and quickly drawn, not jerked, rotating the hammer on its bolt until it was brought down on the vent, setting off the percussion primer. Continued pull on the lanyard drew the hammer clear, avoiding the erosion caused by the gases rushing out of the vent. This action was obtained by an inch-long slot cut at the rear of the hammer. In contrast to the locks on small arms, no springs were included in the mechanism. The photo was taken on the gunboat *Hunchback* on the James River. The identity of the figure is unknown. The information on firing the gun was taken from Canfield, *Ordnance*, pp. 14-15. National Archives photo.

development of rifled ordnance, and comparing the performances of the Dahlgren smoothbores with those of some of the rifled guns in the Civil War.

By November, 1849, when the exploding 32-pounder inspired him to design new ordnance, Dahlgren was already an ordnance expert. He was born the son of a Philadelphia merchant on November 13, 1809. Raised within sight of the shipping along the Delaware River, he early developed a longing for the sea. He entered the navy as a midshipman at age sixteen. For the next several years, he sailed on board the frigate *Macedonian* and the brig *Ontario.* In 1833 he was assigned to the United States Naval Station in Philadelphia where he studied law in his spare time. Skilled in mathematics, Dahlgren was ordered to duty with the United States Coast Survey in 1834, and was promoted to lieutenant three years later. He worked so hard that he nearly became blind, and took a leave of absence to seek treatment in Paris. While there, Dahlgren became familiar with the work of Henri-Joseph Paixhans, an artillery officer under Napoleon who had recently developed shell guns for the French navy. Dahlgren returned to active duty in 1843 and sailed on board the *Cumberland,* where he had his first hands-on experience with shell guns. In 1847, he was ordered to the Washington Navy Yard, where he worked with ordnance under the direction of the Bureau of Ordnance and Hydrography. During the next two years he developed a successful system of bronze 12- and 24-pounder boat howitzers. In 1848, he began working with the navy's recently adopted system of ordnance.

The new system, based on European models, consisted of standardized calibers of shot-firing guns augmented by newly developed shell guns. The French and British navies had adopted shell guns, respectively, in 1837 and 1839. Shell guns, designed to fire explosive shells exclusively, were lighter for a given caliber (bore



After 11-inch Dahlgren pivot gun on the *Kearsarge* (1862-1894). The picture was taken in June, 1864. The figures are Acting Master Eben M. Stoddard (standing) and Chief Engineer William H. Cushman. U.S. Naval Institute photo.

diameter) than guns firing solid shot. Early shells were simply hollow iron spheres filled with gunpowder and fuzed to explode on target. Weighing less than solid shot, shells could be fired with smaller charges. This induced less strain on a gun and thus facilitated the lighter construction of the shell guns. A shell needed to be fired with only enough initial velocity to become lodged in the exterior planking of a ship. The ensuing explosion drove large splinters into the interior and tore a gaping, jagged hole in the side. This inflicted far more damage than a clean, easily patched hole punched through by solid shot. Both the French and British navies adopted shell guns as auxiliaries to shot-firing guns, which remained the primary armament. Early in the 1840s, both European powers standardized the calibers of their shipboard guns, thus simplifying logistics. In 1845, The United States Navy, borrowing European ideas, formally introduced auxiliary shell guns and standardized calibers throughout the fleet. The navy adopted six classes of smoothbore 32-pounders capable of firing solid shot, as well as smoothbore 8-inch shell guns. Now, only two types of ammunition needed to be carried on board ships.

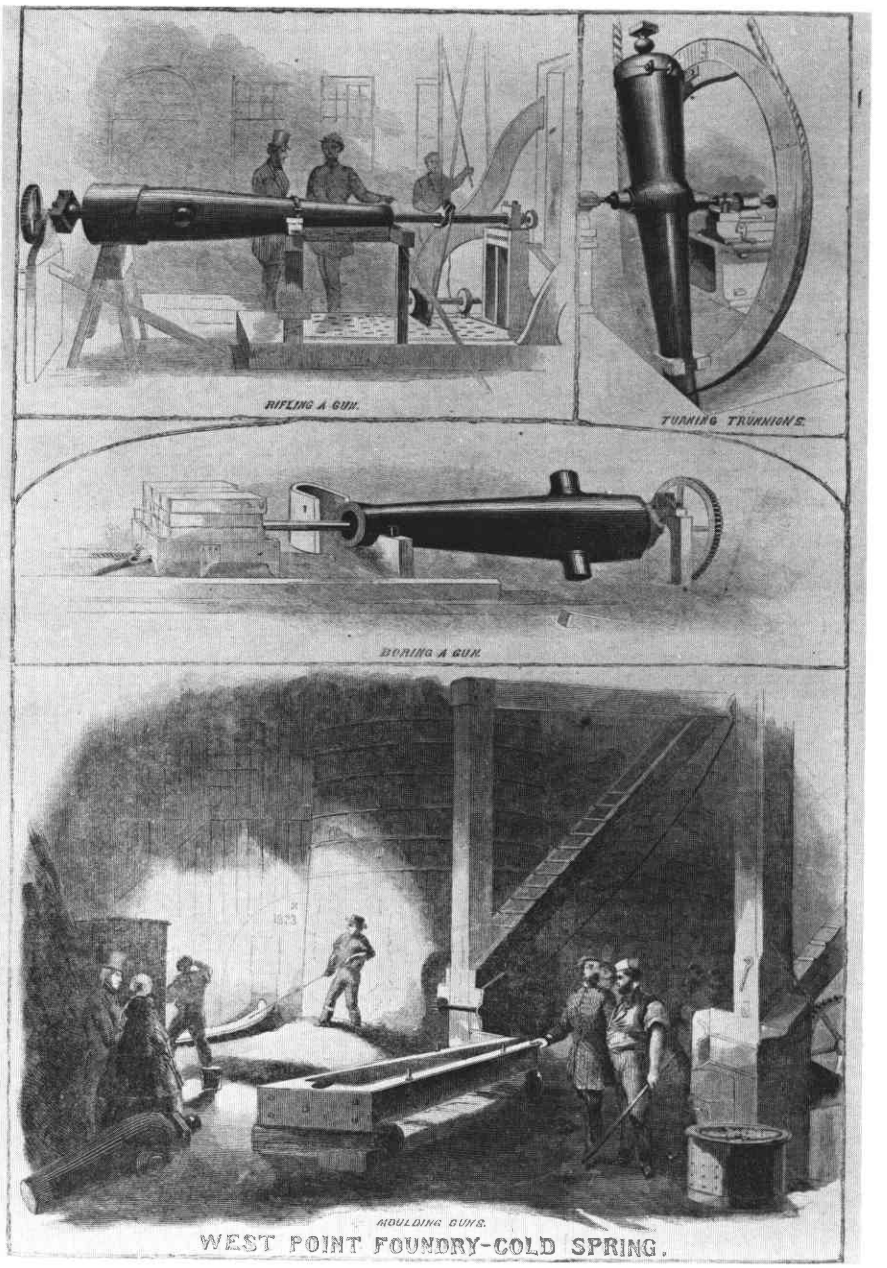
Dahlgren soon found flaws in the performances of the new guns. One of his first jobs at the Washington Navy Yard involved fitting a new type of sight to the various classes of 32-pounders by firing them and plotting the trajectories of the projectiles, using methods he learned while working on the coast survey. He observed that the heavier classes of 32-pounders lacked accuracy while the lighter classes lacked power. In September, 1849, he presented to the Bureau of Ordnance and Hydrography the idea that, in firing shot, there is a certain velocity which cannot be exceeded without adversely effecting accuracy. He argued that the lighter 32-pounders, with their smaller charges and lower initial velocities, delivered their projectiles with sufficient accuracy but insufficient momentum. Heavier 32-pounders lacked accuracy because their muzzle velocity was too high (see footnote [4]). Furthermore, he was dissatisfied with the navy's shell guns because of their inaccuracy and limited range. He concluded that United States naval ordnance achieved its ship-damaging power by increasing projectile speed at the expense of accuracy. Apart from flaws in performance, Dahlgren also believed that the current naval ordnance was unsafe.[4]

The flaws that he perceived in the navy's guns and the ordnance theories forming in his own mind motivated Dahlgren to develop new weapons. Shortly after the accident in November, 1849, that nearly killed him., Dahlgren received permission from the ordnance bureau chief to design a new gun which would incorporate his ideas on accuracy and power and be safer to fire than the navy's 32-pounders and shell guns. He considered lightweight shot-firing guns to be obsolete. He argued that a heavy

9-inch Dahlgren gun on pivot mount. Library of Congress photo.

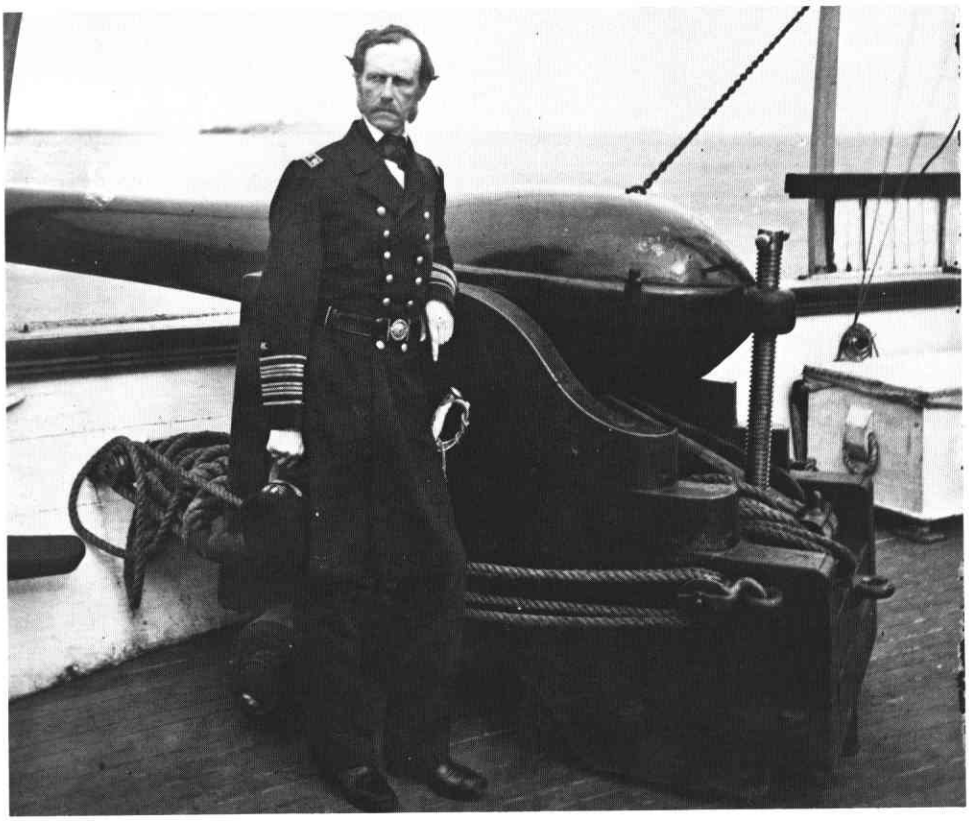
projectile fired at the optimum velocity, lower than that attained by the heavier 32-pounders, would achieve sufficient momentum to damage enemy ships. Although his gun would be strong enough to fire solid shot, he insisted that shells were far more effective. In his opinion, heavy shell guns which were strong enough to fire solid shot when necessary should be the navy's primary ordnance, supplanting the guns adopted in 1845. Only one or two models based on his principles would be necessary to rearm every ship in the fleet. He believed that the only factors that mattered in attaining maximum power from the gun barrel itself were the length and diameter of the bore. He reasoned that the distribution of metal about the bore had no effect on the range, accuracy, or power of a gun. He argued that the only function of the exterior form was to provide safety for the gun crew. By today's standards, metallurgy in Dahlgren's time was primitive. Ordnance experts could not predict what the quality of the iron in a gun would be without actually firing it. In battle, casualties were often higher from a ship's own guns bursting through the breech than from enemy fire. "It may be easily imagined," wrote Dahlgren, "that such an occurrence is very disheartening to the men." Consequently, he designed his first shell gun with an exaggerated breech. If one of his guns did explode, he reasoned, it would do so at the chase, the section of the barrel between the breech and muzzle forward of the trunnions. The danger to the gun crew would be minimized. He would incorporate the exaggerated breech into all of his subsequent models. Amused English critics referred to his uniquely shaped guns as "soda-water bottles."[5]

Naval officials and naval ordnance experts strongly resisted the new guns at first, but the help of the ordnance bureau chief, Lewis Warrington, enabled Dahlgren to proceed with their development. In January, 1850, Dahlgren submitted to the ordnance bureau his first design of a soda-bottle shaped gun, a 9-inch piece weighing about 9,000 pounds. Other bureau chiefs, private gun founders who produced naval ordnance, and naval shipbuilders considered its long, slim chase and exaggerated breech to be a radical departure from traditional design. Many of these men had been involved in developing the ordnance which the navy had adopted in 1845. Fearing that Dahlgren's new gun would burst when fired, naval officials ordered him to redesign it to have a shorter, stouter chase. He did so, and the Cold Spring Foundry in West Point, New York, cast the experimental 9-inch gun. Dahlgren tested it alongside several classes of 32-pounders and the 8-inch shell gun during the summer of 1850. Finding his 9-inch gun to be more powerful and accurate than the others, Dahlgren then received permission from Warrington to design an experimental 11-inch gun of about 16,000 pounds. Warrington, who was pleased with the 9-inch gun, placed the order for the 11-inch gun with Cyrus Alger and Company of Boston in April 1851. Alger and the naval officials again objected to the slim chase of the design. Part of Alger's concern stemmed from the terms of his contract with the navy for



Various phases in manufacturing guns at the West Point Foundry, Cold Spring, New York. The same general process was used to manufacture different guns in this period. First, a full scale model of the gun was built, in several sections. Two cast-iron boxes, called flasks, were then constructed. Each flask held half of the mold. The mold was formed in the flasks by pounding a mixture of sand and clay around the model. When the several parts of the model were extracted from the sand, a channel was dug to allow the metal to flow to the bottom of the mold. The flasks were then bolted together and lowered into a pit with the muzzle end facing upwards. The molten metal flowed from the furnace down the channel cut into the mold so that the breech-end filled first, from the bottom up. Metal was not poured directly into the open muzzle end. After cooling, the gun was extracted. The models were reusable, not the molds. Note that in two of the finishing processes depicted above, machinery turned the whole gun while the cutting tools did not spin. National Archives photo.

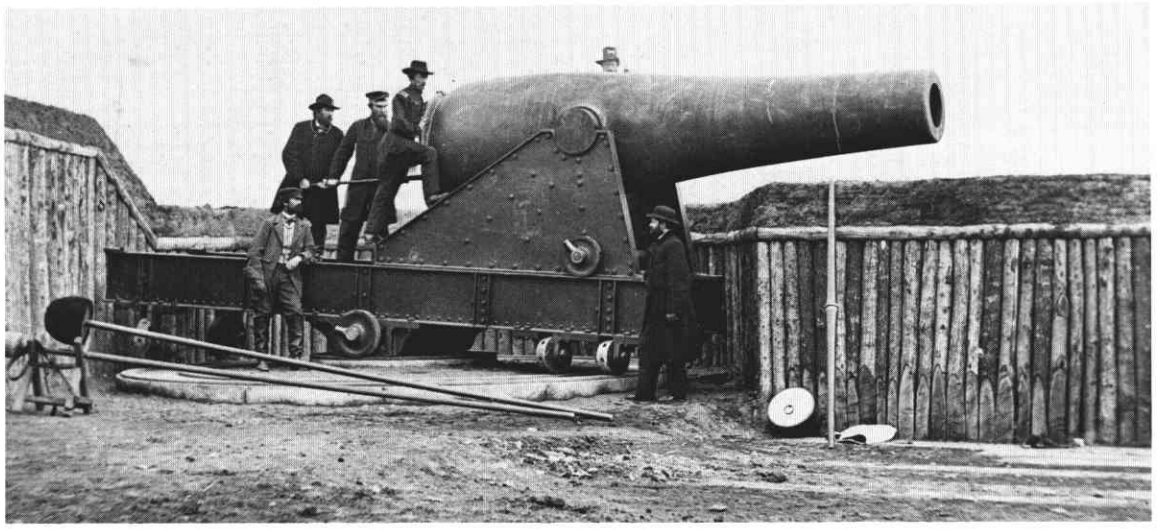
this particular piece. Should the 11-inch gun fail to withstand five hundred firings, he would have to pay for it himself. Naval officials again ordered Dahlgren to change his design, but this time he refused. Warrington backed Dahlgren fully on this, and together they arranged a compromise. Before naval officials would approving casting the 11-inch gun and before Alger would take the financial risk, Dahlgren would have to demonstrate the safety of a slim chase. He had an 8-inch gun turned on a lathe until its dimensions were proportional to the proposed 11-inch gun. After several successful test firings, naval officials agreed that if the metal of the 11-inch gun proved to be as sound as that of the modified 8-inch gun, the 11-inch gun would stand a reasonable chance of surviving. Alger cast the first 11-inch gun in July, 1851. With Warrington's help, Dahlgren had made reasonable progress in developing his guns. The pace slowed abruptly with Warrington's death in November, 1851.[6]



Rear Admiral Dahlgren with 50-pounder Dahlgren rifle on board the *Pawnee* in Charleston Harbor. Note the breech strap securing both the cascabel and the trunnions to the barrel. Dahlgren designed his rifles so that nothing protruded from the casting. He believed that this increased the strength of the gun. Library of Congress photo.

Charles Morris, who succeeded Warrington as chief of the Bureau of Ordnance and Hydrography, approved of neither Dahlgren nor his guns. Morris had joined the navy in 1799. He had been one of the Navy Commissioners, the administrative body that had preceded the bureau system, and had commanded the Mediterranean squadron. He had apparently been a key figure in adopting the 32-pounder based system in 1845. At that time, he was considered to be the navy's intellectual leader and one of its most scientifically oriented officers. In the early 1850s, Morris actively opposed Dahlgren. Perhaps his motive stemmed from the fact that Dahlgren meant to replace the very guns that he himself had been instrumental in developing. Morris may have perceived a threat to his position from the younger officer. The substance of Morris's objections are discussed later in this article. One consequence of this was that although the experimental 11-inch gun arrived at the Washington Navy Yard in March, 1852, Dahlgren was unable to begin testing it until the following October. Regarding Morris, one of Dahlgren's supporters remarked in a letter that "we will never be freed of old fogyism, except through the grave. Railroad collisions and retiring boards seem alike inadequate to the task." Until the day he died, Morris would oppose Dahlgren's plans for the new ordnance.[7]

Dahlgren's plan as it evolved in the 1850s simply involved replacing the guns that the navy had adopted in 1845 with his own. It rested upon several basic premises, arguments, and proposals. He believed that naval ordnance should consist of the heaviest manageable guns firing the heaviest manageable shells. The results of his experiments with various types of ordnance convinced him with his 9- and 11-inch guns were more powerful, more accurate, of greater range, and safer than the navy's other guns. He proposed placing 9-inch guns in broadside mounts on the gun decks of ships. The 11-inch guns would be placed on the spar decks (the upper deck) in pivot mounts. Pivot guns could be trained to fire from either side of a ship. Up on the spar deck, they could be fired at greater elevations than were permitted by the dimensions of gunports. Thus, pivot guns could outrange broadside guns. Dahlgren argued that fewer heavy guns would better arm a ship than a greater number of lighter guns. Perhaps his key argument, this foreshadowed the all-big-gun ships of a later age. By the regulations of 1845, a typical frigate carried eight 8-inch shell guns and forty-two 32-pounders. Dahlgren advocated replacing these with twenty-two 9-inch guns and six 11-inch pivot guns. His proposed battery would weigh four tons less, yet deliver almost six hundred more pounds in projectile



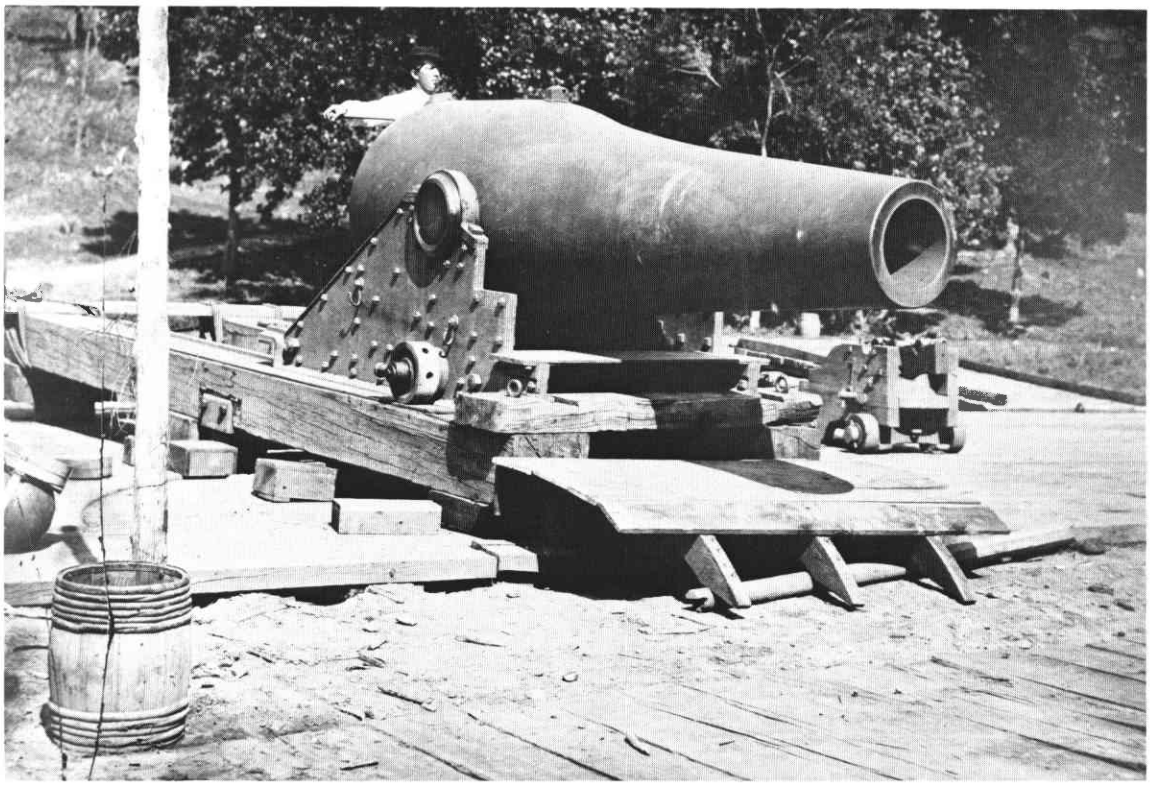
Army 15-inch Rodman gun at Battery Rodgers, Alexandria, Virginia. Assistant Secretary of the Navy Fox ordered Dahlgren to design a navy 15-inch gun when he saw a piece similar to this after the Battle of Hampton Roads. Dahlgren claimed that Rodman used the lines of his 11-inch gun to design the army 15-incher. National Archives photo.

weight from a broadside.[8]

Dahlgren's ordnance theory was not the product of innovation, rather it was a synthesis of existing ideas. In 1747, Ben Robins, a well-known English ordnance expert, had published a paper in which he proposed thickening the breeches of guns. He also believed that a larger, heavier projectile fired at a lower velocity would tear a larger hole in the side of a ship than a clean hole punched by a projectile moving at a higher velocity. Dahlgren read the work and agreed, applying the principle to shells. An English naval officer, Captain T.F. Simmons, had espoused in 1837 the idea that fewer heavy guns would better arm a ship than many light guns. Dahlgren, familiar with Simmons's work, quoted him in his famous book on ordnance, *Shells and Shell Guns.* Dahlgren was heavily influenced by Paixhans, especially in the belief that shells were better than shot at damaging ships. Although Dahlgren improved upon the ideas of others, his ordnance theory was far from revolutionary. Dahlgren's guns, as an improvement of the accepted technological tradition, may be regarded as what historians of science and technology have come to call "normal technology."[9]

Dahlgren's plan to rearm ships co-evolved with a proposal in Congress to increase the number of steam-powered vessels in the navy. Morris, however, opposed Dahlgren's plan nearly every step of the way. In doing so, he probably hindered the efforts of others to enlarge the fleet. Early in 1851, Dahlgren had established ties with Congressman Frederick P. Stanton, who sat on the Committee on Naval Affairs in the House of Representatives. Stanton favored Dahlgren's plan because he believed that a ship armed with fewer guns would be cheaper to maintain. In August, 1852, Stanton demanded congressional appropriations for a frigate to carry Dahlgren's guns. The type of frigate Stanton referred to had been under consideration since 1850 and five would later be built as the *Merrimac* class. Morris objected on the grounds that the new guns were too heavy and the measure did not pass. In May, 1853, the question of whether to build a frigate armed with the new ordnance again came up in Congress. This time, Morris prepared a paper outlining his objections to Dahlgren's guns. Dahlgren responded with a paper of his own, Morris countered with another, and the two made several such exchanges through early 1854. By this time, Morris had accepted the 9-inch gun, although perhaps somewhat grudgingly. Dahlgren's experiments may have convinced him of the superiority of the 9-inch gun over the 32-pounders. Maybe Morris accepted the 9-inch gun simply because several of his superiors did. Nevertheless, he remained adamantly opposed to the 11-inch gun and to most of Dahlgren's ship rearmament plans.[10]

Many of the points Morris raised against Dahlgren's plan seem as reasonable today as they did then. He argued against mounting 11-inch pivot guns on spar decks for several reasons. He believed that there would not be enough room left over to store ships' boats and extra spars. Pivot mounts might hinder the men as they moved about the deck while sailing the ship. Pivot gun crews on an open deck would be vulnerable to enemy grapeshot and musket fire. The 11-inch gun would be difficult to maneuver, especially in rough seas, because of its 16,000 pound weight. Morris's arguments against other aspects of Dahlgren's plan appear equally valid. In 1852 and 1853 Morris had instituted his own changes in shipboard armament, substituting heavier conventional guns for lighter ones. He maintained that these changes brought the broadside weight of projectiles to weight of guns ratio up to an acceptable level. "Advantages which



15-inch Dahlgren gun at the experimental battery, Washington Navy Yard. Library of Congress photo.

have sometimes been claimed for heavier and for lighter calibers by their respective advocates," he reasoned, "seem to have been more properly due to the skill and accuracy with which they were used." He argued that two 32-pounder hits would inflict as much damage on a ship as one 9-inch shell. He insisted that the more guns a ship carried, the better its chances of hitting its target. The supposed superior accuracy of Dahlgren's guns had by this time been demonstrated only on dry land. A rolling ship was a far less stable gun platform. By such arguments, Morris succeeded in blocking Dahlgren's plans for some time.[11]

Meanwhile, Dahlgren had been working with the guns themselves. Serious experiments with the 11-inch gun began in November, 1852. Dahlgren continued firing the 9- and 11-inch guns through the spring of 1853. His confidence boosted by their success, he resubmitted his original plan for the 9-inch gun in May. Criticism of its slim chase arose once again, but this time a 9-inch gun was cast with the slender chase as Dahlgren had originally intended. He continued working with the first 9-inch gun and the 11-inch gun throughout 1853. Early the next year, he began firing the second 9-inch gun. This work yielded data that Dahlgren used to back up his arguments for rearming ships.[12]

Because of Dahlgren's persistence, his connections, the success of his guns, and the Congressional debate on adding new ships to the navy, his ordnance system won partial approval. James Cochrane Dobbin, who became Secretary of the Navy in March, 1853, leaned toward Dahlgren's side in the battle with Morris. In his report to Congress that year, Dobbin praised the new ordnance and again raised the issue of building ships. He requested that Congress appropriate funds for six new steam frigates of the type under consideration for the past four years. In April, Congress authorized the ships. Five would be built as the *Merrimac* class of steam frigates, the sixth as a sloop. In July, Morris ordered Dahlgren to design a 10-inch shell gun along the lines of his others, possibly as a substitute for the 11-inch gun. In October, Dahlgren completed the first five-hundred firings of the 11-inch gun, probably to Alger's relief. The 11-inch and the two 9-inch guns had performed well in experiments throughout 1854. On October 30, Dahlgren and Morris met with the chief gun founders from each of the four principal companies that produced naval ordnance, to discuss Dahlgren's guns. All of the founders, even those who had previously expressed doubts about the guns, gave them a nod of approval. In November, naval officials made a formal decision on how to arm the new steamers. The frigates would each receive 9-inch Dahlgren guns on their gun decks and at least one 10-inch Dahlgren pivot gun on their spar decks. The sloop, which would not have a gun deck, would receive an as yet unspecified number of 11-inch guns on her spar deck. The 11-inch gun, however, was still controversial. The

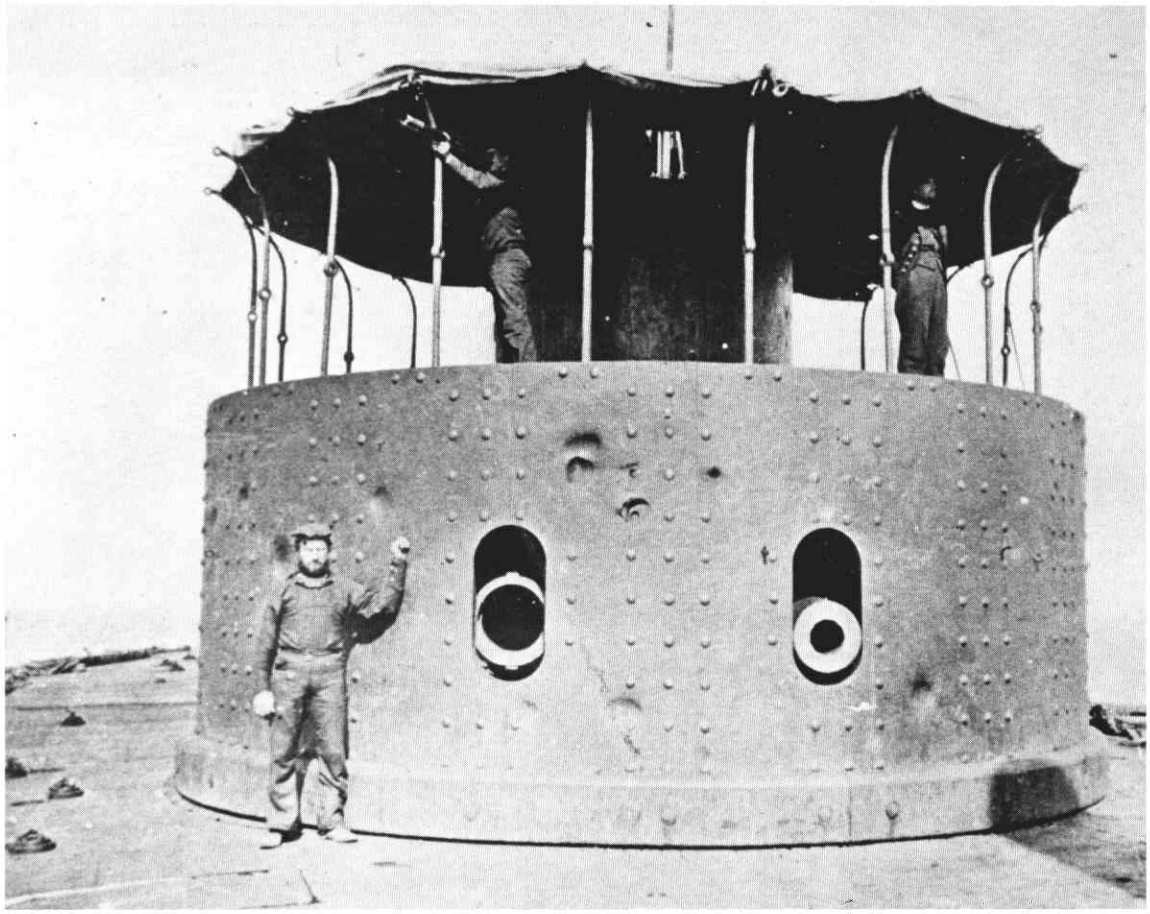
Another 15-inch Dahlgren gun at the experimental battery, Washington Navy Yard. Library of Congress photo.

Ordnance Bureau ordered the guns, as had been standard practice, from private foundries: Cyrus Alger and Company of Boston; the Fort Pitt Foundry in Pittsburgh, the Cold Spring Foundry in West Point, New York, and Tredegar Ironworks in Richmond.[13]

Dahlgren had won a significant victory when the navy chose his guns for the new ships, but a crisis that threatened to wreck his plans soon arose. In the fall of 1855, Dahlgren rejected nearly every gun cast in Boston and Pittsburgh when many of them failed proof, a standard procedure to test the fitness of a gun for service. Proof for Dahlgren guns consisted of firing ten rounds of standard ammunition with service charges and a series of visual inspections. Sometimes a gun was subjected to a more rigorous test called extreme proof, where it was fired repeatedly until it burst. Ordnance officers used extreme proof, a test of endurance, for evaluating experimental ordnance or for determining the quality of a large order from one or two guns. Besides checking the endurance, ordnance officers evaluated the range, accuracy and power of the class of ordnance as a whole during extreme proof. The first 11-inch gun endured 1,958 firings, a remarkable performance for its day. When Dahlgren fired the next round, the gun split into three pieces: the right side of the breech flew ninety feet, the left side turned over with the carriage, and the chase broke off intact and dropped down in front. No injuries resulted, but the exaggerated breech did not behave as Dahlgren had intended. By comparison, many of the first mass-produced guns performed abysmally. The Pittsburgh gun subjected to extreme proof failed on the 206th firing. Thirty-nine of the fifty guns ordered from the Fort Pitt Foundry were not fit enough to be fired at all. Several guns cast in Boston were deemed unfit after the ten proof firings. Why did these guns turn out so poorly? Dahlgren, having invested years in convincing his superiors that his design was sound, searched frantically for an answer.[14]

The problem resulted from differential cooling of the cast iron in the gun molds. The first Dahlgren guns were cast solid, nearly in their finished form, then bored out. In other words, the molds were soda-bottle shaped as well. Cross sections of one of the first Dahlgren guns cooling in its mold were thicker in the breech than in the chase, and varied along the whole length of the piece. We know today that such castings are inherently weakened, but Dahlgren was unaware of this. Castings in which cross sections vary in thickness do not cool uniformly: the iron in the thicker parts cools more slowly. Iron that cools slowly has different physical properties than iron that cools quickly. In castings of variable thickness, the properties of cast iron vary with the cooling rate; this is called section effect. The thicker parts of an early Dahlgren gun, for example the breech, had better thermal conductivity and were less brittle than the thinner parts, but were weaker and softer. A casting with section effects was only as strong as its weakest part. Section effects were only one of the many problems that plagued gun founders who used cast iron. Dahlgren would never solve them all, but he did arrive at a solution for the problem that arose in mass production.[15]

Dahlgren and others believed that because the first 11-inch gun had performed so well, the failure of the first mass-produced guns did not stem from their unique



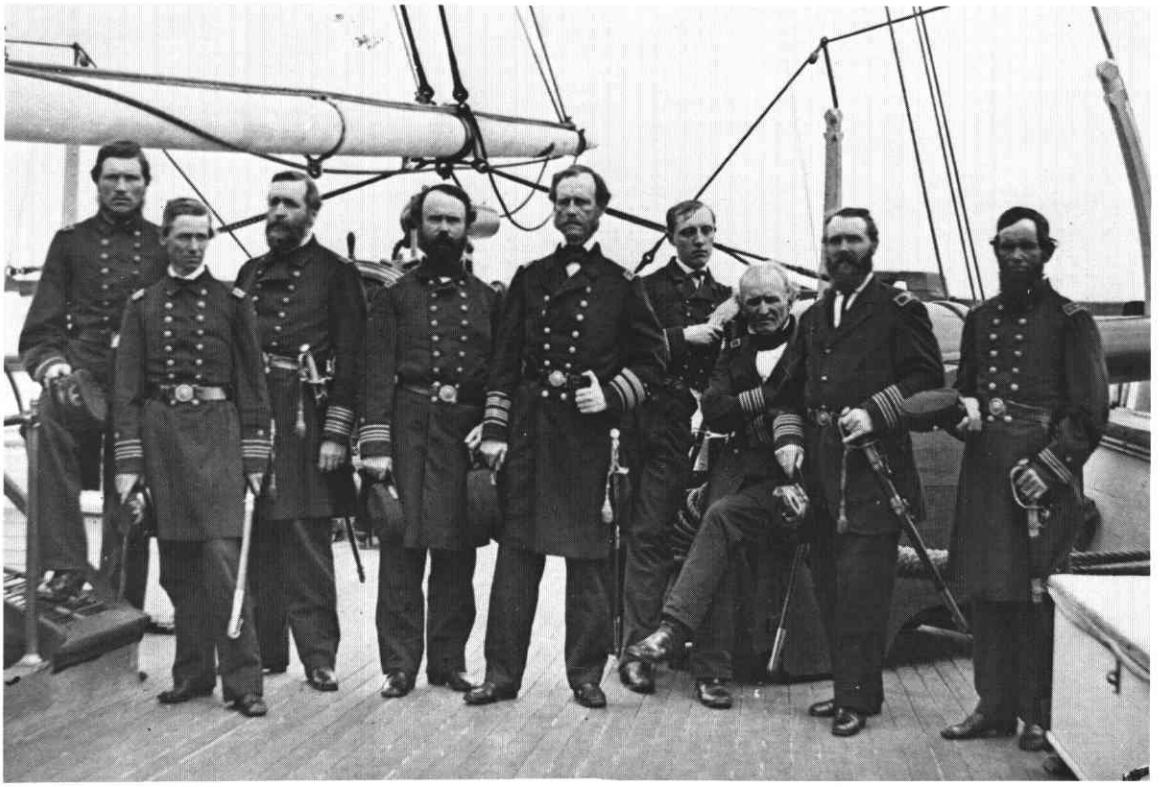
11- and 15-inch guns on board the monitor *Passaic* off Charleston. Confederate gunfire from ashore dented the turret. Note that the 15-inch gun did not protrude through the gunport and had to be fired inside the turret. National Archives photo.

design. William Wade, the chief founder at Fort Pitt, offered one possible explanation. He noted that earlier experiments had indicated that the longer a gun rested between cooling and being fired, the longer it would endure once firing began. The first 11-inch gun, cast in July, 1851, had not been fired until October, 1852. Perhaps the fifteen month delay in firing the 11-inch gun accounted for its remarkable performance. On the other hand, the first mass-produced guns had been fired much sooner after being cast. Maybe this caused their failure. Dahlgren disagreed. He attributed the problem to poor foundry practices and sought a more reliable casting method. He ordered that his guns be cast nearly in the form of a cylinder, then turned on a lathe to their familiar soda-bottle shape. This method probably reduced section effects.[16]

The cylinder-casting technique resulted in a marked improvement in the endurance of mass-produced Dahlgren guns. Every piece produced in 1857 in Boston by this method and subjected to extreme proof endured admirably. Some achieved 1,600 rounds. Robert P. Parrott, chief founder of the Cold Spring Foundry, consided the changes in the casting technique to be "substantial improvements." In 1858, a 9-inch gun cast in Boston withstood 1,509 rounds. Another twenty-two rounds were fired, but these were shells deliberately set to explode before leaving the barrel. The round that finally burst the gun consisted of twenty pounds of powder and ten shot weighing ninety pounds each. This nearly filled the gun to the muzzle. Dahlgren's smoothbores were earning the reputation of being the nation's most reliable ordnance.[17]

In 1857, Dahlgren finally won approval for his 11-inch gun. Although the navy in 1854 had ordered several 11-inch guns, they were still considered experimental. Morris, as chief of ordnance, continued to oppose them. With his death in 1856, however, the opposition to the 11-inch gun virtually vanished. The next year Secretary of the Navy Dobbin gave Dahlgren command of the ship *Plymouth* to determine if the heavy piece would be manageable at sea. Dahlgren cruised on board the *Plymouth* for several weeks, fired its 11-inch gun 121 times, and reported no difficulties. During the next few years the new ordnance, including the 11-incher, became standard on naval vessels. Nearly all the ships built in this period received Dahlgren guns.[18]

Meanwhile, a revolutionary new ordnance had emerged. During the 1850s, French and English ord-

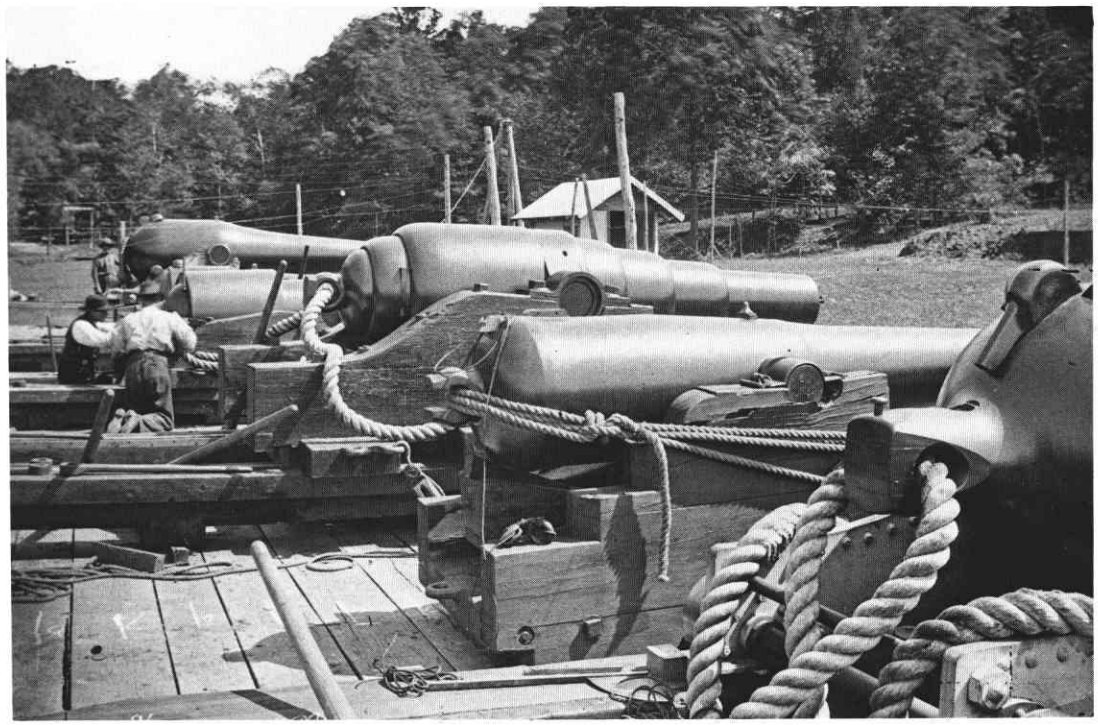


Rear Admiral Dahlgren (center), in command of the South Atlantic Blockading Squadron, and his staff. The gun behind the seated figure is a Dahlgren rifle. The gun behind the ship's wheel is a Dahlgren boat gun. National Archives photo.

nance experts began extensive experiments with rifled guns. European naval officials recognized their potential and became enthusiastic about the prospect of developing serviceable heavy rifled ordnance for their fleets. A few Americans shared their enthusiasm. In the summer of 1859, a board of American army officers convening at Fort Monroe decided that because rifled guns were apparently superior in both accuracy and range, the era of smoothbores had passed. That same summer, even Dahlgren doubted the future of smoothbores. "It may be," he wrote, "that the time for Dahlgrens had gone by, and of all smoothbores, *but it is not determined what shall replace them.*"[19]

Reluctantly, American naval officials once again followed the European lead in ordnance and on the eve of the Civil War, assented to the development of rifled guns. Perhaps the naval officials' lack of enthusiasm for rifles stemmed from the fact that they had just adopted new smoothbores. Dahlgren had requested permission in 1856 to develop heavy rifled ordnance but had been refused. Only after results of English experiments with a new rifle became known did the navy allow him to proceed, in 1859. Dahlgren developed several classes of muzzle-loading rifles. The barrels embodied the familiar soda-bottle shape of his smoothbores, but were cast without trunnions. These were added later, secured by a breech strap. Dahlgren never perfected his rifles and few saw service in the Civil War. Robert P. Parrott, chief founder of the Cold Spring Foundry, developed rifled guns for the navy as well. They ranged in size from a 10-pounder weighing 890 pounds to a 10-inch gun weighing 26,500 pounds. Each model was a cast-iron muzzleloader reinforced about the breech with a wrought-iron hoop. The sole purpose of the hoop was to help the breech withstand the strain of firing, the same rationale behind Dahlgren's soda-bottle design. Parrott made his first rifle in 1860, and Parrott rifles saw widespread service in the navy during the Civil War.[20]

One aspect of rifled guns that particularly intrigued ordnance experts was the uncertainty as to how they would fare against armored vessels. Such vessels had been under development in both America and Europe since the 1840s. The direct cause of European experiments with armor plating was the introduction of shell guns. Events of the Crimean War demonstrated the devastating effects of shell guns on wooden ships, and many Europeans believed that the era of the wooden ship had passed. Consequently, the French and the British launched their first armored warships respectively in 1859 and 1860. Meanwhile, British ordnance experts had been experimenting with armored targets and many came to believe that rifled guns would be more effective than smoothbores against armored ships. American naval officials and ordnance experts had little if any experimental data on which to base their opinions. Unlike the British, the Americans had developed no systematic program for testing ordnance against armor prior to the spring of 1862. American naval officials and ordnance

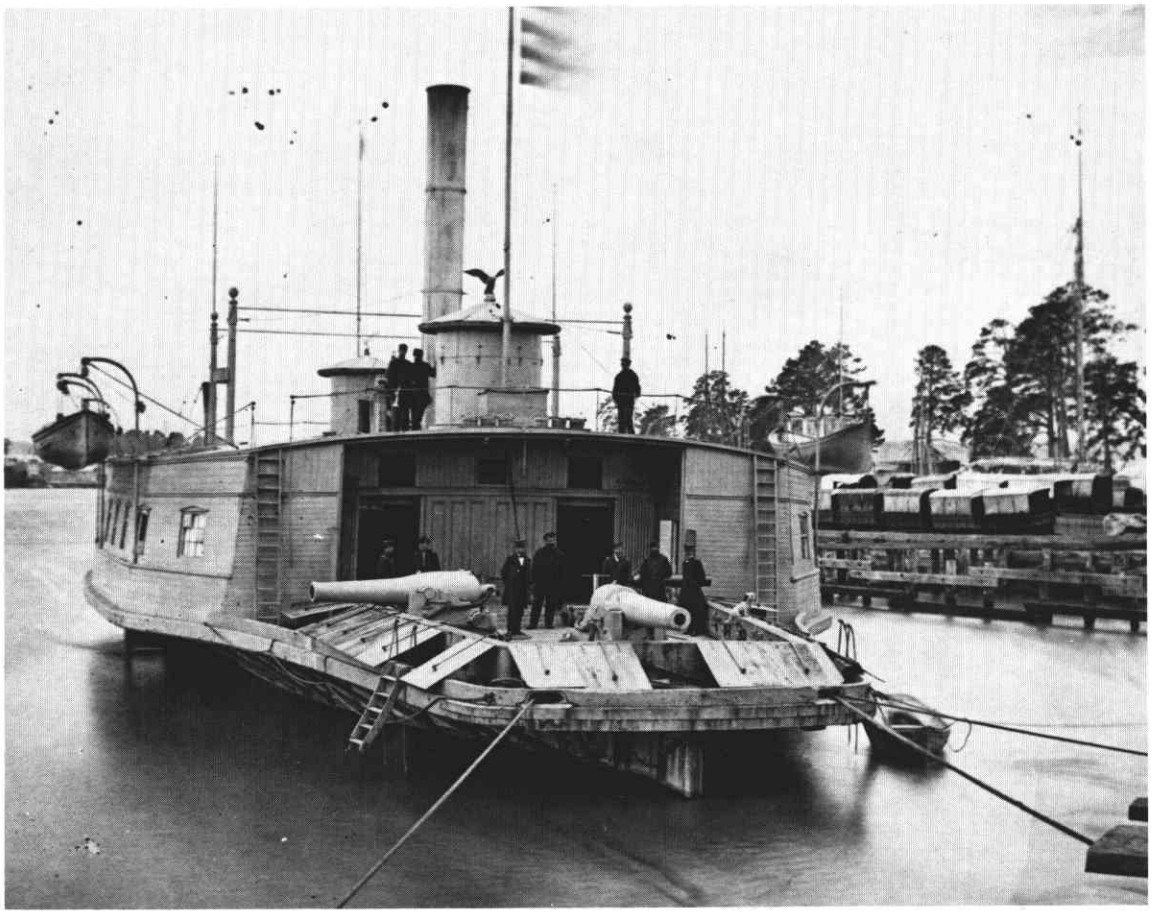


Practice battery at Annapolis, Maryland. The guns depicted, from front to rear, are a Dahlgren smoothbore, a 32-pounder, an English rifle (either a Blakeley or an Armstrong), two Parrott rifles, and a Dahlgren smoothbore. (The calibers are unknown). Note the covers on the sight masses and lock lugs of the Dahlgrens. The Dahlgren in the background does not appear to have a cascabel. The sights on the first Parrott are visible. National Archives photo.

experts did not agree whether rifles or smoothbores would be more effective against armored ships. On the eve of the Civil War, Dahlgren favored rifles. Early in the Civil War, shipbuilders and naval officials favored smoothbores. With the appearance of the Confederate ironclad *Virginia,* the question assumed a dreadful urgency.[21]

The battle of Hampton Roads vividly demonstrated the ascendency of armor over ordnance. On March 8, 1862, the *Virginia* began her historic voyage amid the cheers of Confederate soldiers. At about 1:00 P.M., an officer on board a Union ship spotted the *Virginia* through his spyglass. "That *Thing* is coming down!" he shouted. The Confederate ironclad proceeded to wreak havoc among the Union navy's wooden ships stationed in Hampton Roads. By 5:00 P.M., her ram and mixed battery of rifled ordnance and 9-inch Dahlgren guns had sunk one ship, set another on fire, and damaged a third. Despite concentrated defensive fire from the guns on board the Union vessels and the battery ashore at Fort Monroe, the *Virginia* emerged largely intact. Her guns had shattered the wooden walls of the Union ships and her armor proved impervious to the Union guns. On the following day, the Confederates too would learn of the inadequacy of ordnance against armor. The United States Navy's *Monitor* had arrived in Hampton Roads ready to meet the *Virginia* when she reappeared to finish off the wooden ships. For four hours the two ironclads fought, part of the time touching, and neither one inflicted serious damage on the other. Technically a draw, the Yankees hailed it as a victory as the *Virginia* retired without finishing off the remaining wooden ships. Nevertheless, the problem posed by the Confederate ironclad remained. The *Monitor's* two 11-inch Dahlgren smoothbores, the most powerful type of ordnance possessed by the Union navy, could not smash the *Virginia.* A solution was needed.[22]

Gustavus Vasa Fox, the Assistant Secretary of the Navy, took the problem of defeating armored vessels upon himself. Although experienced in naval and maritime affairs, Fox had had little experience with ordnance during his career and was certainly no expert. Upon receiving a message flashed over the wires about the appearance of the *Virginia,* he left Washington for Hampton Roads to see how the *Monitor* would fare against her. He witnessed the dual between the ironclads from a small tugboat and noticed that neither the Dahlgren guns on board the *Monitor* nor the rifled ordnance on board the *Virginia* seemed to have any effect on armor plating. He reasoned that a larger gun firing heavy shot might smash armored ships. Stepping ashore at Fort Monroe, he saw an experimental 15-inch army smoothbore which had been designed by Major Thomas Jackson Rodman. Then and there he decided that this caliber would be the answer to Confederate armor. Two days later he sent a telegram to Dahlgren stating that "we must have more of these boats [monitors] with fifteen inch guns." On March 17, 1862, the Secretary of the

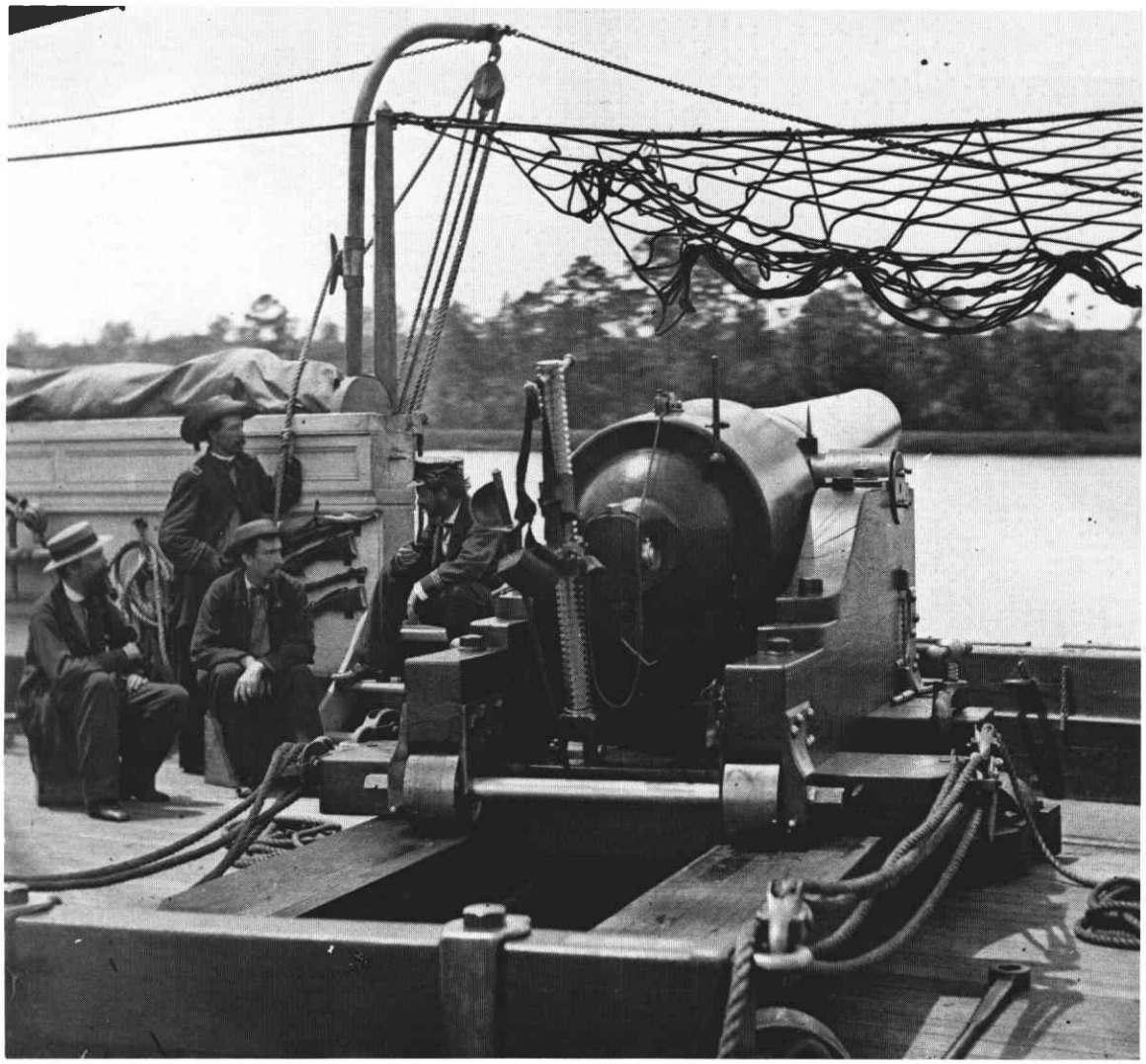


The *Commodore Perry,* a converted New York ferryboat with armor plates fitted around the guns. From left to right, the guns are a Dahlgren smoothbore, a Parrott rifle, and a Dahlgren boat gun (calibers unknown). National Archives photo.

Navy ordered the ordnance bureau to develop 15- and 20-inch naval guns, the former to be placed on board monitors as the solution to Confederate armored vessels. Dahlgren, who would design the huge guns, wrote in his journal that "15in were nothing; 20in at least . . . *Go it!* The national team has run off, and stand clear!" He may have been writing sarcastically.[23]

Dahlgren was dubious of Fox's solution for several reasons. He doubted that a 15-inch gun would be safe in combat. He did not believe that a cast-iron gun could long endure the strain induced by the charges necessary to fire heavy 15-inch projectiles. The gun that Fox had seen at Fort Monroe was Rodman's first 15-inch gun, then the only one in the United States. Its existence demonstrated that making a cast-iron 15-inch gun was technologically feasible, but Dahlgren remained skeptical of its endurance. Rodman had fired his 15-inch gun only 504 times, as compared to the 1,600 plus firings that Dahlgren's guns had withstood. Furthermore, Dahlgren distrusted Rodman's method for manufacturing guns. The army 15-inch gun had been cast hollow, a method that Rodman had perfected over the last dozen years. Rodman believed that hollow-cast guns were stronger than solid-cast guns, but Dahlgren insisted that Rodman's method produced unreliable ordnance. Nevertheless, Dahlgren began working on his own 15-inch gun for the monitor turrets in March, 1862. Dahlgren's design embodied the familiar shape of his 11-inch gun, not the shape of Rodman's 15-inch gun. Because Rodman's method had been used to produce the only extant 15-inch gun, Dahlgren decided to cast the navy version hollow despite his apprehension. Production began in June.[24]

The exigencies of war resulted in a number of teething problems with the first 15-inch navy guns. Production did not keep pace with demand. By the end of August, 1862, two new *Passaic* class monitors were ready for their ordnance. Each one was slated to receive two 15-inch guns, but a total of only three were on hand. John Ericsson, who designed and built many of the monitors for the navy during the Civil War, suggested placing one 11- and one 15-inch gun in each turret until more 15-inch guns became available. He felt confident that "with only one of the large guns in each vessel we shall be able to destroy all rebel craft, inspire a wholsome [sic] dread in rebeldom, and prove to foreign powers that we can punish any intentional meddling." Dahlgren agreed. In 1862, the threat of European intervention in the Civil War seemed as real to Union officials as the threat from

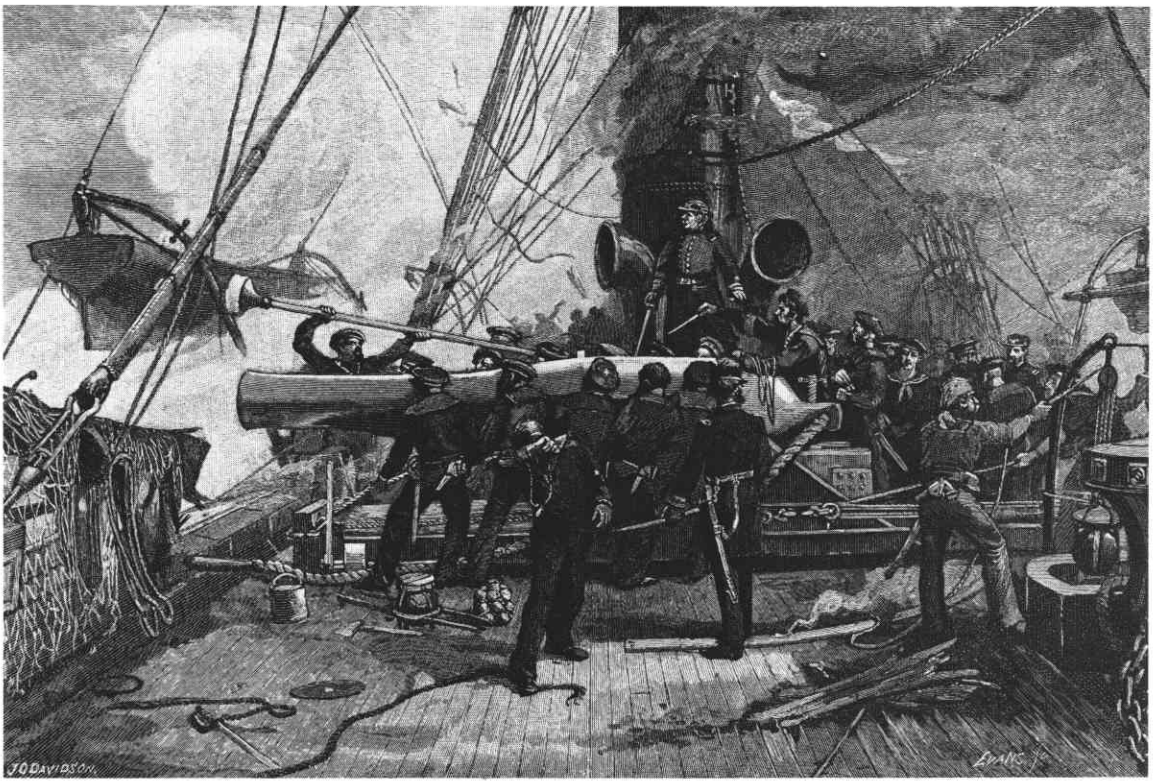


100-pounder Parrott rifle on pivot mount. Note the sights, the lock, the fact that the elevating screw is not threaded through the cascabel, and the small arms. The identity of the figures is unknown. National Archives photo. (This picture is an excellent comparison to the 9-inch Dahlgren.)

Confederate ironclads. Because of inadequate communication between Ericsson and the ordnance bureau, the 26.5-inch diameter muzzles of the first 15-inch guns did not fit through the gunports in the turrets of the *Passaic* class monitors. Consequently, Ericsson devised a smoke box to protect the gun crews from the concussion and smoke produced when the 15-inch guns were fired *inside* the turrets. Problems soon arose with this arrangement and Ericsson took steps to correct them. The fleet desperately needed the new monitors and despite these and other teething troubles, 15-inch guns were rushed into service.[25]

Meanwhile, Dahlgren had been firing different types of guns at armored targets. He began these experiments soon after the *Virginia* appeared, in order to determine which type of gun would be best at defeating armored vessels and to compare the endurance of various classes of ordnance. He tested as many different guns as he could get his hands on. Among these were his own 11- and 15-inch guns and several classes of Parrott's rifles. Whenever European or Confederate guns captured from enemy vessels were available, he tested them as well. The results led him to several conclusions. Changing his prewar opinion, he now believed that solid shot as well as projectiles fired from rifled ordnance were effective against ironclads. He found that the 11-inch gun could withstand firing solid shot with twenty pounds of powder. He believed that had the *Monitor's* guns fired such rounds, they would have destroyed the *Virginia*. These tests also reinforced his doubts about 15-inch guns.[26]

Dahlgren concluded that they were dangerous. As of early 1863, no 15-inch gun had been fired more than 260 times. Dahlgren estimated that the service life of 15-inch guns would be only three hundred rounds. His 9- and 11-inch guns had a life expectancy in service of one thousand rounds. Naval officials realized that the damage inflicted by a gun exploding inside a monitor turret could be far worse than the actual number of casualties. The



The forward 11-inch Dahlgren pivot gun in action on board the *Kearsarge*. Library of Congress.

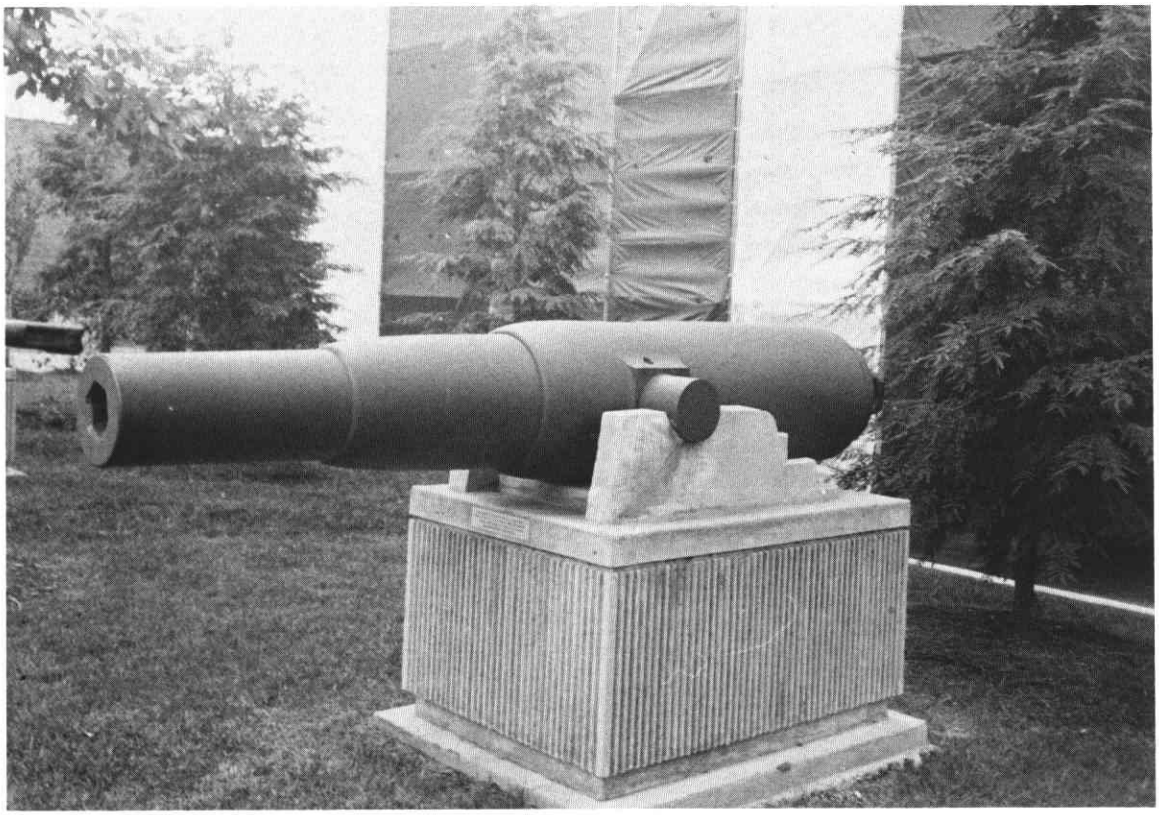
morale of the whole fleet might be effected. On January 5, 1863, Dahlgren issued to naval officers a remarkable document concerning 15-inch guns. He stated that the model remained unproven and that he had no idea how many rounds could be fired safely. He warned that if a 15-inch gun were to explode inside a monitor turret, the ship might sink. He then listed a set of special instructions restricting the use of 15-inch guns. Limited endurance was perhaps the greatest of the problems with 15-inch guns.[27]

Dahlgren would never solve them all. In July, 1862, he was promoted to Captain and became chief of the Ordnance Bureau. However, he was no longer satisfied with merely working ashore. He preferred serving his country afloat, leading men and ships into battle. Toward the end of 1862, the navy prepared for its strike against Charleston, the birthplace of the rebellion. Dahlgren's ambition was to lead the attack. Admiral Samuel Francis DuPont, chosen instead, commented that Dahlgren was "a diseased man on the subject of preferment and position." President Lincoln, who had developed a close friendship with Dahlgren, would later satisfy his ambition. Lincoln pressured Secretary of the Navy Gideon Welles to promote Dahlgren to Rear Admiral in February 1863. The following April, DuPont's attack on Charleston failed. Officials pressed DuPont to renew the attack, but he refused. As a result, DuPont lost his command of the South Atlantic Blockading Squadron. Welles chose Admiral Andrew Hull Foote to replace DuPont, but Foote was too ill to take command. Under pressure from Lincoln, Welles gave the job to Dahlgren. In June, 1863, Dahlgren left the Ordnance Bureau to renew the attack on Charleston. Henry Augustus Wise assumed Dahlgren's duties in the Bureau. Dahlgren remained nominally in charge of ordnance until August, 1864, when Wise officially became Bureau chief.[28]

Wise instituted several changes in ordnance while Dahlgren was at sea. He reduced the diameter of the muzzles of some of the 15-inch guns which were too large to fit through the *Passaic* class monitor gunports. He later redesigned the 15-inch guns, lengthening their barrels. Several months after officially becoming Chief of Ordnance, he proposed casting Dahlgren's 9- and 11-inch guns by Rodman's method. Despite strong objections from Dahlgren, the 9- and 11-inch guns produced late in the Civil War and thereafter were apparently cast hollow. Meanwhile, a myriad of guns were under development in America and Europe.[29]

In addition to the wide variety of naval guns which actually saw service in the Civil War, the period witnessed the emergence of a plethora of ordnance types. Ordnance experts in America and Europe developed smoothbores, rifled guns, hooped guns, breechloaders, and muzzle-loaders. They used cast iron, wrought iron, steel, bronze, and combinations of two or more different metals in their guns. Cast-iron, muzzle-loading smoothbores such as Dahlgren's represented normal technology. Steel guns, breechloaders, and rifled guns may be considered in this era as infant revolutionary technology.

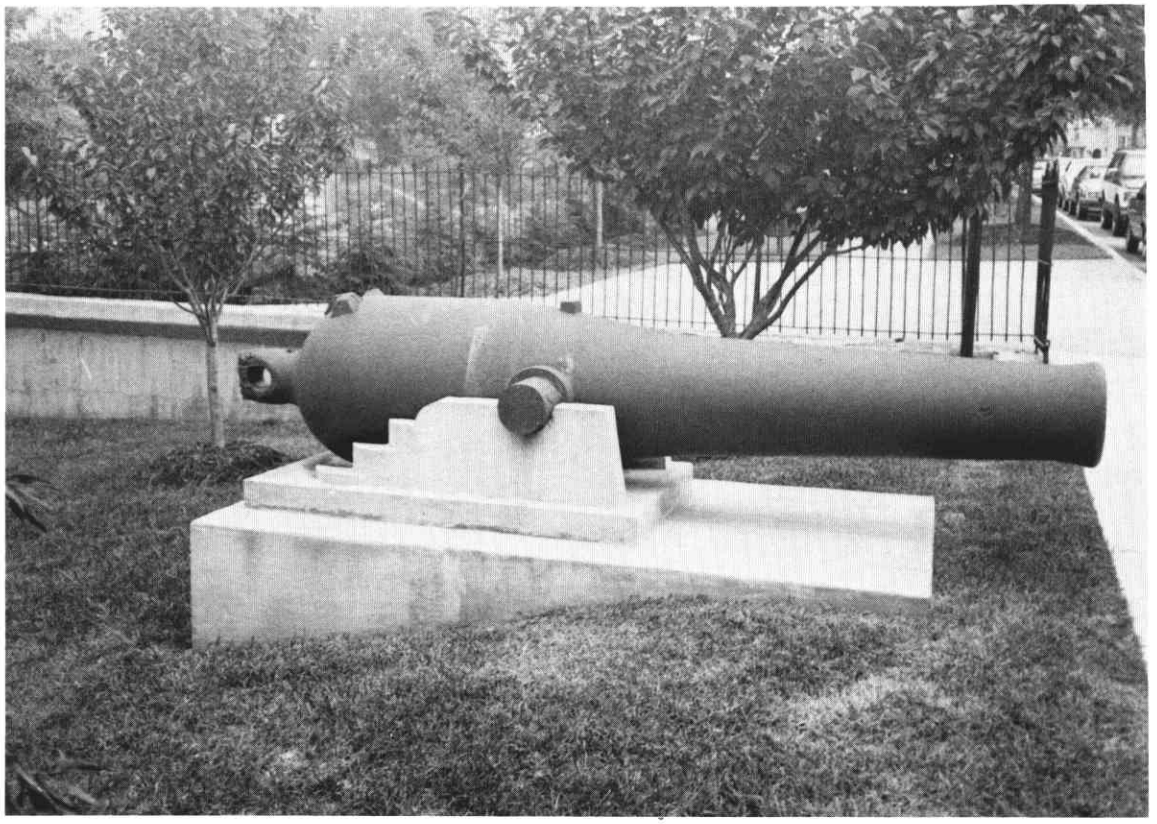
Soda-bottle shaped guns abounded. The Union of



5-inch Whitworth muzzle-loading rifle, captured on board the blockade runner *Princess Royal.* Note the hexagonal bore. Photo taken at the Washington Navy Yard.

course used Dahlgren guns. The Confederates continued to cast soda-bottle shaped guns (so called "Confederate Dahlgrens") during the war and also used what they could capture. Dahlgren's 9-, 10-, and 11-inch guns developed in the 1850s and the 15-inch gun saw extensive service in the Civil War, while his rifles saw limited service. Dahlgren developed other soda-bottle shaped, cast-iron, muzzle-loading smoothbores including a solid-shot-firing 10-inch gun of 16,000 pounds, a 13-inch gun of 34,000 pounds, and a 20-inch monster of 100,000 pounds (see Table I). Each of these was intended for service against ironclads, but none of them saw action. Several other cast-iron, muzzle-loading smoothbores bearing the characteristic soda-bottle form also appeared, but the records are unclear as to whether Dahlgren himself or Wise developed them. These included a 32-pounder of 4,500 pounds, an 8-inch gun of 6,500 pounds, an 8-inch solid-shot-firing gun of 10,100 pounds, and a 9-inch solid-shot-firing gun of 12,000 pounds. It is possible that Dahlgren himself developed none of them. In the first place, he designed his guns to supplant 32-pounders and 8-inch guns. Both of the solid-shot-firing guns were cast hollow, a practice he abhorred. The navy ordered each of the four from foundries after Dahlgren left the ordnance bureau to take command of the South Atlantic Blockading Squadron. Only the 32-pounder and the 8-inch gun of 6,500 pounds saw service.[30]

Like the Dahlgren guns, many other types of ordnance from this period bore the names of their inventors. Parrott's hooped rifles saw extensive service in the war. Several classes of English-made ordnance, such as Armstrong, Blakeley, and Whitworth guns, served on board Confederate vessels and when captured by the Union navy served at the experimental battery in Washington. Armstrong, Blakeley, and Whitworth guns came in a variety of sizes and materials, featured both breech- and muzzle-loading models, were usually rifled, and generally had one or more reinforcing bands around the breech. The Whitworth guns were unique: they were rifled by means of a slightly twisting hexagonal bore and fired hexagonal "bolts." The Confederates also produced their own designs, the best known being the Brooke double-banded, cast-iron, muzzle-loading rifle. Krupp, a German firm, manufactured several types of solid steel guns, the most interesting being a breech-loading, banded rifle. Although no Krupp guns saw service in the war, they were certainly ahead of their time. The name Krupp would later take on a sinister and deadly meaning. Apart from the aforementioned guns, a number of other more obscure types of ordnance were produced during this era.[31]



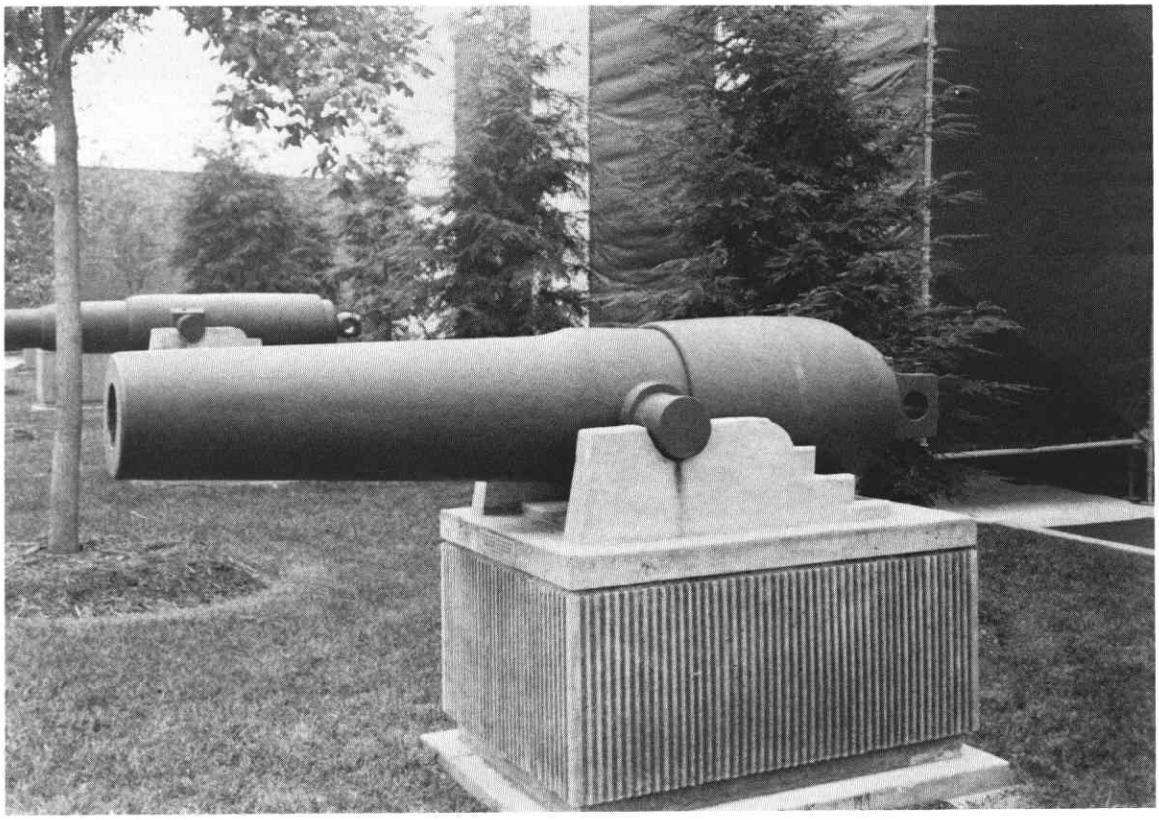
9-inch Dahlgren smoothbore. Photo taken at the Washington Navy Yard.

How did the Dahlgren smoothbores stack up against the newer types of ordnance? This question may be answered by considering the combat performances of ordnance used in the Civil War, the results of experiments made with different types of ordnance, and the opinions of ordnance experts contemporary to the Civil War era. Although a brief glance at these sources may not provide a definitive answer, it certainly provides a clue.

Dahlgren's 9- and 11-inch guns earned a favorable reputation in the Civil War. They certainly were reliable. According to one source, 1,185 9-inch and 465 11-inch guns served in the war; not one burst in action. As previously mentioned, these guns had a service life of one thousand rounds, a remarkable figure in that period. The *Ironsides*, one of the first three Union ironclads built, was armed with 11-inch guns in broadside. In a two month period in 1863, her battery fired 4,439 rounds without mishap. After his attack on Charleston in August, 1863, Dahlgren reported that the "rapid and sustained fire of the 11-inch cannon of the *Ironsides* was more dreaded by the rebels than the 15-inch guns of the monitors."

Alexander Lyman Holley, an American ordnance expert contemporary with the period, believed that against non-armored targets Dahlgren's 9- and 11-inch guns were "comparatively perfect." The classic example of the value of Dahlgren's guns was the duel between the *Alabama* and the *Kearsarge.* American naval officers attributed the victory of the *Kearsarge* in part to the superiority of her 11-inch Dahlgren guns over the English-built guns of the *Alabama*. Admiral David D. Porter, who served in the war and later wrote a naval history, referred to Dahlgren's 9- and 11-inch guns as "the best of (their) kind in the world." [32]

The 15-inch guns did not fare as well. Both versions were less reliable than the 9- and 11-inch guns. Only one 15-inch gun ever fired more than eight hundred rounds. This was the first 15-inch gun ever produced and it burst on the 868th round in extreme proof, not at all a remarkable performance when compared with the one thousand round service life of the 9- and 11-inchers. Of the one hundred 15-inch guns produced, fifty-five were never fired in service, two burst, and ten were deemed unfit for service after firing fewer than eight hundred rounds. Three 15-inch guns were condemned after firing fewer than one hundred rounds. Against Confederate ironclads, the service for which they were designed, the 15-inch performed ambivalently. In June, 1863, the monitor *Weehawken,* armed with one 11- and one 15-inch gun, forced the grounded Confederate ironclad *Atlanta* to surrender largely intact after firing six 11- and eight 15-inch shells. During the battle of Mobile Bay in August, 1864, three monitors armed with 15-inch guns engaged the Confederate ironclad *Tennessee* for about an hour. Only one of several 15-inch projectiles fired during the engagement inflicted critical damage. The *Tennessee* also surrendered largely intact. Against the forts around

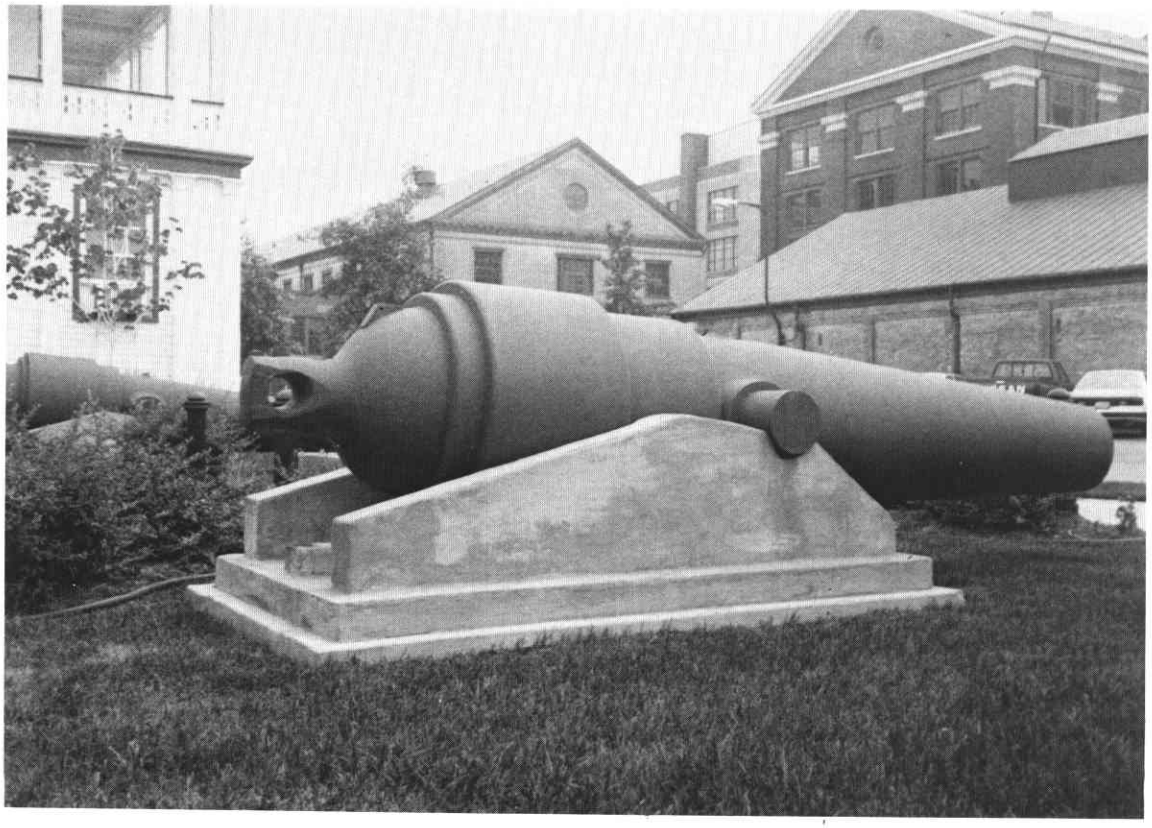


7-inch Blakeley 100-pounder muzzle-loading rifle captured on board the Confederate cruiser *Florida*. Photo taken at the Washington Navy Yard.

Charleston, the 15-inch guns performed abysmally. DuPont was "entirely disappointed" in them, finding their range, muzzle velocity, and rate of fire to be too low. As mentioned earlier, Dahlgren, too, found their rate of fire to be too low. The poor performances of the 15-inch guns contributed to Dahlgren's failure to take Charleston. The Confederates held the city until February, 1865, when they abandoned it as an incident of General William T. Sherman's final campaign. Compared to the 11-inch gun, one can argue that the 15-inch gun was a retrograde development.[33]

Civil War era ordnance experts advanced a variety of opinions about the guns referred to here as infant revolutionary technology. Holley believed that breech-loading mechanisms were too weak to be effective in heavy ordnance. Furthermore, he maintained that breechloaders did not give a substantially higher rate of fire than muzzleloaders. Henry Wise believed that no efficient breechloaders existed anywhere. The Chairman of the United States Senate Committee on the Conduct of the War, B.F. Wade, asserted that "no heavy rifled cannon has been made which meets, even in a moderate degree, the requirements for arming ships-of-war." Charles Knap, chief founder of the Fort Pitt Foundry in Pittsburgh at the end of the war, did not think that English guns were any better than American guns in terms of strength, durability, and efficiency. Speaking before the English House of Commons, the Marquis of Hartington expressed the opinion of English officers serving in the Confederate army that "England is behind America in the weight and power of the guns sent by both nations to sea." Lord Paget, a British admiral, thought that British guns could outrange American guns, but was not sure which nation possessed the better overall ordnance. Assistant Secretary of the Navy Fox believed that Parrott guns were risky to use because many had exploded in service. Wise considered Parrott guns to be "excellent . . . the best, beyond all question, that have yet been brought into service in this or any other nation." Holley noted that the hoops of the Armstrong guns rattled loose from the vibrations caused by large charges. Hartington testified that most of the Armstrong guns were "dead failures." Knap said of the Whitworth gun that "as a toy it is the most wonderful gun in the world, but it not fit for actual service, for it requires such accuracy and delicacy of construction." Admiral Porter reflected several years after the war that "rifled cannon had not at that time made such an advance as to satisfy us that it would be the gun of the future."[34]

Several years after the Civil War, the United States Navy began searching for more efficient and effective ordnance: this search centered on rifles. In 1871,



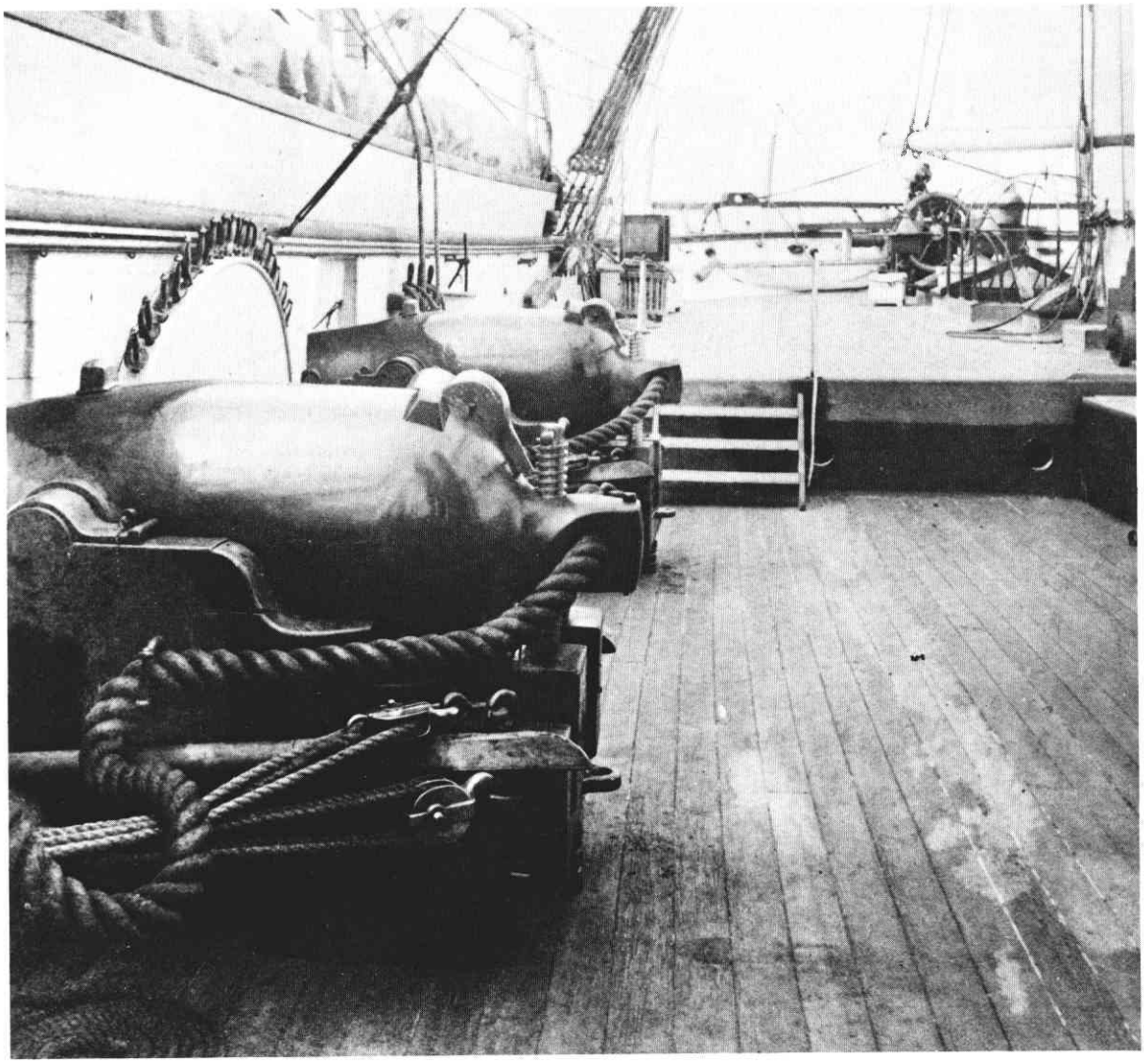
6.4-inch Confederate Brooke muzzle-loading rifle captured on board the Confederate ironclad *Tennessee*. Photo taken at the Washington Navy Yard.

Congress appropriated 200,000 dollars for an experimental rifle of large caliber. Four years later, the ordnance bureau issued a contract to a private firm to convert ten 11-inch Dahlgren guns into 8-inch rifles by inserting wrought-iron tubes, then machining in the lands and grooves. The cost was 2,700 dollars per gun. Neither these nor any of the other measures taken in the immediate postwar years resulted in ordnance comparable to the current generation of European rifles. Largely due to inadequate funding, the navy was unable to develop advanced ordnance technology. When Congress authorized new, modern, vessels in the 1880s, the navy purchased several of its first breech-loading steel rifles in Great Britain. Throughout that decade the United States Navy retained wooden vessels armed with Dahlgren guns, the remnants of a bygone era.[35]

In one respect, the history of the Dahlgren guns may be regarded as a lone inventor's battle against a large bureaucracy. The United States Navy followed the lead of France and England when it first adopted shell guns and standardized its ordnance in the 1840s. Morris, a member of the naval establishment, had been among those who had introduced this system. The initiative to improve naval ordnance in the 1850s came from below, from Dahlgren himself. When he first began working at the Washington Navy Yard in the late 1840s, Dahlgren found the current naval ordnance to be inefficient and unsafe and so embarked on the development of new ordnance. The design of his guns was not revolutionary, but a synthesis of existing ideas. Hence, the Dahlgren guns represented an improvement in the normal technology.

Nevertheless, many naval officers and officials considered them to be a radical departure from conventional ordnance design. Initially, they believed that Dahlgren's guns would be too weak to withstand firing and so resisted their development. Later, Morris accepted Dahlgren's 9-inch gun but objected to his broader plans for rearming ships. Because of the resistance from Morris and others, Dahlgren tapped alternate sources to institute technological change. Specifically, he turned to congressmen, other naval officers and officials, and the Secretary of the Navy. On several occasions, he went over the opposition's heads. In nearly every case, years elapsed between Dahlgren's introduction of an innovation and the navy's adoption of it. Although Dahlgren had begun his work in 1849, the navy did not fully adopt his system until 1857. By then, many ordnance experts considered the Dahlgren guns to be the finest naval cannon in the world.

As Dahlgren fought for improving the the normal technology, Europeans introduced revolutionary technology. In Europe, the need for rifled guns and armored vessels had become apparent during the Crimean War. During the 1850s, the English and French had experimented with armored targets and rifled guns. By the end



9-inch Dahlgren guns mounted in broadside on Marsilly carriages on the spar deck of the *Pawnee*. Note the covers on the sight masses and lock lugs, the breeching tackle, and the cutlasses arrayed between the guns. Library of Congress photo.

of the decade, both powers had launched armored warships and the English had produced several serviceable rifled guns. Meanwhile, the United States Navy had stifled Dahlgren's first request to develop a rifle. Only after the results of English experiments with a certain rifled gun became known did the navy proceed with its own rifled ordnance. Only after the *Virginia* appeared did the navy begin systematic experiments with ordnance and armored targets. Even before these latter experiments had begun, the navy decided that the 15-inch gun would be the answer to armored ships, despite Dahlgren's protests.

The Civil War was a proving ground for both normal and revolutionary technology. The Dahlgren guns represented the apex of normal technology and were probably the best naval smoothbores ever invented. Following a long period of development in the 1850s, Dahlgren's 9-inch and 11-inch guns performed admirably during the war. Contemporary ordnance experts, naval officers, and naval officials praised them. By comparison, the navy rushed the 15-inch gun into service and its performance did not meet the standards set by the 11-inch gun. Nevertheless 15-inch guns served their purpose, if somewhat below expectations. Rifled guns, the revolutionary ordnance technology, were in their infancy. Contemporary opinion on the value of rifled ordnance varied. Dahlgren's smoothbores seemed to perform as well or better than rifles in many combat situations. Rifled ordnance apparently did not demonstrate any significant qualitative superiority over smoothbores at this early stage. Although the naval bureaucracy hindered his efforts, Dahlgren nevertheless managed to develop guns which held their own in the Civil War with the next generation of naval ordnance.

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NOTES

Key:

Dahl Gen Corres, LC = John Dahlgren Papers, General Correspondence, Manuscript Division, Library of Congress, Washington, D.C.

Dahl Nav Ord, LC = John Dahlgren Papers, Naval Ordnance Collection. Manuscript Division, Library of Congress, Washington, D.C.

RG 45, NA = Naval Records Collection of the Office of Naval Records and Library, Record Group 45, National Archives, Washington, D.C.

RG 74, NA = Records of the Bureau of Ordnance, Record Group 74, National Archives, Washington, D.C.

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[1]Madeleine V. Dahlgren, *Memoir of John A. Dahlgren* (Boston: James R. Osgood and Company, 1882), pp. 134-135, hereafter cited as Dahlgren, *Memoir.*

[2]C. Stewart Peterson, *Admiral John A. Dahlgren, Father of U.S. Naval Ordnance* (Cynthiana KY: Hobson Book Press, 1945); U.S., Congress, Senate *Report to the Joint Committee on the Conduct of the War: Heavy Ordnance,* S. Rept. 121, 38th Cong., 2nd Sess., Serial 1211, 1865, pp. 74-75, 170, hereafter cited as *Report to the Joint Committee;* David D. Porter, *Naval History of the Civil War* (Secaucus, NJ: Castle Books, 1984), p. 361, hereafter cited as Porter, *History.*

[3]For an in-depth look at the nineteenth-century naval revolution, see James P. Baxter III, *The Introduction of the Ironclad Warship* (Cambridge: Harvard University Press, 1933), hereafter cited as Baxter, *Ironclad.*

[4]Untitled chronology of Dahlgren's career, 1862, Box 27, Dahl Nav Ord, LC; Dahlgren, *Memoir,* pp. 150-151; Dahlgren to Warrington, "Report to Bureau of Ordnance of Practice made with the experimental Nine-Inch Shell Gun 1850," January 30, 1851, Box 21, Dahl Nav Ord, LC, hereafter cited as Dahlgren, "Nine-Inch Shell Gun 1850;" Paolo Enrico Coletta, ed., *American Secretaries of the Navy,* 2 vols. (Annapolis: Naval Institute Press, 1980), vol. 1, p. 262, hereafter cited as Coletta, *Secretaries.* The round shot of the 32-pounders were neither aerodynamically shaped nor spun by rifling in the gun barrel. When a round shot fired from a smoothbore approached the speed of sound, as was the case with the heavier 32-pounders with their bigger charges and higher initial velocities, the atmospheric resistance to it increased. This caused the shot to wobble from its trajectory and thus lose accuracy. Although Dahlgren was unaware of the concept of the speed of sound, this was approximately the maximum velocity he referred to.

[5]Dahlgren quoted from Dahlgren, "Notice of XI in Shell gun No. 1, cast by Alger from the design by Lieut. J.A. Dahlgren 1852," Box 22, Dahl Nav Ord, LC. hereafter cited as Dahlgren, "Notice;" John Dahlgren, *Shells and Shell Guns* (Philadelphia: King and Baird, 1856), p. 14, hereafter cited as Dahlgren, *Shell Guns;* Dahlgren, "Penetration," 1851. Box 21, Dahl Nav Ord, LC; Dahlgren, *Memoir,* pp. 147, 314.

[6]Crane to Henshaw, November 17, 1843, p. 29, Vol. 1, Entry 1, RG74, NA; Crane to Bancroft, March 17, 1845, p. 68, Vol. 1, Entry 1, RG 74, NA; Dahlgren, "Nine-Inch Shell Gun 1850;" Dahlgren "Notice;" Dahlgren, *Memoir,* pp. 147-153; Dahlgren to Warrington, March 19, 1851, Box 2 Dahl Gen Corres, LC.

[7]Crane to Bancroft, March 17, 1845, p. 68, Vol. 1, Entry 1, RG74, NA; Richard A. Von Doenhoff, ed., *Versatile Guardian: Research in Naval History* (Washington, D.C.: Howard University Press, 1979), p. 165; Thomas S. Hamersly, *Complete Army and Navy Register of the United States of America from 1776 to 1887* (New York: T.H.S. Hamersly, 1888), navy section, pp. 4, 510, hereafter cited as Hamersly, *Register;* Coletta, *Secretaries,* Vol. 1, pp. 207, 263, 289-290; Dahlgren, "Notice;" Quote from Sinclair to Dahlgren, January 23, 1856, Box 3 Dahl Gen Corres, LC.

[8]Dahlgren, "Nine-Inch Shell Gun 1850;" Dahlgren, "Notice;" Dahlgren, *Memoir,* pp. 147-153; Edward Simpson, *A Treatise on Ordnance and Naval Gunnery, Compiled and Arranged as a Textbook for the U.S. Naval Academy* (New York: D. Van Nostrand, 1861), p. 137, hereafter cited as Simpson, *Ordnance.*

[9]Robert J. Schneller, Jr., "The Development of Dahlgren's Heavy Cast-Iron Smoothbores and their Adoption by the Navy," (Unpublished M.A. Thesis, East Carolina University, 1986), pp. 6-7, 16, hereafter cited as Schneller, "Smoothbores;" Dahlgren, *Shell Guns,* p. 233; For a discussion of normal technology and technological change, see Edward W. Constant, *The Origins of the Turbojet Revolution* (Baltimore: The Johns Hopkins University Press, 1980). Although Constant does not address the topic of Civil War naval ordnance, he does propose a useful model for technological change which may be applicable to aspects of other studies.

[10]Dahlgren, *Memoir,* p. 152; "Speech of Hon. F.P. Stanton of Tennessee on Improvements in the Navy," August, 1852, Box 2, Dahl Gen Corres, LC; *Annual Report of the Secretary of the Navy 1852,* S. Ex. Doc. 1, 32nd Cong., 2nd Sess., Serial 659, Vol. 2; Coletta, *Secretaries,* Vol. 1, p. 289; Dahlgren, *Shell Guns,* p. 24; Morris, "Remarks upon Lieut Dahlgren's propositions for substituting heavier guns for the present armament of ships of war," May 30, 1853, pp. 309-315, Vol. 1, Entry 1, RG74, NA, hereafter cited as Morris, "Remarks May 1853;" Morris, "Remarks upon Lieut Dahlgren's propositions for substituting heavier guns for the present armament of our ships of war, transmitted by him Dec. 9, 1853," December 19, 1853, pp. 315-319, Vol. 1, Entry 1, RG74, NA, hereafter cited as Morris, "Remarks December 1853;" Morris et. al. to Dobbin, August 31, 1853, p. 299, Vol. 1, Entry 1, RG74, NA.

[11]Morris to Kennedy, February 17, 1853, p. 275, Vol. 1, Entry 1, RG74, NA; Morris to Shubrick, February 24, 1853, pp. 276-277, Vol. 1, Entry 1, RG74, NA; Morris quoted from Morris, "Remarks May 1853;" Morris, "Remarks December 1853."

[12]Dahlgren to Morris, "Reorganization of the U.S. Naval Ordnance (XI inch gun) by Lieut. J.A. Dahlgren," May 31, 1853, pp. 11-20, Entry 201, RG45, NA; Dahlgren, *Memoir,* p. 161; Dahlgren to Morris, May 3, 1853, Box 22, Dahl Nav Ord, LC; Dahlgren to Parrott, May 30, 1853, Box 2, Dahl Gen Corres, LC.

[13]*Annual Report of the Secretary of the Navy 1853,* S. Ex. Doc. 1, 33rd Cong., 1st Sess., Serial 692, Vol. 3, p. 302; Frank M. Bennett, *The Steam Navy of the United States* (Pittsburgh: Warren and Company, 1896), pp. 145-151, hereafter cited as Bennett, *Steam Navy;* Dahlgren to Morris, July 20, 1854, p. 63, Vol. 15, Entry 19, RG74, NA; Dahlgren to Morris, October 19, 1854, p. 95, Vol. 15, Entry 19, RG74, NA; John Dahlgren Dairies, October 30, 1854, J.A.B. Dahlgren Papers, Syracuse University Library, Syracuse, New York, hereafter cited as Dahlgren Papers, Syracuse; Dahlgren, *Memoir,* p. 169.

[14]Schneller, "Smoothbores," pp. 48-75.

[15]*Ibid.*

[16]*Ibid.*

[17]Parrott quoted from Dahlgren, "Report to Bureau of Ordnance on thirty-one IX-inch Guns Cast at Alger's Foundry 1857," March 9, 1858, Box 24, Dahl Nav Ord, LC; "Casting Heavy Guns," *Scientific American* 30 October 1858, p. 60.

[18]Morris and Lenthall to Dobbin, June 27, 1855, p. 383, Vol. 1, Entry 1, RG74, NA; *Annual Report of the Secretary of the Navy 1857,* S. Ex. Doc. 1, 35th Cong., 1st Sess., Serial 812, Vol. 3.

[19]Dahlgren quoted from Dahlgren, *Memoir,* pp. 227-229.

[20]*Report to the Joint Committee,* pp. 123, 138-147; Eugene B. Canfield, *Civil War Naval Ordnance* (Washington: Government Printing Office, 1969), p. 8, hereafter cited as Canfield, *Ordnance;* Dahlgren, Memoir, pp. 269-279; Alexander Lyman Holley, *A Treatise on Ordnance and Armor* (New York: D. Van Nostrand, 1865), pp. 50-56, hereafter cited as Holley, *Ordnance.*

[21]Baxter, *Ironclad,* pp. 32, 48ff; Björn Landström, *The Ship: An Illustrated History* (New York: Doubleday and Company, 1961), pp. 236-237; U.S., Congress, House, *A Report of the Superintendent of Ordnance at the Washington Navy Yard on Rifled Cannon and the Armament of Ships of War,* H. Ex. Doc. 25, 36th Cong., 2nd Sess., Serial 1097, 1860, pp. 1-5; U.S., Congress, House, *Letter of the Secretary of the Navy in Relation to the Operations of Armored Vessels Employed in the Service of the United States,* H. Ex. Doc. 69, 38th Cong., 1st Sess., Serial 1193, 1864, p. 4, hereafter cited as *Report on Armored Vessels,* Simpson, *Ordnance,* p. 441.

[22]Quote from Richard M. Ketchum, ed., *The American Heritage Picture History of the Civil War* (New York: American Heritage Publishing Co., 1960), p. 177.

[23]John D. Hayes, "Captain Fox – *He* Is the Navy Department," 91 *United States Naval Institute Proceedings* (September 1965), pp. 64-71; Porter, *History,* p. 362; Canfield, *Ordnance,* pp. 8-10; Thomas J. Rodman, *Reports of Experiments on Properties of Metals for Cannon, and Qualities of Cannon Powder, with Account of Fabrication and trial of 15-Inch Gun* (Boston: Charles H. Crosby, 1861), pp. 191-225, hereafter cited as Rodman, *Experiments;* Howard K. Beale, ed., *Diary of Gideon Welles,* 3 Vols. (New York: V.W. Norton and Co., 1960), Vol. 1, p. 64, hereafter cited as Welles, *Diary;* Fox quote from Fox to Dahlgren, March 11, 1862, Box 5, Dahl Gen Corres, LC; Welles to Harwood, March 17, 1862, p. 69, No. 0368, Roll 2, Microcopy 480, Entry 13, RG45, NA; Dahlgren quote from Dahlgren, *Memoir,* p. 361. Canfield and Porter disagree as to whether Fox witnessed the duel between the ironclads from a small tugboat or from ashore.

[24]*Report to the Joint Committee,* pp. 127-133; Dahlgren to Harwood, March 19, 1862, Box 5, Dahl Gen Corres, LC; Dahlgren "Memoranda Connected with the Draft of XVin Gun," April 7, 1862, Box 27, Dahl Nav Ord, LC; Berrien to Harwood, June 7, 1862, p. 78, Fort Pitt Vol. 3, Entry 21, RG74, NA; Rodman, *Experiments.*

[25]Ericsson quote from Ericsson to Dahlgren, August 29, 1862, p. 46, Vol. 1, Entry 51, RG74, NA; Dahlgren to Ericsson, August 31, 1862, p. 261, Vol 22, Entry 6, RG74, NA; Canfield, *Ordnance,* p. 10; Robert Mears Thompson and Richard Wainwright, eds., *Confidential Correspondence of Gustavus V. Fox: Assistant Secretary of the Navy, 1861-1865,* 2 Vols. (New York: Naval History Society, 1919), Vol 2, pp. 439-441, hereafter cited as Fox, *Correspondence;* Ericsson to Gregory, July 12, 1862, p. 7, Vol. 1, Entry 51, RG74, NA. The last source cited above is the best example of the lack of communication between Ericsson and the ordnance bureau. Apparently, Ericsson did not have adequate plans of the 15-inch gun at his disposal from which to design carriages, even at this late date. Sources do not agree on whether the monitors contracted for before the appearance of the *Virginia* were to receive 11- or 13-inch guns.

[26]Harwood to Dahlgren, March 20, 1862, p. 231, Vol. 14, Entry 6, RG74, NA; "Reports Concerning Target Practice on Iron Plates, 1862-1864," 2 Vols., Entry 98, RG74, NA; Fox, *Correspondence,* Vol. 2, pp. 312-314; *Annual Report of the Secretary of the Navy, 1862,* H. Ex. Doc. 1, 37th Cong., 3rd Sess., 1862-1863, Serial 1158, pp. 715, 717, 719.

[27]*Report to the Joint Committee,* pp. 129-130; *Annual Report of the Secretary of the Navy, 1863,* H. Ex. Doc. 1, 38th Cong., 1st Sess., 1863-1864, Serial 1183, p. 845, hereafter cited as *Annual Report 1863;* U.S. Bureau of Ordnance, Navy Department, *Ordnance Instructions for the United States Navy,* Third Edition (Washington: Government Printing Office, 1864), Part 3, p. 20, hereafter cited as *Ordnance Instructions 1864;* Harwood to Welles, May 13, 1862, p. 290, Vol. 17, Entry 6, RG74, NA; Fox, *Correspondence,* Vol. 1, pp. 190-191, 194-195.

[28]DuPont quoted from Fox, *Correspondence,* Vol. 1, pp. 160-161; For Lincoln and Dahlgren's friendship, see Robert V. Bruce, *Lincoln and the Tools of War* (Indianapolis: Bobbs-Merrill, 1956); Roy P. Basler, ed., *The Collected Works of Abraham Lincoln,* 8 Vols. (New Brunswick, NJ: 1953), Vol. 6, pp. 111-112; Welles, Diary, Vol. 1, pp. 239, 310-318, 341; Hamersly, *Register,* Navy Section, p. 4; Allen Johnson, ed., *Dictionary of American Biography,* 20 Vols. (New York: Charles Scribner's Sons, 1959), Vol. 20, p. 425.

[29]Canfield, *Ordnance,* p. 10; *Report to the Joint Committee,* p. 30; Dahlgren, "Objections to Casting IX and XIin Guns Hollow," November 20, 1864, Box 27, Dahl Nav Ord, LC.

[30]Warren Ripley, *Artillery and Ammunition of the Civil War* (Van Nostrand Reinhold Co., 1970), pp. 87-107, hereafter cited as Ripley, *Artillery;* Harwood to Knap, Rudd, and Co., June 13, 1862, p. 141, Vol. 19, Entry 6, RG74, NA; Harwood to Ericsson, May 15, 1862, p. 20 Vol. 18, Entry 6, RG74, NA; Jara to Wise, April 27, 1865, p. 3, Fort Pitt Vol. 19, Entry 21, RG74, NA; "XV an XIII in Guns," September 15, 1868, (1863 folder), Box 27, Dahl Nav Ord, LC; Aulick to Berrien, May 7, 1864, p. 421, Fort Pitt Vol. 1, Entry 4, RG74, NA; Contract between Builders Iron Foundry, Providence, Rhode Island and the Bureau of Ordnance, June 20, 1864, p. 25, Vol. 3, Entry 162, RG74, NA; Aulick to Berrien, June 25, 1864, pp. 458-459, Fort Pitt Vol. 1, Entry 4, RG74, NA; Wise to Yard, November 9, 1864, pp. 39-40, Fort Pitt Vol. 2, Entry 4, RG74, NA. Other soda-bottle shaped guns may have existed as well.

[31]Holley, *Ordnance,* pp. 12-13, 48-49, 90-103, 131; *Report to the Joint Committee,* pp. 12, 13, 117. Holley's massive treatise lists almost every known type of gun produced during the Civil War years.

[32]"Cannon and Howitzers in the Navy during the Rebellion," 1863 Folder, Box 27, Dahl Nav Ord, LC; Dahlgren, *Memoir,* p. 284; Bennett, *Steam Navy,* pp. 272-274; Dahlgren quoted from Dahlgren, "Objections to Casting IX and XI in Guns Hollow," November 20, 1864, Box 27, Dahl Nav Ord, LC; Holley quoted from Holley, *Ordnance,* p. 133; For the classic account of the duel between the *Alabama* and the *Kearsarge,* see *Battles and Leaders of the Civil War,* 4 Vols. (Reprint ed., Secaucus, NJ: Castle Books), Vol 4, *Retreat with Honor,* pp. 615-625; Porter quoted from Porter, *History,* p. 361.

[33]"XV in and XIII in Guns," September 15, 1868 (1863 Folder), Box 27, Dahl Nav Ord, LC; *Report to the Joint Committee,* pp. 71-72, 90-92; For the surrender of the *Tennessee,* see Porter, *History,* pp. 575-578; For Dahlgren's failure at Charleston, see J.G. Randall and David Herbert Donald, eds., *The Civil War and Reconstruction* (Lexington, MA: D.C. Heath and Company, 1969), p. 452.

[34]Holley's comments on breechloaders and Armstrong guns are taken from Holley, *Ordnance,* pp. 580, 583, 254. Most of the rest of the material for this paragraph comes from *Report to the Joint Committee.* Wise on breechloaders from p. 29; Wade quoted from p. 113; Knap concerning American and English guns from p. 88; Hartington quoted from p. 118; Paget reference from p. 120; Fox reference from p. 170; Wise on Parrott guns from pp. 23-24; Hartington on Armstrong guns from p. 117; Knap on Whitworth guns from p. 88. The last quote is from Porter, *History,* p. 361.

[35]*Construction of an Experimental Rifled Gun,* H. Ex. Doc. 56, 41st Cong, 3rd Sess. Serial 1453, 1871; Contract between the Bureau of Ordnance and Paulding, Humble, and Company of Cold Spring, New York, October 8, 1875, p. 39, Vol. 3, Entry 162, RG74, NA; For developments in American naval ordnance after the Civil War, see Richard Dwight Glasow, "Prelude to a Naval Renaissance: Ordnance Innovation in the United States Navy During the 1870s," (Unpublished Ph.D. Dissertation, University of Delaware, 1978).

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TABLE 1: THE DAHLGREN GUNS

Class	Weight of Gun (pounds)	Diameter of Bore (inches)	Length of Bore (inches)	Maximum Diameter (inches)	Weight of Service Charge (pounds)	Projectile Type	Projectile Weight (pounds)	Range in Yards at Elevations of: 5°	Range in Yards at Elevations of: Max	1864 Price per Gun
20-inch	100,000	20	163	64	60 to 100[1]	shot	1,080	*	*	$32,000
15-inch Version 2	42,900	15	146	48	35	shell	350	1,700	2,100	$7,000
						cored shot	400	*	*	
15-inch Version 1	41,576	15	130	48	35	shell	*	*	*	$6,500[2]
						cored shot	*	*	*	
13-inch	34,000	13	*	*	50[1]	shell	215	*	*	*
11-inch	15,900	11	131.2	32	15	shell	130	1,712	3,400	$1,809
						shot	170	*	*	
10-inch Solid Shot	16,500	10	*	*	*	shot	*	*	*	$1,877
10-inch	12,000	10	119.25	29.1	12.5	shell	103	1,740	*	*
9-inch Solid Shot	12,000	9	*	*	*	*	*	*	*	*
9-inch	9,200	9	107.3	27.2	10	shell	70	1,710	3,400	$897
						shot	93	*	*	
8-inch	6,500	8	96	23.2	7	shell	51.5	1,657	*	$813
32-pounder	4,500	6.4	92.25	*	*	*	*	*	*	$563

The data in this table have been compiled from the various contemporary and modern sources cited in the text. These sources frequently conflict because of the variation in individual guns and a host of other reasons. The fact that contemporary ordnance manuals do not contain complete performance statistics for all of the classes of ordnance used during the Civil War is a notable omission reflected in the table. This table does not contain every soda-bottle shaped gun produced.

* Data unencountered.

1 Various charges were used in experiments with the gun.

2 This is the 1862 price, as this version was not produced in 1864.