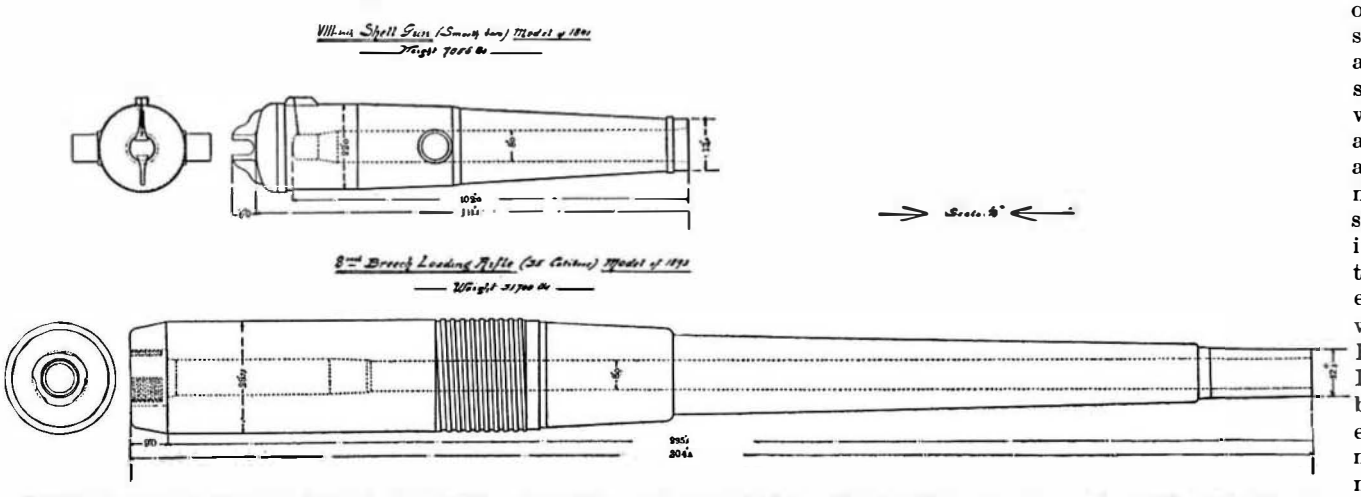
panies continued the same proportion of increase in their output as did several of the larger ones. In this year two manufacturing establishments in the city of Chicago made more than 200,000 machines, half of which were binders, and the other half mowers and reapers, and these two institutions alone employed in their various branches of manufacturing and selling 10,000 employes. In 1895 the output of the largest of these manufacturing establishments in the city of Chicago was 60,000 self-binding harvesters fitted with bundle carrier and trucks; 61,000 mowers, 10,000 corn harvesters and 5,000 reapers. The number of employes materially increased, but the total number of employes in the business has not increased for the last few years.

There were exported in the year 1880 about 800 self-binding harvesters, 2,000 reapers, and 1,000 mowers. In 1890 this advance increased to 3,000 self-binding harvesters, 4,000 reapers, and 2,000 mowers. The Argentine Republic, Paraguay and Uruguay take most of the machines that go to South America, and perhaps one-quarter of the total exports are to these countries; another quarter goes to the colonies of Australia and New Zealand, while the remainder go largely to the Continent of Europe, where they harvest the grains along the banks of the Red Sea and the Volga in Russia, along the Danube, in France, and in Germany, Sweden, Norway, England and Scotland. From these figures it will be seen that the great user of the labor-saving device is the American farmer. It is only by employing these labor-saving implements that he is enabled to compete in grain raising with the hordes of cheap laborers of India, and with those on the plains of Russia.



COMPARATIVE DIAGRAM, DRAWN TO SCALE, SHOWING THE DIMENSIONS AND WEIGHT OF THE CAST IRON SMOOTH BORE 8 INCH GUNS OF THE MISSISSIPPI (1846) AS COMPARED WITH THE STEEL 8 INCH RIFLE GUNS OF THE MASSACHUSETTS (1896).

NAVAL AND COAST DEFENSE.

The student of the past half century of progress in naval construction in the United States is tempted to exceed the further limits of his subject. As, in the history of the steam merchant marine, he cannot refrain from mention of the Savannah, so, in tracing the development of the steam warship, he is constrained to go back to the time of the war of 1812 and record the fact that it dates from that year. It appears that, in spite of the splendid service which was being rendered by the navy during the course of that war, it was felt that the sea coast and harbor defense was insufficient, and as a measure of protection to the city of New York it was decided to build a powerful battleship which should rely mainly upon steam for its propulsion. A committee of the Coast and Harbor Defense Association of that day appointed Robert Fulton as engineer, and from his designs a large coast defense steam battleship of 2,475 tons was built and launched on June 20, 1814. According to the plans of the Fulton, as she was named, the paddle wheel was in the center, between what appear to have been practically two hulls, with the boiler in one hull and engine in the other. On her trial trip she made a speed of 5½ miles an hour with her armament on board. As originally designed, she was to have carried 32 heavy guns. Such was the first war steamer the world ever saw. Like the Savannah among transatlantic steamships, she was the pioneer of her class, and she anticipated by several decades the general introduction of steam into the navy.

The progress of the American navy during the past half century has been strangely intermittent, and it may be defined as a long stretch of comparative stagnation, relieved by periods of sudden and remarkable activity, in which the resourcefulness and inventive genius of the nation were shown to be merely dormant. The first awakening came in the great civil war; the second in the last decade—1886–1896—of the period of which we are treating, in which a new navy, comprising ships of the very latest type, has been placed at the nation's service.

Fifty years ago the United States navy was mainly composed of line-of-battle ships and frigates, some of which carried the scars and the glory of many a hard fought duel in the war of 1812. The Naval Register for 1846 gives the following summary of the number of vessels in the navy at that time: Ships of the line, 11; razee (Independence), 1; first-class frigates, 12; second-class frigates, 2; sloops of war, 23; brigs, 8; schooners, 6; steamers, 11; storeships and brigs, 4; a total of 78 vessels of all classes. Of the battleships, the most important was the grand old Pennsylvania, a giant for those days, of 3,241 tons and 120 guns, built in 1837. She had a full complement of 1,100 officers and men and cost $694,500 to build and equip. The other battleships were much smaller, being of about 2,600 tonnage and carrying 84 guns. The frigates of 1,726 tons carried 50 guns and the sloops of war averaged about 800 tons, carrying from 16 to 24 guns. The armament of these vessels consisted of from four to twelve 8 inch guns and from sixteen to seventy-two 32 pounders, according to the size of the ship. All of the guns were smooth bores, firing round shell.

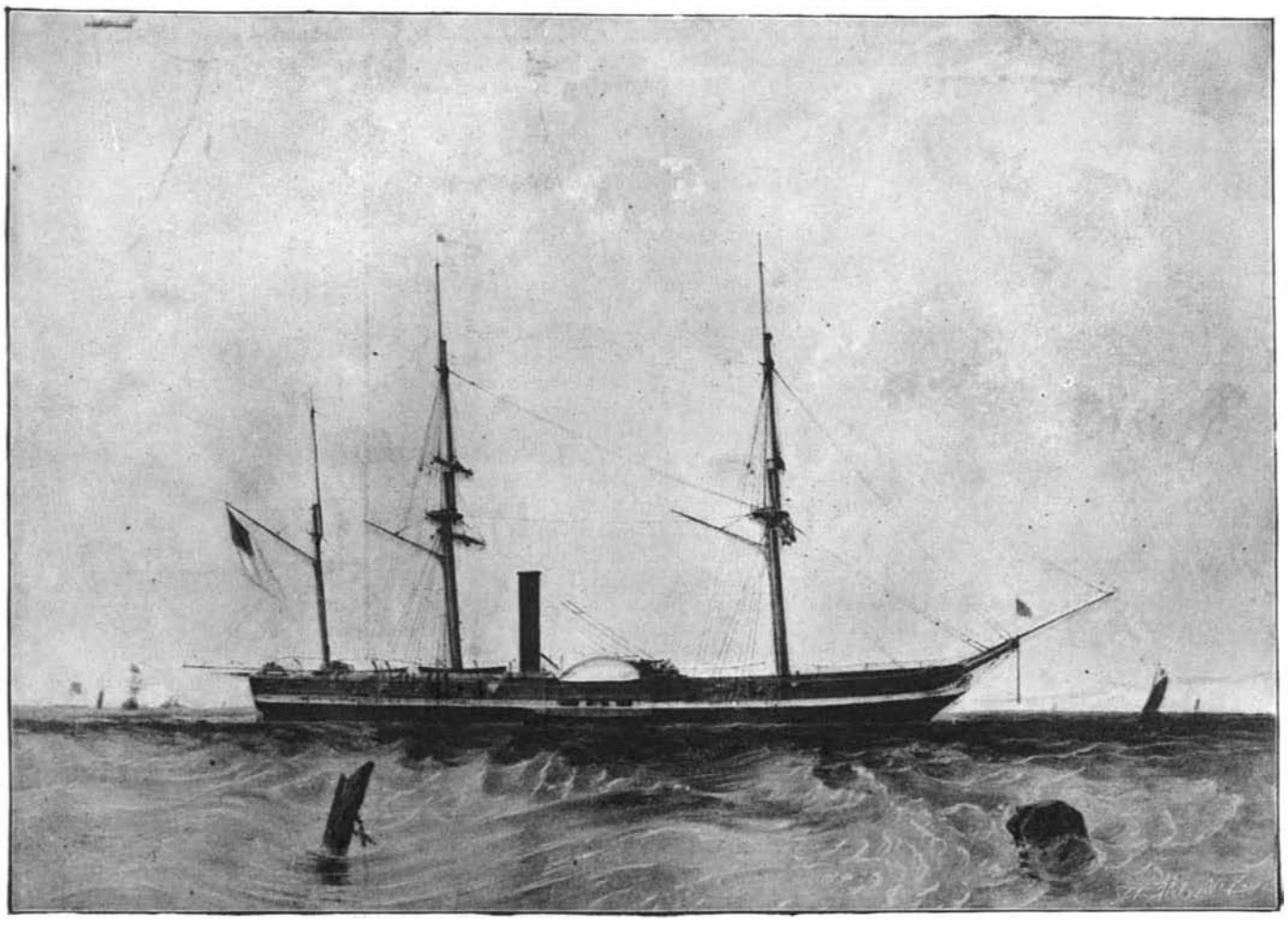
The appearance of nearly a dozen steamers upon the register reminds us that we are dealing with the period which witnessed the passing of the sailing ship. During the next fifteen years, which intervened before the outbreak of the civil war, only half a dozen sailing vessels were built, as against 33 steam warships. In addition to the service rendered by steam to ocean navigation in the merchant service, in the navy it brought further advantages of a tactical nature, which rendered it of special value. As compared with the sailing frigate, the steam frigate was independent of the wind and could place herself in the best position for a fight, giving or accepting battle as she pleased. This alone was sufficient to sound the doom of the grand old wooden two and three-deckers, with their towering topsides and lofty stretch of glistening spars and snowy canvas.

The accompanying illustration, from a daguerreotype of the Mississippi, shows rig and general appearance of a war steamer of 1846. She was launched in 1841, and in 1853 C. B. Stuart, the chief engineer of the navy, speaks of her as having been altogether the most useful and economical side wheeler in the navy. Her dimensions were: Length, 220 feet; beam, 40 feet; moulded depth, 39 feet; tonnage, 1,692; displacement, 3,220. There were two side lever condensing engines, with cylinders 75 inches diameter by 7 feet stroke. The boilers, three in number, were built of copper, with three furnaces, double return, ascending flues, and a total heating surface of 6,000 square feet. They weighed, empty, 120 tons. The paddle wheels, 28 feet diameter, were of the plain radial pattern. The average performance of the Mississippi under steam alone during an aggregate of 30 days was as follows: Speed, 7⅛ knots an hour; revolutions, 10·65 per minute; steam pressure, 10½ pounds; coal consumption, 37 tons per day. The hull cost $306,683 and the machinery $243,571. She was armed with two 10 inch smooth bore guns, mounted on pivots, one on each bow, and eight 8 inch smooth bores, mounted in broadside abaft the paddle box. The range, penetration, etc., of these guns were as follows:

Gun.	Charge.	Projectile.	Initial velocity.	Penetration through seasoned white oak at			
				500 yds.	1000 yds	1500 yds	2000 yds
10 in....	10 lb.	120 lb. shell.	1,160 f. s.	32·1 in.	24·2 in.	18·2 in.	13·7 in.
8 in....	9 lb.	51 lb. shell.	1,500 f. s.	33·0 in.	23·0 in.	15·9 in.	11·0 in.

The above penetration of 33 inches through oak would be equal to a penetration of 3 inches through iron. This was the maximum performance of the guns of those days. Today the penetration at 500 yards of the heavy guns carried by our ships has increased from 3 to 30 inches, an impressive evidence of the growth of heavy ordnance.

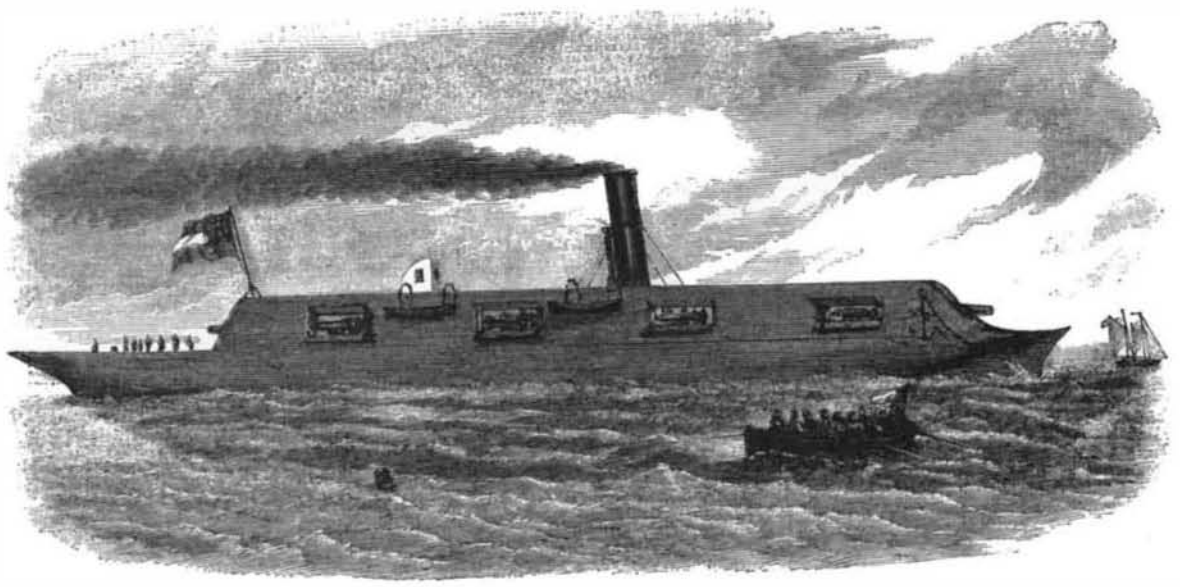
At the opening of the civil war the fleet of sailing ships consisted of 10 ships of the line, 10 frigates, 20 sloops, and a dozen brigs, store vessels and receiving ships. The steam fleet included 7 screw frigates built in 1855, namely, the Niagara, of 12 guns and 4,580 tons, and 6 of the Roanoke type, of 40 guns and 3,200 tons; 6 first-class screw sloops of 13 to 25 guns and 1,446 to 2,360 tons; 4 sidewheelers of 9



THE MISSISSIPPI—UNITED STATES WAR STEAMER OF 1846.

Displacement, 3,220 tons; speed, 7½ knots; armament, two 10 inch and eight 8 inch smooth bore guns; total broadside, 394 pounds.

to 15 guns and 1,446 to 2,450 tons; 8 second-class screw sloops of 3 to 6 guns and 694 to 1,289 tons; 5 third-class screw steamers of 5 to 8 guns and 500 tons; 4 third-class sidewheelers of 1 to 3 guns, 450 tons, and 2 screw steam tenders, making a total of 52 sailing and 36 steam warships. Considering the magnitude of the conflict and the vast stretch of coast line and rivers upon which it was to be waged, this fleet was altogether inadequate, and the government strained every nerve by building and by purchase to increase its strength and efficiency.



CUT OF THE CONFEDERATE IRONCLAD MERRIMAC.

Drawn for the SCIENTIFIC AMERICAN from descriptions furnished by a mechanic who assisted in her construction, and published in the issue of November 9, 1861. Probably the earliest illustration of this vessel.

How far they succeeded is shown by a government inquiry made shortly after the close of the war, which showed that since 1861 there had been built by and for the navy department the following vessels:

54 screw sloops of	500 to 3,200 tons	and 4 to 21 guns.	
36 double-ended sidewheelers	825 " 974	"	6 " 12 "
8 " " " " (iron)	1,030	"	6 " 10 "
9 tugs	350	"	2 "
2 "	170	"	2 "
2 seagoing casement ironclads	5,090 and 3,486	"	16 and 18 "
2 seagoing single turret ironclads	3,265 " 3,033	"	2 "
5 double turret ironclads	1,564	"	4 "
4 " " "	970	"	4 "
45 single " "	525 to 1.034	"	2 "

10 other vessels of smaller size and various types.

In addition to the above there were purchased for the navy 497 vessels, ranging in size from 100 to 1,200 tons. To this must be added what is known as the "stone fleet," comprising 44 vessels of 300 tons, 12 canal boats and 22 schooners; these were purchased to be filled with stone and sunk for the obstruction of channels, etc.

In seeking for the birthplace of the modern battleship we are carried back to the European war of the Crimea in 1854, and the American civil war of a few years later. The former gave us the first practical application of side armor; the latter the first actual test of the revolving turret. On October 17, 1855, the French contingent of the allied fleet dispatched three armor-plated ships against the Russian forts at Kinburn, and after a stubborn resistance, during which "the steady clang of the enemy's shot upon the" four inch "plating echoed like the blows of a cyclopean sledge-hammer," the forts were silenced, and these little 1,400 ton ironclads came out of the fight victorious, and practically unharmed. But while it is true that this was the first practical test of the ironclad, it is but just to mention the fact that to Mr. Stevens of New York is due the credit of having commenced the construction of an armored floating battery in the United States as far back as the forties. In 1841 he wrote a letter to the Naval Harbor Defense Board, proposing to build a warship which should embody the following features—an iron hull, inclined side armor, engines and boilers below the water line, high pressure steam, the screw propeller, and rifled wrought iron guns, loading at the breech. This remarkable letter formed the basis of a subsequent contract. Limits of space forbid a more detailed description of this ship; but the letter with cuts of the vessel will be published in a subsequent issue of the SCIENTIFIC AMERICAN SUPPLEMENT.

At the outbreak of the civil war the South realized that, with its very limited means for naval construction as compared with the North, it could only hope to prevail by adopting some special type of ship. This conviction led to the reconstruction of the Merrimac, a forty-gun steam frigate of 3,500 tons. She was partially burnt and sunk at the Norfolk navy yard by the United States officers at the opening of the war, to prevent her falling into the hands of the enemy, who subsequently raised her, and finding the hull and machinery in good order, determined to convert her into a side-armored battleship. Her upper works were cut down to the water line, and a rectangular casement, with sides inclined about 35 degrees, was built amidships. The sides were formed of 20 inches of pine and 4 inches of oak, and were covered with two layers of 2 inch iron plating.

The plates, 8 inches wide, had been rolled at the Tredegar Foundry, Richmond, from old iron rails. The first layer was placed horizontally and the second vertically, the whole being secured to the backing by 1⅜ inch bolts. The ends of the casement were rounded, and the roof was formed by an iron grating. Her armament consisted of two 7 inch rifled guns pivotally mounted fore and aft on the center line. On the broadside were two 6 inch rifled guns and six 9 inch smooth-bore Dahlgren guns.

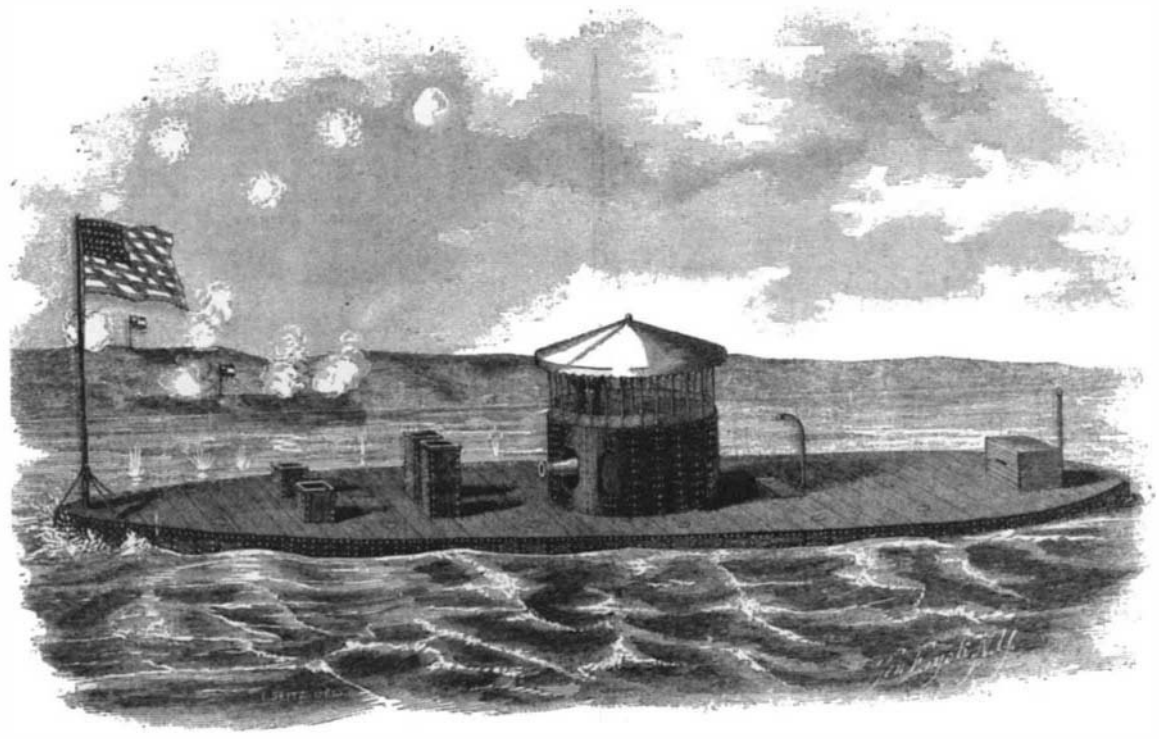
Our illustration, which is probably the first representation of the Merrimac ever published, was drawn from the description of a mechanic who had just come from the South, where he had assisted in the reconstruction of the ship. It was published before she was at her load line, which will account for the fact that she is shown with a much higher freeboard than she actually possessed.

The answer of the North to the challenge of the South was made in the launch of the turret ship Monitor, Ericsson's famous creation. In her design it was sought to produce a ship that should be invulnerable, of light draught for operation in the Southern harbors, carrying few guns, and that should be capable of rapid construction. The most novel and epoch-making feature was the placing of the guns within an armored revolving turret. This was not a new idea, but it was the first practical application and test of it. Others had already suggested it, but to the United States navy belongs the credit of the successful adoption of a design, which as far back as the Crimean war had been offered by Ericsson to the Emperor Napoleon, and rejected in favor of broadside plating.

The Monitor was built in 118 days. She was of 1000 tons displacement; 172 feet long, 41½ feet beam, and drew 10½ feet of water. Her deck was plated with 1 inch, and her sides, which overhung the hull proper, with 5 inches of iron, her freeboard being only 2 feet. The turret was 20 feet diameter, inside, by 9 feet high, and revolved, not, as is the practice now, upon peripheral rollers, but upon a central pivot within the ship's hull. It was protected by eight one inch iron plates, and the armament consisted of two 11 inch Dahlgren smooth bores. Forward of the turret was an iron pilot house 4 feet high covered with a 2 inch plate. The deck was pierced by two square smoke stacks and two blow holes. In the face of a storm of adverse criticism and prediction of disaster, the Monitor was completed and launched and dispatched to Southern waters. None too soon did she appear on the scene. The Merrimac was already at her work of destruction, and in one day, March 8, 1862, she had engaged three Northern ships of from thirty to fifty guns, in Hampton Roads, and administered a crushing defeat, receiving but little hurt herself. On the evening of the same day the Monitor steamed into the harbor, and on the day following was fought one of the most memorable duels of history. The story of the fight is too well known for repetition. It proved the superiority of armor to shot, the latter glancing from the former, and inflicting but little damage. The Monitor fired once every 7 minutes, the Merrimac once every 15 minutes. The superior turning power of the Monitor and the wide arc of fire through which she could use her guns proved a great advantage. The failure of either ship to inflict serious injury upon the other, however, was due largely to the fact that the Monitor was using light charges, lighter than was necessary, in her 11 inch guns, and the Merrimac was without solid shot.

The effect of the Monitor and her successors upon naval construction was far reaching, and showed itself in the general adoption of the turret by the navies of the world. It may without exaggeration be said that this little vessel was the father of the modern battleship, whether it be a Massachusetts, a Majestic, or a Charlemagne.

Equally valuable were the lessons of the war in relation to all matters of sea coast and river defense. One of the first encounters took place at New Orleans, when Farragut forced his way past the forts and through a strong boom and captured the city. It was a bold stroke on the part of the Northern admiral, for it was considered in those days that stone forts such as those below New Orleans were sufficient to bar the passage of a stronger fleet than that possessed by Farragut. The forts, however, were indifferently armed with old pattern 8 and 10 inch guns, and would undoubtedly have rendered a better account of themselves if better armed and manned. There were 17 ships in the fleet, mounting in all 192 guns. The same feat was repeated two years later at Mobile, when the fleet forced its way through a line of torpedo defenses under the concentrated fire of Fort Morgan. On both occasions the value of extemporized side armor was proved, and in these early days of the contest between gun and armor, the advantage lay with the armor. On the other hand, the early actions off Charleston, and particularly against Fort Sumter, were a triumph for the forts, On this occasion the fleet under Dupont, the Northern commander, consisted of nine ironclads, mounting in all seven 15 inch, twenty-two 11 inch and two 50 pounder smooth bores, with three 150 pounder rifled guns. The forts mounted ten 10 inch, nineteen 8 inch, and eighteen 32 pounder smooth bores, with ten 10 inch mortars, two 8 inch, seven 42 pounder and eight 32 pounder rifled guns, or 74 guns in all. The ironclad fleet concentrated its fire upon Fort Sumter, and bombarded it for an hour, but "the 15 inch shells which were to have blown in the masonry of Fort Sumter did nothing of the kind." One 10 inch gun was temporarily disabled,



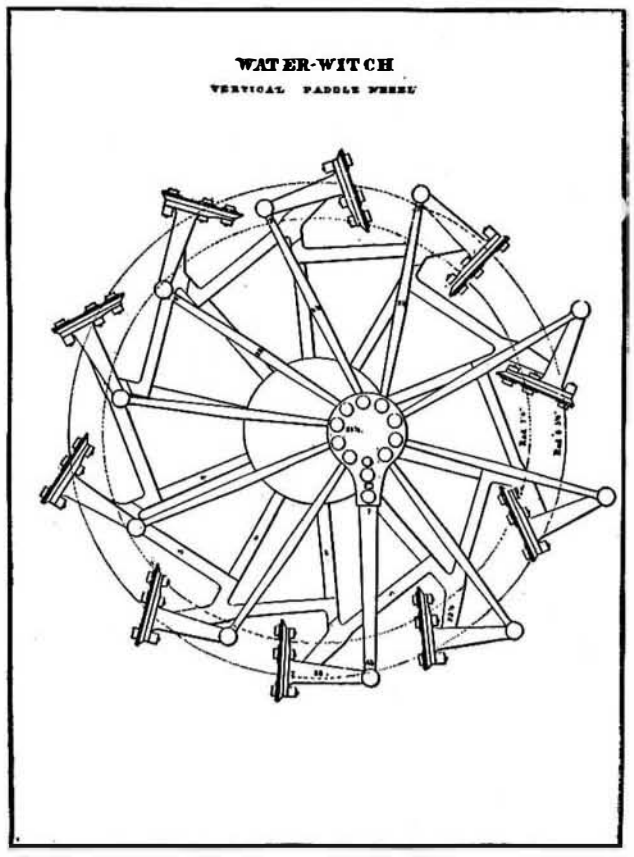
THE FEDERAL IRONCLAD MONITOR, 1861.

Displacement, 1,000 tons; length, 172 feet; breadth, 41½ feet; draught, 10½ feet; armor on turret, 8 inches thick; armament, two 11 inch smooth bores.

one 8 inch gun burst, seven men were wounded and one killed. In the fleet the Keokuk was sunk, and the other ships were hit from thirty-five to sixty times, with temporary disablement of guns and turrets, though the damage was on the whole slight, considering the hail of heavy projectiles. The failure of this attack seems to show that the coast defense fortifications of those days were proof against the attack of battleships, though a later attack on Sumter with Parrott rifles, it is true, was more destructive. It is certain that the developments in artillery since the war are favorable to the modern fort, inasmuch as the enormous weight of the heaviest modern guns limits their use on the ship, but offers no objection to their emplacement within land fortifications.

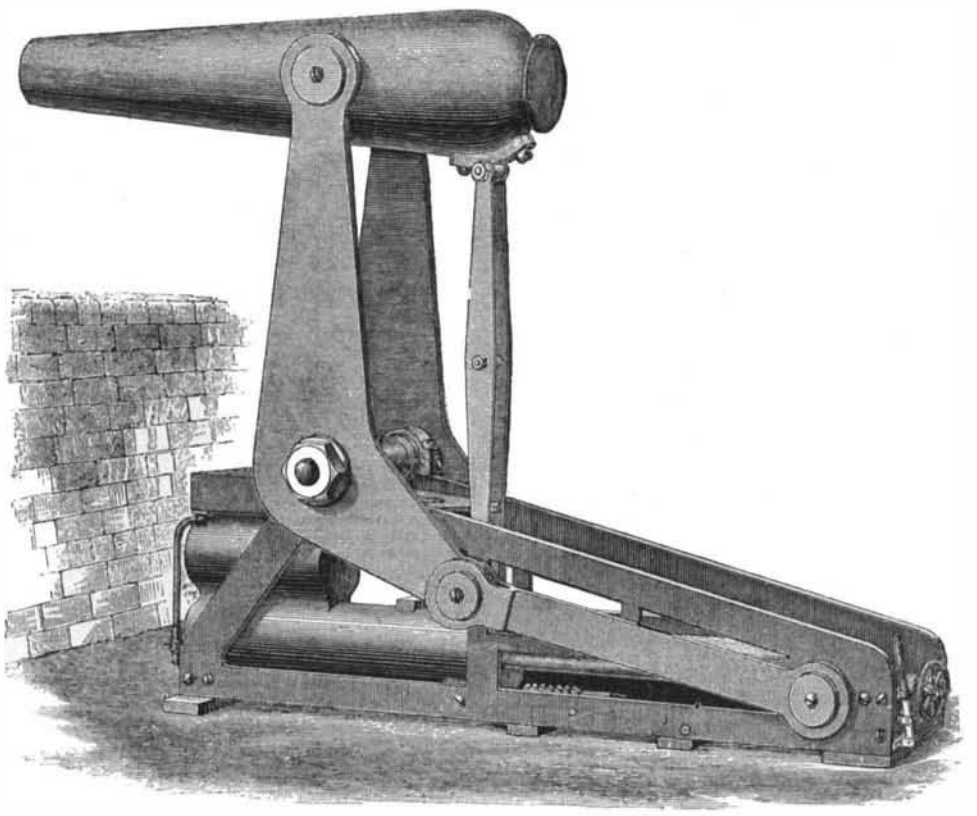
Before passing on to the present decade mention must be made of the destructive work of the Confederate cruisers. The story of the ravages of the Alabama and her final sinking by the Kearsarge is well known; and it is largely to the striking success of this ship that the large percentage of swift, lightly armed cruisers in modern navies is due. The Alabama and her mates practically swept the American merchant marine from the high seas, and had it not been for its fleet of swift blockade runners, the South would have collapsed many months before the final capitulation actually took place.

At the close of the war silence fell upon the busy dockyards of the navy—a silence which was to be practically unbroken for the next twenty years. All the accumulated experience of the past four years, and the ships of the new navy in which it was embodied, were laid open as a kind of reference library or school of instruction for the world at large. Foreign naval constructors were not slow to learn therein; and the student of naval progress must cross the water if he would follow the development of ships, guns, and armor during the next two decades. As the British navy stands at the front during this interim, both in constructional developments and numerical strength, it will be sufficient to show the advance approximately by quoting the details of particular ships of this navy. (See table below.)



VERTICAL OR "FEATHERING" PADDLE WHEELS OF THE WATER WITCH THE SECOND.

First of this type to be used in the navy, 1853.



PNEUMATIC DISAPPEARING GUN CARRIAGE FOR COAST DEFENSE.

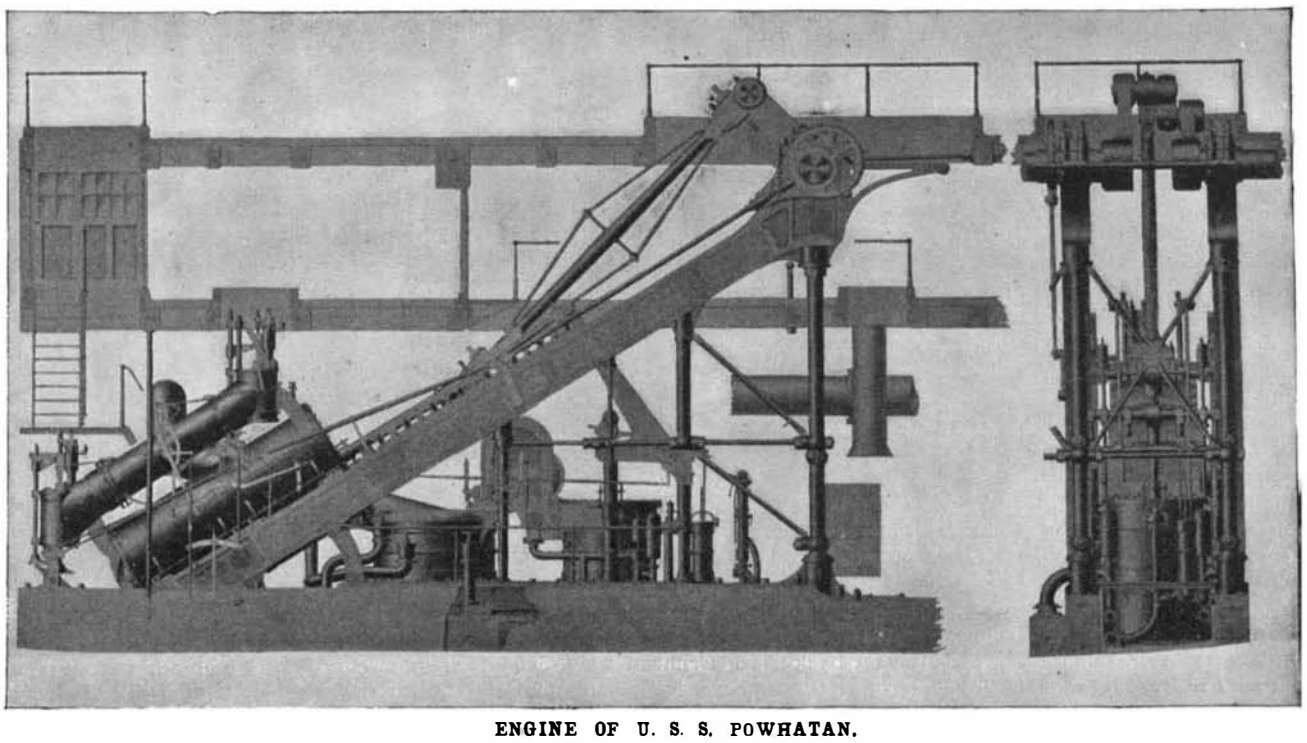
Invented by Captain James B. Eads in 1872.

Ship.	Date of design.	Displacement.	Speed in knots.	Armor in inches.	Guns.	Stages of development.
Devastation..	1870	9,330	14	12 in. to 14 in. iron.	12 inch 35 ton muzzle loading.	Great increase in size of ships, guns and thickness of armor.
Inflexible	1876	11,880	12·8	16 in. to 24 in. steel and iron compound armor.	16 inch 80 ton muzzle loading.	Use of steel for armor. Continued increase in size of ships, guns, and armor.
Camperdown.	1880	10,600	16·9	18 in. compound.	13½ in. 67 ton breech loading, 6 in. B. L. secondary battery.	Use of steel for hull. Twin screws. Breech loading guns mounted in lofty barbettes. Strong secondary battery.
Imperieuse ...	1881	8,400	16·75	10 in. compound.	9·2 in. and 6 in. breech loading.	Belted cruiser type.
Medea	1885	2,800	19	1½ in. protective deck.	6 in. guns B. L.	High speed protected cruiser type.

The interval from 1865 to 1885 had also seen the launching of the Esmeralda, the first of the modern cruiser type, and the development of the automobile torpedo and the torpedo boat, with a host of minor but important devices for increasing the destructiveness of naval warfare.

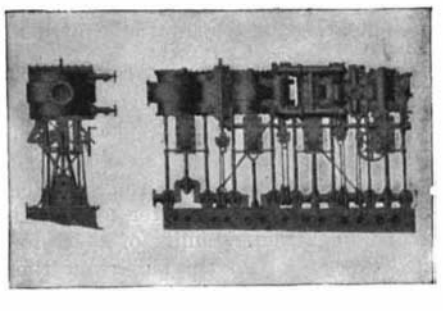
Toward the close of this period the United States awoke to the fact that, in the modern sense of the term, they were practically without a navy, and Congress made a modest start in the construction of one by authorizing, in 1883, the building of three protected cruisers, the Atlanta and Boston, single screw ships, of 3,000 tons displacement and 15·6 knots speed, and the Chicago, of 4,500 tons and 15·1 knots; the armament consisting of 6 and 8 inch breech-loading rifled guns. The work of creating a modern navy has gone forward steadily ever since, and the story of its growth and success is epitomized in the table on the next page.

Bearing in mind how thoroughly up to date are the various war ships in this tabulation, it is a most creditable showing, and in many respects the new navy is unique among the navies of the world. Compared with the ships of other nations, upon a basis of displacement,



ENGINE OF U. S. S. POWHATAN.

Designed by the Bureau of Steam Engineering, 1849. Charles H. Haswell, Engineer-in-Chief. Built by A. Mehaffy & Company, Norfolk, Va. Horse power, 1,172; steam pressure, 15 pounds; total weight of machinery, 508 tons; weight per horse power, 972 pounds.



ENGINE OF U. S. TORPEDO BOAT No. 2.

Designed by the Bureau of Steam Engineering, 1891. George W. Melville, Engineer-in-Chief. Built by Iowa Iron Works, Dubuque, Iowa. Horse power, 1,800; steam pressure, 250 pounds; total weight of machinery, 45 tons; weight per horse power, 56 pounds.

1849—ILLUSTRATION SHOWING THE ADVANCEMENT IN MARINE ENGINEERING—1891.

(The two engines are drawn to the same scale, so that the drawings show the relative sizes.)

THE NEW UNITED STATES NAVY.

Name.	Authorized.	Type of Ship.	Displacement.	Speed.	Armor.	Main Armament.
Atlanta, Boston,	1883	Protected cruiser.	3,000	15 6	1½ in. deck.	2 8-in. B. L. rifles. 6 6 " "
Chicago	1883	" "	4,500	15·1	1½ " "	4 8 " " 8 6 " " 2 5 " "
Dolphin	1883	Dispatch boat.	1,486	15·5		2 4 " R. fire "
Charleston	1885	Protected cruiser.	3,730	18·20	2 " to 3 in. deck.	2 8 " B. L. " 6 6 " " "
Newark	1885	" "	4,098	19·00	2 " " 3 " "	12 6 " " "
Petrel	1885	Gunboat.	892	11·8	⅜ " " ⅝ " "	4 6 " " "
Yorktown	1885	"	1,710	16·14	⅜ " deck.	6 6 " " "
Maine	1886	Turret battleship.	6,682	17·45	8 " to 12 in.	4 10 " " " 6 6 " " "
Texas	1886	" "	6,315	17·00	12 "	2 12 " " " 6 6 " " "
Baltimore	1886	Protected cruiser.	4,413	20·09	2½ " to 4 in. deck.	4 8 " " " 6 6 " " "
Vesuvius	1886	Dynamite "	929	21·42	1⅜ " deck.	3 15 " dynamite guns.
Cushing	1886	Torpedo boat.	105	22 5		3 1-pounder R. F. 3 18-in. torpedoes.
Monterey	1887	Monitor.	4,084	13·6	7½ " to 13 in.	2 12 " B. L. rifles. 2 10 " " "
Philadelphia	1887	Protected cruiser.	4,324	19·68	2½ " " 4 " "	12 6 " " "
San Francisco	1887	" "	4,098	19·53	2 " " 3 " "	12 6 " " "
Bennington	1887	Gunboat.	1,710	17·5	⅜ " deck.	6 6 " " "
Concord	1887	"	1,710	16·8	⅜ " "	6 6 " " "
New York	1888	Armored cruiser.	8,200	21·00	3 " to 6 in. deck. 4 " " 10 "	6 8 " " " 12 4 " R. F. "
Olympia	1888	Protected "	5,870	21·78	2 " " 4¾ " "	4 8 " B. L. " 10 5 " R. F. "
Cincinnati	1888	" "	3,213	19·00	1 " " 2½ " "	6 " " rifle. 10 5 " " rifles.
Detroit	1888	Cruiser.	2,089	18·71	1/16 " " 7/16 " "	9 5 " " "
Marblehead	1888	"	2,089	18·44	1/16 " " 1/16 " "	9 5 " " "
Montgomery	1888	"	2,089	19·05	1/16 " " 1/16 " "	9 5 " " "
Raleigh	1888	Protected cruiser.	3,213	19·00	1 " " 2½ " "	1 6 " " " 10 5 " " "
Bancroft	1888	Training ship.	839	14·37	¼ " " ⅜ " "	4 4 " R. F. "
Katahdin	1889	Harbor defense ram.	2,155	16·25	3 " " 6 " "	4 6-pounder R. F.
Castine	1889	Gunboat.	1,177	16·03	1/16 " " 3/16 " "	8 4-in. R. F.
Machias	1889	Gunboat.	1,177	15·5	1/16 " " 3/16 " "	8 4 " "
Indiana	1890	Coastline battleship.	10,288	15·55	6 " " 18 "	4 13-in. B. L. rifles. 8 8 " " " 4 6 " " "
Massachusetts	1890	" "	"	16·15	do.	do.
Oregon	1890	" "	"	16·78	do.	do.
Columbia	1890	Protected cruiser.	7,375	22·8	2½ " " 4 " "	1 8 " B. L. rifle. 2 6 " R. F. rifles. 8 4 " " "
Ericsson	1890	Torpedo boat.	120	24·00		3 1-pdr. " "
Minneapolis	1891	Protected cruiser.	7,375	23·07	2½ " " 4 " "	1 8-in. B. L. rifle. 2 6 " R. F. rifles. 8 4 " " "
Iowa	1892	Seagoing battleship.	11,410	16·00	6 " " 15 "	4 12 " B. L. " 8 8 " " " 6 4 " R. F. "
Brooklyn	1892	Armored cruiser.	9,271	21·07	3 " " 6 " " 4 " " 8 "	8 8 " B. L. " 12 5 " R. F. "
Three Helena type	1893	Gunboats.	1,392	13·00	1/16 " " ⅜ " "	8 4 " " "
Submarine boat	1893	Torpedo boat.	168	8·00		2 torpedo tubes.
Nos. 3, 4 and 5	1894	" "	142	24·5		3 1-pdr. R. F. guns. 3 18 in. Whiteheads.
Kearsarge	1895	Seagoing battleship.	11,525	16·00	9 " " 17 "	4 13 " B. L. rifles. 4 8 " " " 14 5 " R. F. guns.
Kentucky	1895	" "	11,525	16·00	do.	do.
Six gunboats	1895	Gunboats.	1,000	12·00		6 4 " " "
Nos. 6, 7 and 8	1895	Torpedo boats.	190	27·5		3 18 " Whiteheads. 4 1-pdr. R. F. guns.
Three battleships	1896	Battleships.	12,000	16·00	Similar to Kearsarge.	
Nos. 9, 10 and 11	1896	First-class torpedo boats.		30·00		
Nos. 12—18	1896	Second class torpedo boats.		26·00		

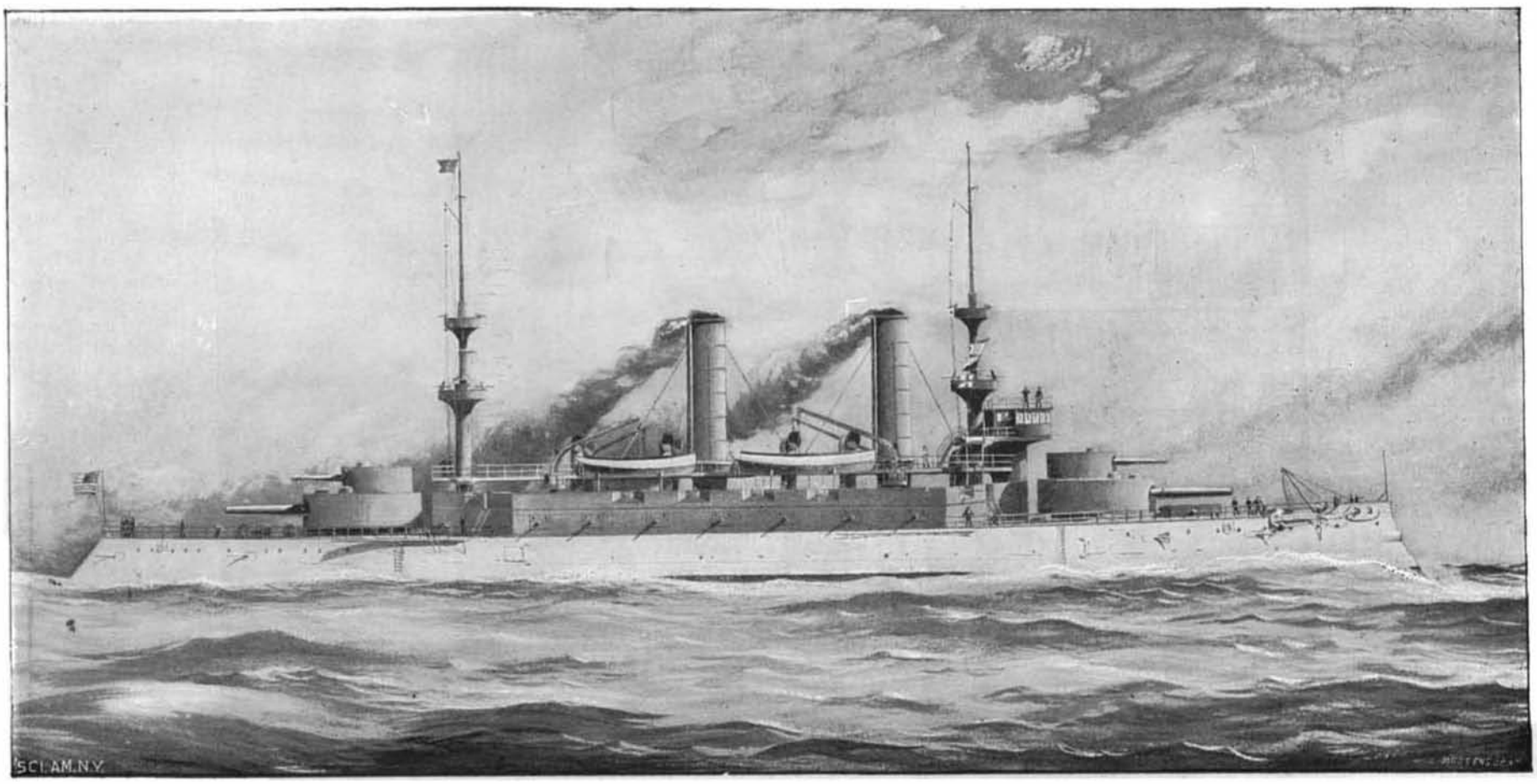
Note 1. To this list must be added the four completed monitors of the Miantonomoh type, and the Puritan.
Note 2. Where not specified as deck armor the dimensions relate to side and turret armor.

they are certainly in many respects greatly superior. That is to say, size for size, they are faster, more heavily armed and armored, and better protected. The Massachusetts, as a battleship; the Brooklyn, as an armored cruiser; and the Minneapolis, as a protected cruiser, are relatively unmatched by anything afloat today. The following table shows the increase in fighting power of the individual ship in the past fifty years:

	Date.	Displacement. Tons.	Speed knots	Armor.	Weight of broadside.	Maximum penetration through iron.
Mississippi	1846	3,220	7·33	none	324 lb.	3 in. at 500 yds.
Massachusetts	1896	10,288	16·15	18 in. steel.	5,724 lb.	30 in. at 500 yds.

Equally remarkable has been the improvement in engines and boilers; indeed, it may safely be said that the development of the marine engine, both in the merchant marine and in the navy, has been the most potent factor in bringing the steam engine up to its present high standard of efficiency. The necessity of keeping down the size of war ships, coupled with the high speed required, and the all too scanty space allotted to engines and boilers, have led the marine engineer to bend every energy to the reduction of weight, and the increase of efficiency. What was merely desirable on land was absolutely imperative on the seas, and hence the marine engine has usually led the way in the improvement of steam machinery. The compound engine, with its higher pressures and wider range of expansion; the triple and then quadruple expansion engine—a further advance upon the same line; the larger use of steel in construction of engines and boilers; the extended use of water tube boilers; forced draught; and many other advanced forms of steam engine practice, were early utilized and improved by the naval engineer. The accompanying illustration of the engines of the Powhatan, 1849, and the Ericsson, 1891, for which we are indebted to the present Engineer-in-Chief of the Navy, George W. Melville, shows very graphically the decrease in bulk and the increase in power of the marine engine. While steam pressure has increased from 15 to 250 pounds, and the revolutions per minute from 14 in the paddle steamer to 412 in the screw steamer, the weight of machinery per horse power has decreased from 972 to 56 pounds!

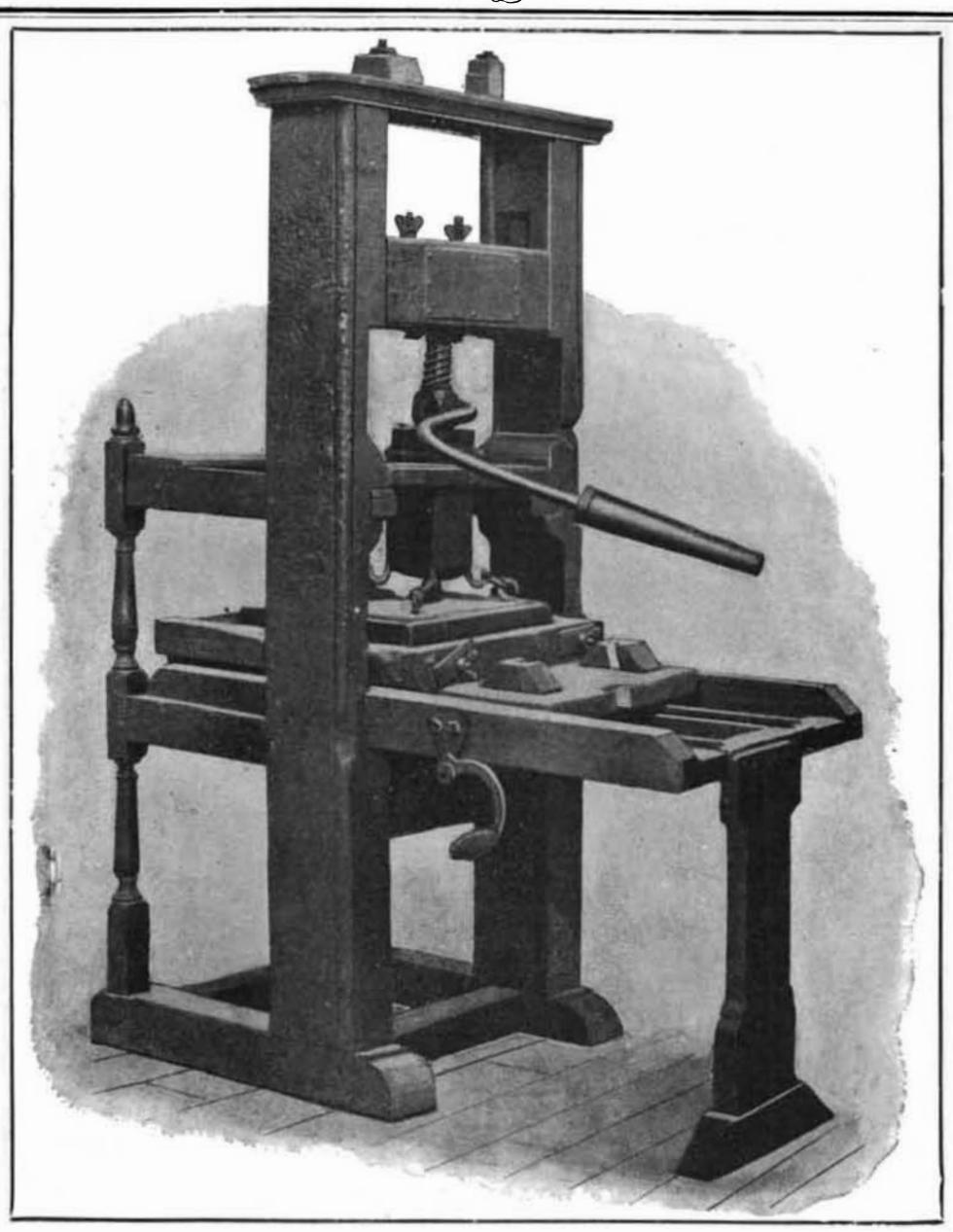
The development of guns and armor during the past half century has fully kept pace with the advance in ships and engines. In 1846 the guns were cast iron smooth bores, firing spherical projectiles at low velocities; and for armor the ships relied upon great thickness of wood. The cast iron Columbiads ranged in size from the 8 inch, 4¼ ton gun, to the 20 inch, 57½ ton gun, the former throwing a 68 pound, the latter a 1,000 pound projectile. The year 1860 saw the commencement of the manufacture of the celebrated Parrott gun, which was destined to play such an important part in the war. In this gun were introduced the two elements of reinforcement and rifling, the body of the gun being of cast iron, with a wrought iron hoop shrunk on over the breech. They were very formidable weapons, an 8 inch rifle having, in 1865, thrown a 52½ pound shell, with an initial velocity of 1,809 feet per second, thereby establishing a claim for the Parrott as "the most formidable service gun extant" at that time. After the war there was twenty years of stagnation, similar to that in the navy, in the matter of ordnance and coast defense, and in 1885, the brick and stone forts of 1860–65, surmounted by antiquated smooth bores and Parrott rifles, were all the defense which the nation could offer in the event of attack by the powerful artillery of a foreign power. In that year a complete investigation of the defenseless condition of our various seacoast cities was made by what is known as the Endicott Board, who reported that to put the coastline in a state of thorough defense would require the expenditure of about $100,000,000 for guns and forts. The recommendations of this board, modified to



THE KEARSARGE, 1896; SEA-GOING BATTLESHIP.

Displacement, 11,525 tons; speed (proposed), 16 knots; material of construction, steel; type, superimposed turret and rapid-fire broadside; armor, 9 inches to 17 inches, Harvey steel; armament, four 13 inch and four 8 inch breech-loading rifles; fourteen 5 inch rapid-fire guns; thirty smaller rapid-fire guns; five torpedo tubes.

meet the present requirements, would call for the mounting of about 1,500 modern guns and mortars of from 8 inch to 16 inch caliber, and 360 rapid fire guns. At the present writing New York, San Francisco and Boston have between them some 50 to 60 modern guns and mortars mounted in place; and including the sum voted at the close of the Congress of 1895-96, about 20 per cent of the necessary sum has been appropriated. The accompanying diagram of a modern United States 8 inch rifle may be taken as typical of the guns which will be mounted in the proposed system of coast defense. It is an all-steel, built-up hooped gun, with a breech-loading mechanism of special pattern, and great facility of manipulation. This comparative diagram, together with the comparative table of the 8 inch guns of the Mississippi and the Massachusetts, show the growth in size and power during fifty years. It is only during the past few years that the manufacture of modern armor has been undertaken in the United States, yet we have easily moved to the front place by the introduction of the Harvey system of face-hardened armor, by means of which the resisting power of a plate is increased some 50 per cent. Already our makers are filling important orders for European navies, and the English Admiralty have adopted a modified form of the system in preference to any other for all ships now building and planned.



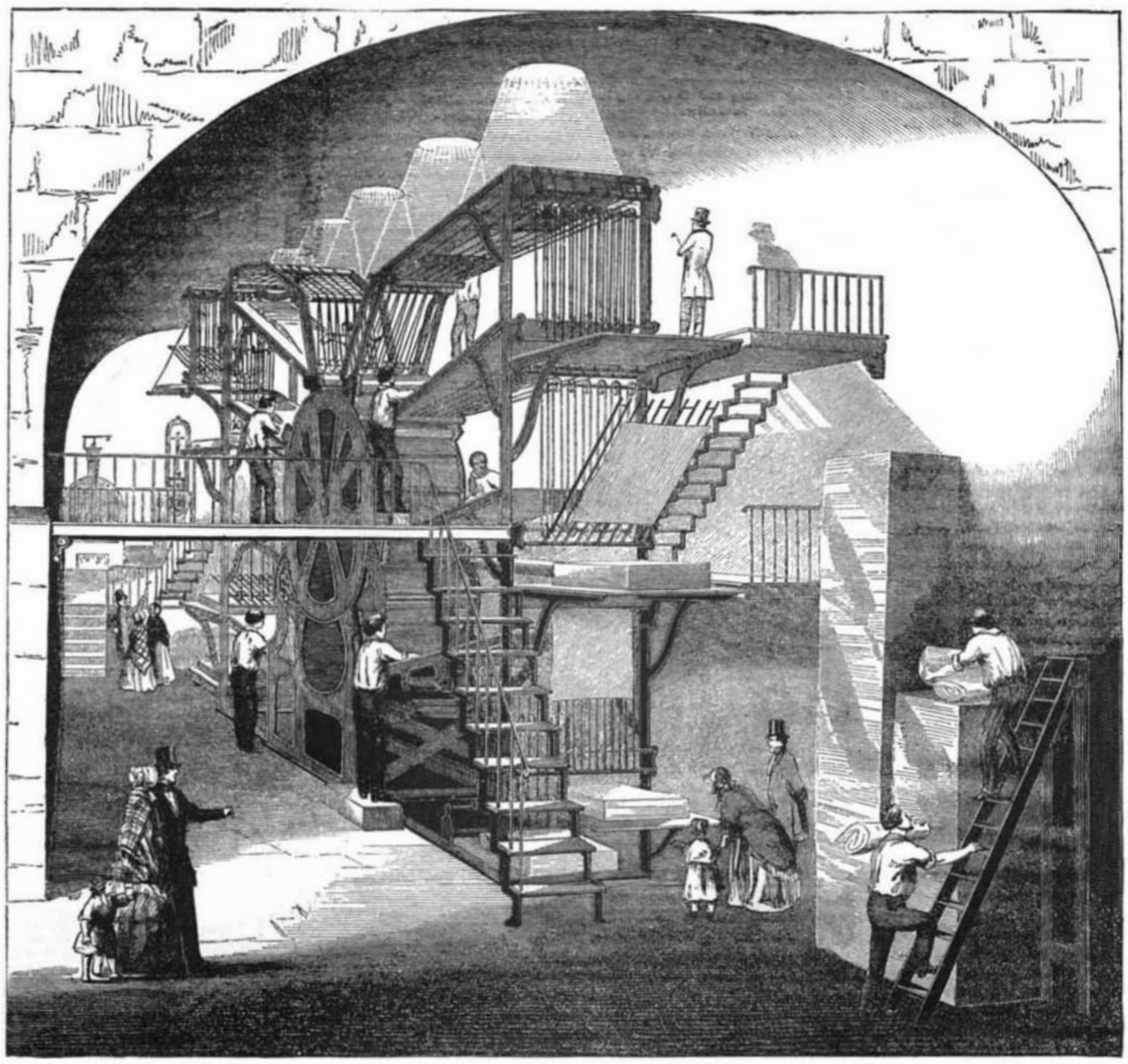
THE FRANKLIN HAND PRESS IN THE NATIONAL MUSEUM WASHINGTON.

FIFTY YEARS IN THE PRINTING BUSINESS.

The far more general dissemination of intelligence, the rapid and efficient means of intercommunication between all parts of the world, with the cheapening and broadening of all educational facilities, constitute, perhaps, the most notable feature of the progress of the world during the past half century, and the one most vitally contributing to the success of all our great industries—the perfection and introduction of most of the world's great inventions. The printing press has been the great disseminator of knowledge, the cheap educator of the people. As a promoter of its efficiency the electric telegraph has performed most splendid service, finding therein its earliest efficient support, and an array of inventors have found a profitable field in the numerous devices which contribute to the perfection of the printing press of to-day or add to its ability to most promptly and cheaply serve the largest number of readers. In the development of the printing art in the United States the name of Franklin will ever be memorable, so that it is most fitting that we should illustrate Franklin's own press before reviewing the great inventions which contributed so largely to the dissemination of cheap literature and which more properly belong to the epoch we are considering.

The press shown in the engraving is what is known as a Ramage press, and it was used by Benjamin Franklin in London in 1725. The press is constructed almost entirely out of wood, though iron was subsequently used in many of the parts. On the clumsy frame the great statesman has left the marks of his inky fingers. It is now in the National Museum, at Washington. In the early part of the present century Earl Stanhope invented a press made entirely of iron, the frame being cast in a single piece. The power was applied by a combination toggle joint and lever. The Columbian press was invented by a Philadelphian in 1817. The power was applied by a compound lever. In 1829 the Washington press of Samuel Rust was introduced, and many improvements were introduced in inking, and later a self-inking device was invented. The first power press produced in America was that of Daniel Treadwell, of Boston, in 1822. The Adams press was invented in 1830, and has superseded all other platen presses, the impression being given by raising the bed upon which the form rests against a stationary platen. The first attempt to make a rotary press was that of Friedrich König, in 1814. In this the type moved horizontally, and it could give 1,800 impressions per hour.

The first great step toward facilitating the rapid and cheap production of the modern newspaper was made by Col. Robert Hoe, of New York, about 1840, when the first of the type-revolving presses was built. At about the same time a type-revolving press on materially different lines, the Applegath machine, was brought into practical use in England. This machine was first employed by the London Times in 1848. In the Applegath machine the typeholding cylinder revolved on vertical axes, and the machine could print about 12,000 single sheets on one side in an hour. In the Hoe machine the type cylinder revolved on a horizontal axis. This arrangement for feeding the sheets was more simple, and the capacity of the press varied according to the number of impression cylinders arranged around the type cylinder, these presses being successively made with four, six, eight, and ten impression cylinders, respectively. A four-cylinder press of this kind was built for the Philadelphia Ledger in 1845. The first eight-cylinder press was built for the New York Sun in 1850, and the first ten-cylinder press for the New York Herald in 1857. Our engraving shows the eight-cylinder Hoe press of 1850 as furnished to the New York Sun office. The average capacity of the presses was 2,000 single sheets per hour per cylinder, or 20,000 sheets per hour, on one side, on the largest press, the ten-cylinder. These presses were 37 feet long, 18 feet high, and 21 feet wide, and were



EIGHT CYLINDER HOE PRESS OF 1850 USED IN PRINTING THE NEW YORK SUN
Capacity, 20,000 per hour. Reproduced from an early print in the SCIENTIFIC AMERICAN.