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OUR SEA-COAST DEFENCES

BY

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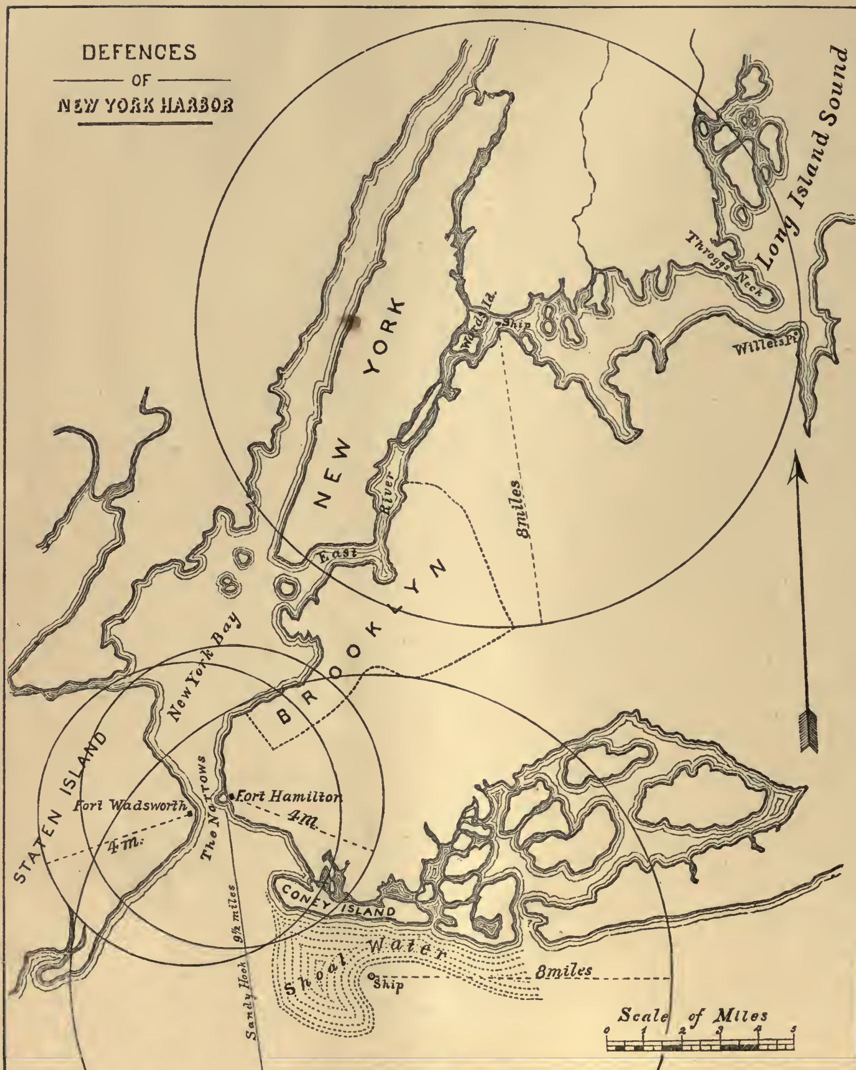

Military Service Institution, U. S. *Monographs, No. 1.*

OUR SEA-COAST DEFENCES.

By LIEUT. EUGENE GRIFFIN, U.S.A.,

CORPS OF ENGINEERS.

PART I. OUR SEA-COAST DEFENCES, PAST AND PRESENT.

ENGINEERS have divided our early fortifications into three systems: (1) those built before and during the Revolutionary War; (2) those built subsequent to the Revolution but previous to the War of 1812; (3) those built since 1816. The last alone are of present importance, as they still constitute the major part of our maritime defences.

The utter inadequacy of temporary sea-coast fortifications was painfully evident during the second war with Great Britain, and demanded immediate attention upon the declaration of peace. In 1816, a comprehensive system was devised by a board of engineer officers, approved by the Chief of Engineers and the Secretary of War, and adopted by Congress; and yearly appropriations were thereafter made for the construction of the works.

In planning this system the board considered that "fortifications must:

"1st. Close all important harbors against an enemy and secure them to our military and commercial marine.

"2d. Deprive an enemy of all strong positions where, protected by naval superiority, he might fix permanent quarters in our territory, maintain himself during the war, and keep the whole frontier in perpetual alarm.

"3d. Cover the great cities from attack.

"4th. Prevent, as far as practicable, the great avenues of interior navigation from being blockaded at their entrance into the ocean.

"5th. Cover the coast-wise and interior navigation by closing the harbors and the several inlets from the sea which intersect the lines of communication, and thereby further aid the navy in protecting the navigation of the country.

"6th. Protect the great naval establishments." *

To accomplish these results fortifications were so placed as to command the harbor entrances, channels, and rivers requiring defence, and interior works constructed to command all positions which might be occupied by the enemy should he succeed in forcing the main line. These works consisted mainly of masonry casemates with two or more tiers of fire, surmounted by earthen barbette batteries. Stone walls were less vulnerable than wooden walls, and land fire more accurate and steady than that of ships; hence, while engineers had long recognized the principle that all masonry should be shielded from land fire by earthen masks, the same secure cover was not necessary for sea-fronts. Guns at least equal in numbers and calibres to those of any possible attacking squadron were mounted in these works; the several tiers providing sufficient emplacements and permitting a great concentration of guns on a comparatively contracted site.

The works were given but slight command, the better to utilize the advantages of ricochet fire; and land-fronts of greater or less strength were added, to enable the garrison to withstand a siege of from ten to fifty days.

During the long periods of peace which followed the War of 1812, many conditions were altered both in the attack and defence, and corresponding changes were required in the system. The introduction of the steam-engine rendered ships independent of wind and weather, and this advantage was so greatly increased by the invention of the screw propeller, which placed the motive power out of sight and reach of the guns, that channel obstructions, to prevent the ships from running by the batteries, became an absolute necessity and an important feature of the defence.

The invention of the magnetic telegraph and the construction of innumerable lines of railroads so facilitated the concentrations and movements of troops that the costly land-fronts became unnecessary, except in specially isolated works; it being deemed sufficient to provide such defences as would protect the garrison from surprise or enable them to repel a sudden assault.

The latest and strongest of our granite forts were built with eight-foot walls, reduced to five feet in the vicinity of the gunports. Totten's iron casemate embrasure protected the can-

* Revised Report of the Board of Engineers, March 24, 1826.

noneers from direct fire when the shutters were closed, and from glancing shots when open, a degree of security not possessed by the works of any other nation. This invention of our chief engineer is of historic interest as the first instance of the use of iron plating on land batteries.

These works were model sea-coast fortifications in their day, and none better existed in the world; but it should be remembered that they were only intended to withstand the fire of the old 10- and 13-inch smooth-bores, guns inferior in power to even the 8-inch rifle of the present day, to say nothing of the 16- and 17-inch guns.

The appearance of the French iron-clad floating batteries during the Crimean War marked the beginning of a new era in naval warfare; and their engagement with the Russian forts at Kinburn * gave rise to serious doubts as to the ability of masonry casemates to withstand these new engines of attack. Heretofore ships had been unable to remain under fire sufficiently long for their guns to produce serious effect upon the batteries, but the use of iron plating reversed the conditions as to security of cover and inclined the balance in favor of the attack.

The developments of our civil war,—the broadside and turreted iron-clads and the long-range heavy ordnance, both smooth-bore and rifled, demonstrated this superiority beyond question, and marked the complete downfall of our third system of sea-coast defences.

The period since the close of that war has been prolific in great advances in the means and methods of attack. The iron plating of ships-of-war has been increased from four inches to twenty-five inches on the English ship *Inflexible*, and when a practicable limit as to the thickness of iron plates seemed reached, compound armor and all-steel plates were introduced. Recent British ships carry eighteen inches of compound armor, and the *Admiral Baudin* and *Formidable* of the French navy are protected by solid steel plates twenty-one and seven eighths inches in thickness.

Heavy ordnance has increased in weight and power to a like extent. Whereas in 1862 our 200-pounder Parrott rifle was one of the most effective weapons extant, we have, in 1872, the English 17¾-inch, 100-ton gun, firing a projectile weighing one ton with a

* Oct. 17, 1855. The three floating batteries (Devastation, Lave, and Tonnante) were protected by iron plates each three feet long, twenty inches wide, and four and one half inches thick.

powder charge of 550 pounds, and in 1884, the 16¼-inch, 110-ton Armstrong, which fires an 1,800-pound projectile, with the enormous charge of 900 pounds of powder, giving a muzzle energy of 61,200 foot-tons, and a penetration of over thirty inches of wrought iron at 1,000 yards. The recent Krupp 15¾-inch steel gun weighs 119 tons, and penetrates 29.2 inches of iron at 1,000 yards; and the projected French gun is to weigh 124 tons, with a calibre of 18.11 inches, and to fire a projectile weighing 2,645 pounds, with a powder charge of 575 pounds.*

Important improvements in the manufacture of powder have greatly increased the power of heavy ordnance. The grains have been made larger and denser, so as to burn more slowly and to diminish the initial and dangerous strain on the gun. Grains of uniform size insure uniform results, and perforated prismatic grains give increasing surfaces of combustion, and hence increasing volumes of gases during the movement of the projectile in the bore. Where we used a 35-lb. charge for the 15-inch gun during the war, we now use 130 lbs. "Cocoa" powder, so called from its color, is now superseding all other varieties for heavy ordnance. The grains are dense hexagonal prisms about one inch long, and one and a third inches across the hexagon, with a cylindrical perforation about one third of an inch in diameter. Its method of manufacture is still a secret, but it is said to light with great regularity, burn very slowly at first, and then with tremendous rapidity. It is claimed that this powder gives less smoke than any other variety, an important point when we consider the heavy charges now used with sea-coast ordnance. It is rather a striking fact that a six-gun field battery of three-inch rifles, firing two rounds per minute from each gun, would, in an hour and a quarter, only consume as much powder as is fired in one round from the 110-ton gun. The impenetrable veil of smoke surrounding a sea-coast battery after even a single discharge from its heavy guns will, at times, be a great obstacle to accurate fire, and will make well-scattered works a necessity.

To insure the complete combustion of such large charges of slow-burning powder, guns have been gradually increased in length up to the present limit of 35 calibres.

Important improvements have likewise been made in the manufacture of projectiles. One measure of the efficiency of a gun is its power of penetrating a wrought-iron plate at a dis-

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* See Table I.—Modern Heavy Ordnance, page 5.

TABLE I.

MODERN HEAVY ORDNANCE.

Country where made.	Nature of gun.	Date.	Weight of gun in tons.	Calibre of gun in inches.	Length of gun in feet.	Charge. Weight of Powder.	Charge. Weight of Projectile.	Muzzle velocity.	Muzzle energy.	Energy per ton of gun.	Penetration; in inches of wrought iron at 1,000 yds.	Remarks.
France	46 c. m., B. L.	*	124	18.11	33.6	575	2,645	1,640	49,315	398	28.1	* Not yet constructed. † Capt. Noble says that 51,900 ft.-tons muzzle energy has been obtained with the 100-ton gun, and that 61,200 ft.-tons is the *computed* energy of the 110-ton gun. Armstrong is constructing 17″ guns for the Italian iron-clad "Lepanto," similar to the 100-ton gun in all respects except in length. They weigh 102 tons.
	42 " "	1875	75	16.50	30.2	?	1,716	1,738	35,932	480	24.2	
	37 " "	1884	71	14.56	36.4	546	1,180	1,955	31,272	440	24.5	
	34 " "	1881	52	13.38	34.1	362	926	1,968	24,868	478	22.9	
England	Elswick, B. L.	1884	110	16.25	43.5	900	1,800	2,020	50,924 †	513	30.5	
	" "	1882	100	17.00	39.5	772	2,005	1,832	46,600 †	460	28.5	
	" M. L.	1872	100	17.72	32.6	550	2,022	1,715	41,226	412	25.9	
	" wire gun, B. L.	1884	18	9.20	20.0	200	380	2,200	12,759	709	20.0	
	Woolwich, M. L.	1875	81	16.00	26.8	445	1,760	1,657	33,360	412	24.7	
	" B. L.	1884	63	13.50	36.0	625	1,250	2,050	36,415	569	28.6	
	" "	1883	46	12.00	27.4	450	849	2,100	26,412	574	24.0	
	" "	1882	43	12.00	25.0	260	714	1,936	18,882	439	20.3	
	" wire gun, B. L.	1884	19	9.20	24.2	330	380	2,520	16,730	880	23.2	
Germany	Krupp, 40 c. m., B. L.	1884	119	15.75	45.1	615	1,632	2,017	46,061	387	29.2	
	" " " "	1881	71	15.75	32.8	485	1,715	1,703	34,502	486	23.8	

tance of 1,000 yards. The shot is the medium through which the power stored in the powder is made effective on the plate; and the energy of the projectile depends directly upon its weight and the *square* of its velocity. Every foot-pound of this energy which is expended in distorting or disintegrating the shot itself is so much wasted work, and in these days of armor plates of tremendous resistance the necessity of having a perfect projectile becomes more and more apparent. Cast-iron shots were replaced by chilled iron years ago, and now forged steel has come to be regarded as the best material that can be used against armored ships or forts. The manufacture of steel projectiles has been carried to the greatest perfection in France, Germany, and England, and their great tenacity has been demonstrated on many occasions.

To give a single instance: In August, 1883, Sir Joseph Whitworth, in testing a 20-ton steel gun intended for the Brazilian iron-clad, *Riachuelo*, fired a 403-lb. steel shell through eighteen inches of wrought iron, thirty-seven inches of well-packed wet sand, one and one eighth inches of steel, various balks of timber, and about sixteen feet more of sand. *The projectile was recovered practically uninjured.*

Against hard armor, however, such as cast iron, steel, and compound, the superiority of steel projectiles is not so marked. This point will be discussed later on.

As to the results of these successive improvements: The ratio of the weight of the powder charge to the weight of the projectile has increased from about $\frac{1}{4}$ in the 100-ton gun of 1872, to $\frac{1}{2}$ in the 110-ton gun, and to nearly unity in the 19-ton Woolwich wire gun of 1884; the calibre of the heavy Armstrong guns has diminished from $17\frac{3}{4}$ inches in 1872 to 17 inches in 1882, and to $16\frac{1}{4}$ inches in 1884, yet the weight of the gun itself has increased; the initial velocity has increased from less than 1,700 f. s. to over 2,000 f. s., and the muzzle energy has been nearly doubled in the past twelve years.

Recent experiments have demonstrated the entire feasibility of firing shells containing nitro-gelatine bursting charges. Up to the present, such trials have been limited to six-inch shells holding about eleven pounds of nitro-gelatine; but there is manifestly no limit as to their use for curved fire with reduced powder charges, and it is highly probable that in future wars we shall have to encounter horizontal fire of this nature from the heaviest guns. The development of this use of high explosives seems to rather favor the attack, and for distant bombardments it will be found most effective.

As regards the so-called dynamite guns, in which compressed air is used as the propelling force, while they may be found economical and even highly effective for certain purposes, their use against iron-clads will be very limited. Their penetrative power is slight, the range is limited, and it will be found very difficult, if not impossible, to throw charges of sufficient size to seriously affect side armor of moderate thickness. The gun is of great length and fires at high angles of elevation, which makes it difficult to secure good cover. No one supposes, nor does the inventor claim, that dynamite guns can ever replace heavy ordnance.*

The Gatling, Nordenfeldt, Hotchkiss, and other machine guns now constitute an important part of the armament of every man-of-war. Some of these guns are mounted in the tops, the gunners being protected by steel or iron shields, and in this commanding position their fire is extremely destructive when directed upon barbette batteries of low command. It is said that two of the Egyptian batteries at Alexandria were practically silenced by the fire of machine guns alone.

The number of iron-clads has, of course, greatly increased. Whereas England had but four such ships in 1861, she now has fifty-seven; and the six ships possessed by France in the same year have been increased to thirty-eight.

Such has been briefly the progress of the attack. Let us now see what we have been doing for our defences.

Soon after the close of the war, experiments were instituted to determine the best method of ameliorating our existing masonry forts to adapt them to the new conditions of sea-coast warfare. These finally culminated in the destruction of the Fort Monroe and Fort Delaware experimental casemates in the fall of 1868. The object sought was to increase the resistance of that portion of the scarp immediately surrounding the embrasure, which was necessarily the weakest portion of the wall. Substantial iron embrasure shields were tried, placed first, near the face of the scarp, and secondly, on the interior. In the first position it was

* The 8-inch gun, now nearly completed, is 60 feet long, and will fire a 75-lb. shell containing 125 lbs. of nitro-gelatine. (Total weight, loaded, 200 lbs.) It is expected that a 2,000-lb. pressure will give an initial velocity of 1,200 f. s., and a range of two miles at an elevation of 30°.

found that the transmitted shock of the projectile was sufficient to detach fragments and splinters on the interior and in some cases even entire stones, which were hurled across the gun chamber to such an extent as would have endangered the lives of any gun detachment had the casemate been so occupied. In the second case the iron shield gave better protection to the interior, but on the exterior the masonry was rapidly smashed to pieces and the embrasure soon became choked by the débris. Ultimately the entire wall between the piers was demolished and the interior fully exposed. These experiments, while not entirely satisfactory, plainly indicated the great difficulties which would be encountered and the great expense which would be involved in the application of iron armor to our masonry forts.

Recent experiments have shown that the 80-ton gun projectile will penetrate twenty-five feet of granite and concrete masonry or thirty-two feet of best Portland cement concrete, and it is now universally admitted that no masonry should be exposed to such fire ; but in 1868 the development of guns and armor was still in its earlier stages, and the condition of our finances did not permit of great outlays in experimental constructions. Earthen barbette batteries were therefore provisionally adopted.

Our armament at this time consisted mainly of smooth-bores, and for this reason the earlier works were built with slight command. Batteries were commenced in all the important harbors, but work progressed slowly, owing to the limited annual appropriations, which fell to $725,000, in 1875, and then entirely ceased. Since 1875 not one penny has been appropriated for the *construction* of sea-coast defences. The annual appropriation of $100,000 for *preservation* and *repairs*, increased to $175,000 since 1881, has not even sufficed to preserve our *unfinished* works, and our defences are actually in a worse condition to-day than they were ten years ago.

The fire of machine guns and small-arms, together with the shell and shrapnel fire of the large guns and the greatly increased length of modern breech-loading ordnance, have made the service of barbette guns in low batteries an impossibility, and in batteries with greater command so difficult as to be practically impossible, without extensive modifications looking towards security of cover for the cannoneers. The penetration of projectiles has greatly increased, and it is now estimated that seventy feet of compact sand, or equivalent thickness of other material, is necessary to stop the heaviest projectiles at close range. Increased thickness of parapets and traverses, bomb-proof shelters for relief detachments, thoroughly protected magazines, good shelter for the cannoneers, and arrangements for depressing carriages must all be made before our batteries can be considered as even ready for modern armaments.

TABLE II.

APPROPRIATIONS FOR FORTIFICATIONS SINCE 1866.

Year.	Appropriation.	Object.	Year.	Appropriation.	Object.
1866	$1,495,000	For construction, preservation, and repairs, including purchase and surveys of sites.	1876	$100,000	For protection, preservation, and repairs.
1867	1,080,000		1877	100,000	
1868	200,000*		1878	100,000	
1869	200,000*		1879	100,000	
1870	1,311,500		1880	100,000	
1871	1,627,500	* Contingencies of fortifications.	1881	175,000	
1872	2,037,000		1882	175,000	
1873	1,579,000		1883	175,000	
1874	719,000		1884	175,000	
1875	725,000		1885	100,000	
Total.	$10,974,000	For construction.	Total.	$1,300,000	For repairs, etc.

Insufficient appropriations have also retarded the development of our heavy ordnance, and while other nations have been making great progress in this respect, we, at the present moment, do not possess a single modern rifle.* For the defence of our entire coast, we have only the following armament: (1) About 150 † 8-inch rifles which have been converted from the old 10-inch smooth-bores. These guns fire projectiles weighing 180 lbs. with 35 lbs. of powder and can penetrate 8 inches of iron at 1,000 yards. (2) About 310 15-inch smooth-bores. (3) A considerable number of smooth-bores of smaller calibres and some cast-iron Parrott rifles. (4) One modern 12-inch rifled mortar and a number of smooth-bore 10- and 13-inch mortars. It has been proposed to convert the 15-inch Rodmans into 11-inch breech-loading rifles, and several have been so converted, but I believe this project has been abandoned since the Sandy Hook experiments of 1883 showed that this gun, when fired with 130 lbs. of hexagonal powder and a steel or chilled cast-iron projectile, gave an initial velocity of 1,676

* Several modern steel rifles of 8- and 6-inch calibres are now being constructed, but none are as yet completed; naval guns are of course not included.

† Fifty more are now in progress of conversion.

feet and a penetration of 10 inches of wrought iron at 1,000 yards. The shortness of the gun makes it difficult to completely consume a large powder charge, and the shape and size of the projectile cause its velocity to diminish rapidly with the distance; but still the results given above show that the 15-inch smooth-bore as well as the 8-inch rifle are useful as subordinate weapons. We cannot, of course, depend upon them alone; a modern iron-clad could lie beyond their effective range and destroy such works as we have by piecemeal, dismount our guns, and drive away our gunners.

Although appropriations have been made for the construction and testing of various experimental guns, and boards have been constituted whose labors have resulted in the accumulation of much useful and important data, and whose reports have contained urgent and specific recommendations, Congress has thus far taken no decided action toward providing a suitable armament for our sea-coast defences.

As the Italians were fourteen and one half months in constructing their first 100-ton gun, and the English took sixteen months to build their first 80-ton gun, it would seem the part of wisdom to begin the purchase or manufacture of our heavy ordnance at once.

In one respect only have we made satisfactory progress. Our system of fixed torpedoes has been gradually developed by experiment and practice, and is now at least equal to any in the world. Plans for the torpedo defence of every important harbor have been prepared and filed ready for use, and torpedo cases, anchors, and such heavy and imperishable parts of the apparatus are being gradually stored in the various works where they are needed. Electrical operating-rooms, with shafts for submarine cables, are being prepared as rapidly as the yearly appropriations permit, and the torpedo corps (Engineer Battalion at Willets Point) has recently been increased to 400 men.

But it should be remembered that torpedoes are of little value without adequate land defences, and in this respect we are lamentably deficient.

For a number of years past careful experiments have been carried on at Willets Point with the Sim's electrical fish torpedo —a type of the offensive class. These torpedoes can be controlled and steered from the shore while travelling at a speed of from ten to twelve miles an hour, have a range of two miles, will penetrate or dive under any ordinary obstruction, and carry charges of four hundred pounds of dynamite, which can be exploded at will or by contact. Weapons of this class should be provided as auxiliary defences of our harbors, but at present we have but the single experimental one.

Such is briefly the history of our sea-coast defences, and such their condition to-day. "With old casemated works designed long before the introduction of the 800- to 2,000-pounder rifled guns into modern warfare; their walls pierced for guns long since out of date; without iron armor or shields, and but partially armed, even with the old ordnance; with old earthworks, some of them built in the last century; with new ones for modern guns and mortars but partially built, and rapidly being destroyed by the elements by reason of their incompletion; with gun batteries without guns, and mortar batteries without mortars; with no carriages whatever for barbette guns of large size, except such as require the cannoneers to load from the tops of parapets, from which they can be picked off in detail by the enemy's sharpshooters; we can make but a feeble defence." * There is not a harbor on our coast that cannot be captured with comparative ease by an iron-clad fleet properly armed and equipped; there is not a single important power in the world which does not possess such a fleet.

PART II.—NECESSITY FOR SEA-COAST DEFENCES.

The great increase in cost of war material during the past century is most striking. In 1873, the British navy included about 118 actual sea-going line-of-battle ships, representing a total original outlay of about twenty-two millions of dollars or $187,000 per ship. Now England has only fifty-seven sea-going armored ships, yet their original cost, for hulls and machinery alone was over ninety millions of dollars. Since 1878, every new armored ship has cost England over two millions, while each of the recent Italian ships represents an outlay of over three and a half millions.

In the revised report of the Board of Engineers on the defence of the sea-board, dated March 24, 1826, the total cost of all works for the defence of the entire coast from Mount Desert Island to the Louisiana frontier was estimated at $16,537,454. Now the Board asks for seventeen and one-half millions to defend New York harbor alone.

* Report, Chief of Engineers, 1880.

One of the results of these increased expenditures has been the establishment of war on a financial basis. It has been truly said that "the modern system is to make war sudden, sharp, and decisive, and *to make the beaten party pay expenses.*" A large war indemnity has now come to be regarded as one of the essential articles of a treaty of peace. As war becomes more expensive yearly, *the cost of defeat increases proportionally.* Germany exacted a billion of dollars from France in 1871, and under similar circumstances we would probably have to pay even more.

Omitting all coast-defence vessels and unarmored cruisers, England has at the present time, 57 ships; France, 38; Russia, 16; Italy, 14; Germany, 13; Turkey, 14; Austria, 9; Holland, 7; Denmark, 6; Spain, 5; Brazil, 5, and Chili, 3; all sea-going, armored ships with powerful armaments.* The number of unarmored ships is, of course, far greater. Should we be so unfortunate as to become involved in war with any one of these powers, their navy would soon be on our coast. To those who remember the panic which swept our northern cities when the telegraph brought the news of the appearance of the *Merrimac* and the result of the first day's battle in Hampton Roads, and the universal feeling of relief from great and unknown disasters which followed the plucky fight of the *Monitor*, it is not necessary to enlarge upon the effect which would be produced by the knowledge that not one but twenty or even fifty such monsters were hurrying to our destruction with all the speed of steam and sail. The prostration of all business and the decline of all securities which would certainly follow a declaration of war, should we remain in our present defenceless condition, would represent a loss which cannot be estimated. Then would we appreciate the significance of the trite but ever important adage: "*In Peace, prepare for War.*"

The objectives of such fleets would be our commerce, our military and naval establishments, and our large cities. The first they would capture, the second destroy, and the third lay under contribution.

A hostile fleet lying in the upper bay of New York would have within reach of their guns about two billion dollars' worth of destructible property in New York City alone, and including Brooklyn and Jersey City, over two and a half billions. These guns would be of the largest calibre, many of them capable of throwing 16- and 17¾-inch shells charged with 75 pounds of ex-

* See Appendix, Table III., Foreign Armored Ships.

plosive gelatine. Should the enemy resort to a bombardment in order to enforce his terms, the result would be terrible beyond description. Even when we read of the havoc wrought by a few pounds of dynamite in the public buildings of London, we have but a slight idea of the completeness of demolition which would result from the explosion of 75 pounds of nitro-gelatine in the interior of such a building as the New York Produce Exchange. There are within gunshot of this room eight buildings,* the assessed valuation of which for 1885 was over twelve millions of dollars. Every one of these might be totally wrecked by just eight happily directed shots. Yet the value of these eight buildings alone would more than suffice for the complete defence of the southern entrance to New York harbor, including works, armaments, and torpedoes of the most modern type.

But the effect produced by shells alone would be insignificant in comparison with the sweeping destruction resulting from the fires caused by their explosions. No fire department, however efficient, could check the progress of the flames, extinguished at one point only to break out at another, even should the men attempt such a hopeless and dangerous task. *New York would be doomed.* It is probable that any terms would be accepted in preference to such a bombardment, and two or three hundred millions would be a small price to pay for exemption from such a calamity.

This is not an exaggerated picture. It is a fair statement of what we have to expect in case of a foreign war, and it places squarely before us the value of what we have to defend here in New York harbor. We must face the alternative of the ransom or the bombardment. No rules laid down by closet students of International Law will protect us ; history teems with examples of the destruction or confiscation of private property in time of war. The bombardment of Paris in 1871, of Alexandria in 1882, and the French operations in China at the present time, are recent examples of how little consideration is accorded to private interests. The truth is that war knows no inflexible law but that of necessity, and necessity would compel such a bombardment as I have pictured as the only means of enforcing the payment of a ransom. If sufficient time were allowed for the removal of non-combatants, women and children, humanity could expect no more.

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* Produce Exchange, Mills, Equitable, Boreel, Mutual Life, and Western Union buildings, the Astor House, and the old Stewart Building (Broadway and Chambers Street).

I have prepared a table giving the value of all destructible property within the reach of an enterprising enemy, in eight of our wealthy seaports.*

This table has been compiled with care, and, while great accuracy is not claimed, it is as nearly correct as possible, considering the uncertain and variable quantities which are involved. All figures and estimates are for the year 1884, and have been obtained from Collectors and Receivers of Taxes, Boards of Assessments, Collectors of Ports, Annual Reports of Tax Departments, and other official documents of a similar nature.

In these eight harbors there is a grand total of four and a half billion dollars' worth of destructible property without any adequate security against the vicissitudes of war.† The continued indifference of the general public to the condition of our sea-coast defences, with such great interests at stake, is indeed difficult to comprehend. Where their personal interests are so directly involved, they are not wont to be so short-sighted.

New York City pays over one and a half millions annually for one of the most efficient fire departments in the world. As a consequence, the total losses by fire, in *insured* buildings and contents (which comprises nearly all the city), have only amounted to sixty-six and a half millions of dollars in the past twenty-eight years. The Secretary of the New York Board of Fire Underwriters ‡ estimates this to be fully ninety per cent. of the total value of property destroyed by fire during that period. On this basis, the total losses in one hundred years would amount to about two hundred and sixty-four millions. Yet New York pays an average of over six millions § annually for insurance against fire, or a total of eighteen millions *every three years.* One outlay of seventeen and a half millions would complete the entire defence of the Narrows and East River to the full extent recommended by our engineers, and the works once completed could be maintained by merely nominal annual appropriations.

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* See Table IV.—Value of Destructible Property Exposed to an Enemy, p. 15.

† It is interesting to note that the value of destructible property is approximately $1,000 for each unit of population.

‡ I am indebted to Mr. William M. Randall for valuable statistics compiled from sworn statements on file in his office.

§ The average for the past eighteen years is $6,267,361.48. The annual premiums have varied but little during that period, the greatest being $8,281,508.75 in 1873, and the smallest $4,608,789.65 in 1878.

TABLE IV.

VALUE OF DESTRUCTIBLE PROPERTY EXPOSED TO AN ENEMY.

City.	Population by census of 1880.	Total assessed valuations for 1884. Real estate and personal property.	Value of real estate after deducting value of land.	Value of personal property after deducting non-destructible portion.	Exempt and untaxed real estate, deducting land value.	Exempt and untaxed personal and movable property.	Total value of destructible property.	Remarks.
Portland	33,810	$32,808,735	$15,595,725	$9,611,548	$2,590,000	$5,348,181	$33,145,454	Local estimates of land valuations differ considerably for different cities. Many items are partially estimated from known values in other cities. In all items the full value of the land is deducted.
Boston	362,839	682,648,000	195,252,280	154,517,300	36,745,543	88,955,275	471,470,398	
Cambridge *	82,508	90,000,000				Estimated.	60,000,000	
Newport	15,693	27,543,600	10,613,700	5,052,960	2,858,000	5,717.000	24,241,660	
New York	1,206,299	1,338,298,343	746.507,731	174,829,397	199,270,545	734,695,370	1,855,303,043	
Jersey City	120,722	64,494,850	38,865,211	3,757,626	24,979,108	46,102,217	113,704,162	
Brooklyn	566,663	317,853,850	198,084,296	16,581,925	96,939,074	293,878,148	605,483.473	
Philadelphia	847,170	583,612,683	382,485,404	7,907,662	92,527,757	306,344,568	789,265,391	
Baltimore	332,313	249,651,699	76,606,445	46,508,469	27,428,570	68,571,430	219,114,914	
New Orleans	216,090	160,000,000	87,600,000	14,000,000	21,865,116	52,932,000	176,397,116	
San Francisco	233,959	244,987,559	47,830,975	52,130,658	23,687,000	57,343,000	180,991,633	
Totals,	4,318,066						$4,529,117,244	

* Including Chelsea and Brookline; all exposed to a fleet in Boston Harbor.

War may do this city more injury in one day than would fire in a century. Such being the case, if insurance against fire is worth eighteen millions triennially, is not insurance against war worth a single payment of seventeen and a half millions?

It is not contended that fortifications should be erected in every harbor along our four thousand miles of coast-line. Our present defences are limited to only thirty* rivers, harbors, and bays, and the increased cost of iron defences will tend to reduce even this number. Modern fortifications should be erected in those harbors only, where the importance of the defence would be commensurate with its cost. But it must be understood that it is not security of property alone which we should seek; fortifications have other requirements.

Our merchant-men, and even our navy, must have secure harbors of refuge at intervals along the coast. The enemy must not be permitted to possess himself of secure and commodious harbors in our own waters, which he can convert into bases of operations, harbors of refuge, places of rendezvous, and supply, and, to a certain extent, repair stations. This point is of special importance inasmuch as iron-clads have far less coal-carrying capacity than other ships,† and with the exception of England, which has the fortified stations of Halifax, Bermuda, Jamaica, and Antigua on the Atlantic coast, and the naval port of Vancouver on the Pacific, no foreign power could maintain a hostile iron-clad squadron on our coast without the continual use of coal transports.

On the other hand, certain harbors are of great importance to ourselves as naval stations or naval strategic points. Such a harbor is Hampton Roads. It would be impossible to exclude the enemy from Chesapeake Bay, but a small fleet of war ships, monitors, gun and torpedo boats, lying under the secure protection of permanent works located at and around Old Point Comfort, would go far towards paralyzing any operations which the

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* The Penobscot and Kennebec rivers; the harbors of Portland, Portsmouth (N. H.), Boston, and New Bedford; Narragansett Bay; the harbors of New London, New Haven, and New York; Delaware River; the harbor of Baltimore, and approaches to the capital *via* the Potomac River; Hampton Roads; the harbor of Beaufort, N. C.; the mouth of the Cape Fear River; the harbors of Charleston and Savannah; Cumberland Sound; the harbors of St. Augustine, Key West, Dry Tortugas, Pensacola, and Mobile; Ship Island; the mouth of the Mississippi, and the other approaches to New Orleans; the harbor of Galveston; the bays of San Diego and San Francisco; and the mouth of the Columbia.

† Vessels of the *Alexandra* class can barely carry sufficient coal for *four* days' steaming at full speed.

enemy might undertake in the upper bay. The case would be analogous to that of a land fortress near the line of operations of an army, and the enemy would be compelled to detach a fleet of observation or reduce the works before advancing. In addition, Hampton Roads is one of the most commodious and safe anchorages on our coast, and would be used as a naval base in case of war.

Perhaps one of the strongest arguments in favor of sea-coast fortifications is the fact that complete protection means not only security of property, tranquillity of business, and facilities for offensive operations in case of war, but it also means protection against war itself. History shows that there is no surer means of avoiding war than by such a thorough preparation as leaves no weak point exposed to an enemy's attack, and no temptation to his cupidity. "Invulnerability to all attacks, except those of an extraordinary character, is the most perfect insurance attainable by a powerful and peaceful nation against the calamity of war" [Report Mil. Com. H. R., April 23, 1862]. Our present condition is well known abroad, and would be far from conducive to a peaceable or honorable settlement of any delicate international or diplomatic question which might arise. A nation that would not hesitate to attack us now, however, would think twice before engaging in such a struggle were we armed and ready at all points.

And now a few words as to the arguments which we see so constantly urged against the construction of permanent sea-coast fortifications. These are principally:

(1.) That the navy should constitute our defence.

(2.) That torpedoes alone will suffice to close any channel.

(3.) That earthen batteries of sufficient strength can be hastily thrown up in the event of war.

There are indeed others who talk vaguely of "millions of strong arms being ready for our defence," but the absence of any definite suggestions as to how these "strong arms" are to be made available against iron-clad fleets leaves us nothing to discuss.

A perfect defence would always require the use of torpedo boats, gun-boats, monitors, and even ships-of-war in addition to land fortifications, but I do not think that any officer, either military or naval, would advocate a purely naval defence. It would be objectionable, first, because the sphere of action of our navy is, or ought to be, essentially offensive, and they should not be tied down to our own coast, leaving the enemy free to sweep our commerce from the seas. The memory of our glorious naval victories during the War of 1812 should be sufficient to prevent any attempt to restrict our navy to such a passive rôle. And, second, because guns on fixed land supports possess certain decided advantages over guns on floating supports. These advantages are: less original cost; less cost of maintenance; less rapidity of deterioration; greater accuracy of fire; certainty of position and availability at the critical moment; invulnerability to the attacks of modern improved torpedoes such as the Whitehead; and freedom from such accidents as collisions or grounding which may cause serious injury to naval batteries or even their total loss.

To completely protect our coast by the navy alone would require a fleet in each harbor at least equal to the enemy's fleet, since we cannot foresee the point of attack; and even then the forces being equal we would simply have the advantage of the defensive, while defeat to us would mean not only the loss of our fleet but also of the place to be defended. It is needless to say that we shall never possess a navy of such strength.

The practice of all nations has been to defend their coasts by permanent fortifications, and unanimity of opinion on such a point is always a safe guide.

Entire ignorance of the nature and object of torpedoes could alone excuse such an argument as the second. Torpedoes have been introduced into defensive warfare to offset the advantages gained by the attack in the invention of the screw propeller. Their function is simply to prevent the enemy from running by the batteries, and to hold him under the close fire of the guns in case of such an attempt. They are not self-defending, and unless protected by land batteries will offer but a slight obstacle to an enterprising enemy. Electrical torpedoes are dangerous only so long as the connecting cables are continuous from the torpedoes to the battery on the shore. If these arteries be severed, the torpedoes, deprived of their life-giving current, become inert and harmless buoys. Whatever be the system, a single ship may blast a way through the lines and buoy a safe channel for the balance of the fleet. These operations would be comparatively simple if unopposed, but would be nearly impossible in the face of modern batteries with modern armaments.

I doubt whether the advocates of extemporized earthern batteries have ever figured upon the time necessary to construct such works. Should it unfortunately happen to be the winter season, no earthworks at all could be constructed on our northern coasts; and even under favorable circumstances, making the most extravagant estimates, allowing the largest available force and working both day and night, it would still take over a week to construct even the seventy-foot parapet. Long before the expiration of that period the enemy might be upon us. Bermuda is only seventy-one hours' steaming from Savannah, sixty-six hours from Charleston, and fifty-eight hours from New York. Thirty-one hours would bring a British fleet from Halifax to Portland, and thirty-six hours to Boston. A Spanish fleet in Havana would only require forty-five hours to reach New Orleans, and ninety-six hours from Vancouver would place a British fleet in front of San Francisco. But even granting that the parapets may be finished (and much would depend upon the length of the negotiations preceding the declaration of war, and upon the use made of this time), of what use would they be without guns, and where would we obtain our armaments? Should we to-day send our order to Krupp or Armstrong, it would be three years before we could obtain guns sufficient for the defence of New York harbor alone. It would take much longer to manufacture them ourselves, as at present we have neither the necessary machinery nor experience.

Again, even should we have the good fortune to complete our batteries and the foresight to procure our guns in times of peace, how would we mount them? This is one of the most difficult questions of all, and yet, strange to say, the one least considered. One-hundred-ton guns cannot be mounted on wooden platforms like siege pieces. Depressing carriages are a *sine qua non* for barbette guns, and such carriages weigh nearly as much as the gun itself. The ordinary carriage of the 110-ton gun weighs ninety tons, or the gun and carriage together weigh two hundred tons. Large masses of masonry, with deep, broad, and secure foundations, are necessary to bear such weights. The only attachment of the carriage to this platform is a single iron or steel bolt or shaft called the pintle, around which the carriage revolves to permit of loading and pointing. The pintle must be solidly anchored in this masonry platform, and no mere mass of concrete hastily mixed and placed would stand the strain to which it would be subjected in action. The muzzle energy of the 110-ton Elswick gun is 50,924 foot-tons, or, in other words, should the projectile encounter some obstruction just as it leaves the gun, it would have the same power to produce smashing or penetration as would a solid column of cast iron of the same diameter, one mile long, falling from a height of thirty-three feet and striking on its end. The phenomenon of recoil is familiar to all, but few realize what this word means in the case of heavy ordnance. Omitting from consideration the weight of the top carriage, the gun would be impelled backwards with a velocity of fourteen feet per second, by the same force which imparts a velocity of 2,020 feet per second to the 1,800-pound projectile. If any one can conceive of the power required to suddenly stop this mass of 246,400 pounds moving at the rate of fourteen feet per second, he will have some idea of the tremendous strain thrown on the pintle. The modern tendency is to hold the gun well up to its work, and to limit the recoil to a very short distance. Vavasseur's rule is to allow only three calibres recoil, and with some of the smaller guns Krupp permits practically none. The effect of this is to theoretically slightly increase the velocity of the projectile, but practically to economize space and to greatly increase the *shock* on the pintle. The recoil is checked by the aid of friction and hydraulic buffers, and the pintle is somewhat assisted by deeply grooved chassis wheels and other devices; but however the strain may be regulated or distributed it is still enormous, and no platform not composed of carefully cut stone, well bonded together and laid in good hydraulic cement, could stand it. It would require weeks to construct such a platform, even in the most pressing emergency, and months would be necessary for it to set and harden before it could be used.

Magazines and bomb-proofs, loading galleries and store-rooms, boiler- and engine-rooms, shell-lifts and machinery for loading and manipulating the guns must all be constructed or mounted, and must have secure cover against projectiles capable of penetrating 60 feet of sand or 32 feet of concrete masonry. Such works cannot be "improvised." The time necessary for their construction is easily estimated, and is measured by months, not days. If we wait for the commencement of hostilities, the war will probably be over before our batteries are ready for action.

I have devoted considerable time to the question of extemporized fortifications, as it seems to be the favorite argument of all those who give so little attention to this subject that they do not or will not realize our defenceless condition; who see no necessity for constructing harbor defences in times of peace; and who (as has actually been stated on the floor of Congress) "see no indication that the food shall be taken from the mouth of labor to gratify the insatiate ambition of any man or body of men."

If such men would only devote a few moments to the consideration of the practical difficulties of such hasty constructions, some of which I have endeavored to portray, we might hope that our next war would not find us entirely unprepared.

It is always difficult to foretell what the future may bring forth, but every thing indicates that the limit of armored plating for war ships is about reached. Twenty-five inches of wrought iron is the greatest thickness yet attained with that metal, and we have already reached nearly the same thickness with steel. A few more inches and the flotation will be cut down to the minimum limit. Referring to the Spezia trials of last October an English authority says: "The advent of forged steel projectiles has demonstrated once more the incomparable superiority of the gun over armor, and has suggested to many the necessity of either proceeding to armor of a minimum thickness of 24 inches, or else of abandoning it altogether."

The future of heavy ordnance is not so easily predicted. The difficulty of mounting and manœuvring guns of great weight must ultimately limit progress in this direction, but we may undoubtedly look for improvements in other ways. Heavy guns are now made entirely of forged or compressed steel, but of late steel wire has been regarded with more favor, and it seems at least possible that the wire gun, so long and so persistently advocated, and so systematically neglected, may become *the* gun of the future.

Improvements in powders and means and methods of ignition may, in time, give us greater velocities, and, therefore, greater power than we now obtain, with perhaps even smaller guns. We already use a powder charge nearly equal in weight to the projectile, and nothing indicates that we shall stop at this point. With heavy powder charges, however, the recoil becomes a serious consideration, and weight in some shape is necessary to sustain it.

But none of these possible changes requires further delay in the construction of coast defences, while every thing points to the necessity of immediate action. General Newton says: "For the first time in the development of the modern art of war, the engineer has solved, with mathematical certainty, the problem of closing harbors and rivers against hostile ships, so that the sole question in each particular case would be whether the importance of the place would justify the cost." The bloodless battle between guns and armor has been well fought on the trial grounds of Europe, and the time has now come when we should profit by the result and begin to put our house in order against any emergency. It is true that our horizon is not yet darkened by the war-clouds that hang so threateningly over Europe, but no one can foresee when war may come, and history, including our own, teaches us that even the most just, equitable, and upright policy will not always avail to preserve the blessings of peace. We should not commit the folly of waiting till the time for preparation is past and the hour for action is upon us.

PART III.—MODERN SEA-COAST DEFENCES.

A complete system of sea-coast defences consists of three lines. The outer line is composed of war ships; the second or skirmish line of torpedo boats; and the third or inner line of land fortifications and channel obstructions, usually fixed electrical torpedoes. Besides these, there should be a reserve of war ships, torpedo boats and launches, gun-boats, etc.

The first two lines and the reserve constitute the naval defence. The outer line is frequently wanting, either through accident, or design, or lack of ships. The second line is a comparatively recent addition to the defence, but has been adopted by all nations, and now constitutes a most important part of the system.

The torpedo boats of this line are light and handy, have great speed, and are built of steel, with low free boards and flush decks, when possible, so as to expose a minimum surface to the enemy. First-class boats are ordinarily "about 100 feet long, with a draught of from 4½ to 6 feet of water; a capability of maintaining a speed at sea of not less that 16½ knots; an endurance at this speed of over 150 miles, and a maximum endurance of from 650 to 1,200 miles; an armament of torpedoes and revolving cannon; and a capability of keeping the sea under all conditions of weather." * Whitehead torpedoes are almost exclusively used with these boats, and are discharged by means of compressed air or steam from under-water tubes permanently built into the bow, or in some cases from torpedo guns on deck. Second-class boats are smaller, being from 50 to 80 feet in length, and those of minimum size constitute a part of the equipment of a first-class man-

* Lieut. Very's "Report on Torpedo boats for Coast Defence," August, 1884. Recent torpedo-boats are built with greater dimensions than those given, and develop a speed of from 20 to 22 miles an hour.

of-war. The average cost, including armament, has been placed at $57,000.

A fleet of these boats, if superior to the enemy's torpedo fleet, would effectually prevent the close blockade of any harbor, as a blockading squadron would be forced to haul off the coast at night for fear of their attacks.

All foreign powers are expending large sums in the construction of torpedo boats. In 1883, including those building, England had 129, France 76, Russia 125, Italy 53, Holland 24, Norway and Sweden 15, Austria 14, and Denmark 9. Germany is rapidly completing a fleet of 150 boats, and other powers are continually increasing their fleets. These figures are sufficient evidence of the general estimation in which this form of defence is held abroad.

At present we have no coast-defence torpedo boats of this class. Lieutenant Very estimates 90 * as the minimum number for effective resistance in case of war, and 34 as the smallest allowable peace footing.

The third line of defence is of course the most important—I may say the all-important. On this our chief reliance must be placed, and no efforts and no expense should be spared to make it complete and impregnable. The works of this line must be so located that the enemy cannot come within range of the objects to be protected without passing the line, and must be sufficiently strong to prevent him from forcing a passage. This requires that they should be placed at distances of not less than seven miles from our cities and navy yards; should be located at favorable (preferably narrow) parts of the channel; should be constructed with all possible strength; and should have armaments at least equal in weight of metal to those of any possible attacking squadrons; and that the torpedo defence should be so complete that no ship could attempt to cross the lines without incurring the risk of almost certain destruction.

The most common problem will be to close the channel leading to one of our large cities. We may expect the efforts of the enemy to be proportioned to the importance of the objective, and we must mount as many guns as can be brought to the attack, or compensate for any deficiency in numbers by increased power. The great cost of 100-ton rifles will limit the number of such weapons to that necessary to ensure the destruction or

* The German rule of one boat to each ten miles of coast line would require some 300 boats for the Atlantic coast alone.

serious injury of the heaviest-armored ships. Smaller and more rapid-firing guns will suffice for the weaker iron-clads and unarmored ships, and by multiplying these we can obtain the necessary preponderance of fire.

The works containing the heaviest guns should evidently be placed close to the bank, or even in the water, on natural or artificial islands, so that we may have the closest range and every chance of penetrating the enemy's armor and disabling his ships. Each round from the 100-ton gun costs from three hundred to one thousand dollars, according to the nature of the projectile; it is, therefore, of the greatest importance that such fire should not be wasted. As the enemy will attempt to clear the channel and run the gauntlet of the batteries, we should so arrange these defences that he cannot remove the torpedoes without remaining so long under our close fire that the issue shall not admit of a doubt.

Guns ranging from twenty to fifty and possibly eighty tons in weight should be placed in well-scattered batteries—some along the banks, so as to thoroughly command the channels of approach, and some on higher and more retired ground, where they have better protection and the advantage of a plunging fire. The position and armament of each battery will determine its method of construction.

The 100-ton gun batteries will usually have little command, and will be fully exposed to the enemy's fire. This requires the use of covered defences, and, as it is desirable to utilize to its full extent the great power of these expensive weapons, they should generally be mounted in revolving armored turrets.

The Board of Engineers "deems it advisable to make the armor of turrets or casemates not less than 36 inches thick, if of wrought iron, or of equivalent resistance, if of other material." On this basis, the estimated cost of a revolving turret for two 100-ton guns, complete, is given as $600,000 The estimated cost of the turret, *exclusive* of the armor, is $220,000.* The guns cost $100,000 each.

The low shore batteries must likewise be covered, and this again requires armored fronts. There are three classes of such

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* Capt. Bixby, Corps of Engineers, U. S. A., gives the following estimates. Approximate cost of a turret for two 16-inch rifles, armored with 14-inch steel-faced armor or its equivalent, and furnished with steam or steam-hydraulic gear for the entire service of ammunition, guns, and turrets, but *without including cost of guns or foundations*, $200,000 to $300,000. This may be divided as follows: 20% for ordinary iron work, 35% for armor, and 45% for steam or steam-hydraulic machinery.

works: continuous armored scarp or iron-fronted batteries, armor shields with masonry parapets, and armor shields with earthen parapets.

The iron-fronted batteries are similar to our old granite forts, with a single tier of casemates, iron or other armor being substituted for the masonry scarp. The light over-head plates and concrete or earthen roofs are supported by iron columns, and this allows the guns to be spaced at comparatively short intervals; in one example of an English wrought-iron battery the distance between consecutive gun-ports being only eight yards, with a horizontal field of fire of 70°; while in drawings of Grüson's cast-iron forts the guns are spaced at intervals of only five and a half yards.

A contracted site might require two tiers of casemates to afford the requisite volume of fire. Such batteries could be constructed with wrought-iron scarps, though they possess manifest disadvantages, and should always be avoided, if possible.

The Board of Engineers estimate the cost of single-tier wrought-iron casemated batteries at $100,000 per gun. Breech-loading rifles of about fifty tons' weight would be mounted in these works, and such guns cost $50,000 each.

Masonry parapets with iron embrasure shields have been used in the past, but excepting in England they have few advocates at the present time. No masonry walls can withstand the fire of modern ordnance.

Earthen parapets with iron shields constitute a far more efficient form of battery, the Grüson cast-iron and English wrought-iron shields being well-known types of this class. The shield permits of the reduction in thickness at the embrasure which is essential for lateral range; and the use of earthen merlons, between which the shield is fixed, makes this battery more economical than the continuous iron-fronted works. The thick merlons, however, require a great development of front for a small number of guns; in actual examples the guns being spaced at average intervals of twenty yards, and great difficulty is found in securing an unyielding connection between the shield, the parapet, and the floor of the gun chamber. These are serious objections. No form of battery involving the use of shields is recommended by the Board of Engineers.

The Shoeburyness experiments of 1883 have indicated a method by which our existing masonry forts can be made effective, though the advisability of such reconstructions is more than doubtful.

These experiments had for an object the determination of the amount of protection afforded to granite walls by armor plates. A 1,700-lb. Palliser chilled-iron shell from the 80-ton gun, with a striking energy sufficient to penetrate 25 inches of wrought iron, failed to completely penetrate a 12-inch Cammell compound plate. This unexpected result was due to the rigid backing, 22 feet of granite and concrete, and to the excellence of the plate. Col. Inglis, R.E., says: "Considerable importance attaches to this trial, because it has certainly shown an effectual way of making existing masonry proof against any battering guns that can ever be produced, though the great expense of armor-plating large surfaces makes it very desirable that some less costly expedient should be found effective."

The five-foot wall around the embrasures of our granite forts would certainly not afford the rigidity of backing which was evidently so effective in this experiment. Plates of much greater thickness than 12 inches would have to be used, and even should the plate not be penetrated when struck by a heavy projectile, it is certain that the granite blocks would be hurled through the casemate by the transmitted shock, as in the experiments of 1868. Moreover, our masonry forts were constructed for the old muzzle-loading 8- and 10-inch * smooth-bores, and to adapt them to the service of modern 50- or even 30-ton breech-loading rifles would require such extensive alterations that taking all together it might even be cheaper to construct new batteries.

All iron defences should be lined with rope mantelets fitting closely around the guns, to deaden the effect of vibration and sound when the exterior is struck by a heavy projectile; to screen the cannoneers from fragments and splinters thrown off on the interior, and from small projectiles and missiles entering through the gun-ports; to reduce the effect of blast and concussion when the guns are fired; and, as far as possible, to keep the smoke from the gun-chamber.

For more retired batteries with commands of from 75 to 100 feet, earthern parapets may be used, the guns firing *en barbette.* The parapets will require a thickness of 70 feet of compact sand, or equivalent thickness of other material. Ordinary con-

* All works built subsequent to 1835 will hold 10-inch guns, and the latest of our granite forts were planned for 13-inch smooth-bores.

crete is estimated to have twice, and concrete containing large granite blocks, three times the resistance of sand. One or both of these materials should be used in the interior of the parapet. One traverse for each gun will be necessary, and these should be made high enough and thick enough to afford thorough protection to the magazines, loading galleries, engine and boiler-rooms, store-rooms and bomb-proofs, located in or below them. In recent projects prepared by the Board of Engineers, it is proposed to use breech-loading guns with depressing carriages, manœuvred by steam or hand power. The interior crest is to have a height of 16 feet above the terre-plein; the carriage is to permit of a vertical descent of 6 feet after firing; and the gun is then to be traversed parallel to the parapet on a front pintle, so that the breech comes opposite and near to the loading gallery under the traverse. The operation of loading can then be safely performed from the gallery. In this way, the gunner would be the only man exposed and he could be protected from machine gun and small-arm fire by a steel shield on the breech of the gun. To secure proper cover, the traverses have to be raised some 10 feet above the interior crest, and their great width requires the guns to be spaced at intervals of 41 yards. To obviate the conspicuousness of the mark thus offered, it is recommended that small trees and shrubs be planted on the exterior slope and in front of the parapet. The estimated cost of these batteries is $13,164 per gun.

For the defence of anchorages and roadsteads, and for confined positions where fleets must advance in contracted order or take fixed positions for attack, mortar batteries will play an important part. They attack the most vulnerable portion of the ship—that is, the deck; and the accuracy of fire has so increased since the introduction of rifled mortars that they now constitute a most effective part of our sea-coast armament. It would be impossible for a fleet to remain stationary for any length of time when exposed to the fire of modern 12-inch rifled sea-coast mortars.

These batteries should be placed on elevated and retired points which may not be needed for other purposes, and should be constructed with sunken terre-pleins and inconspicuous earthen parapets. Since thc security of cover is complete, except indeed against similar vertical fire, economy of construction would dictate the massing of mortars in large batteries. This is recommended by all authorities. Modern rifled mortars cost about $15,000 each, but their emplacements can be prepared for

$2,000, and $17,000 will cover the cost of each mortar ready for action.

The increased thickness and weight of armor plating of modern war ships has resulted in the development of a class known as central battery or citadel ships, in which the armor protection is limited to the space containing the machinery and heavy armament. The remainder of the ship, both fore and aft, even at the water line, is left at the mercy of the enemy, and flotation is preserved by the use of water-tight compartments, filled with cork, and light deck armor below the water line. This system of construction has been frequently and severely assailed by competent critics. Only a few weeks ago Capt. Fitzgerald of the English Navy said: "From a naval point of view, it is a grave, nay a fatal error, to leave two thirds of the water lines of our line-of-battle ships absolutely unplated, and therefore certain to be penetrated in a hundred places by the terrible hail of light- and machine-gun fire which would be poured upon them in action; seeing that in this condition their seaworthiness would be at least doubtful." It is even asserted that the stability of these ships would be destroyed by the penetration and flooding of either the bow or stern compartments. The present tendency is to supplement the heavy armament of first-class ships by a considerable number of light breech-loading rifles,* rapid-firing and machine guns. If these weapons are useful in combats between iron-clad fleets they will be still more important in engagements between iron-clads and sea-coast fortifications, and the main advantages will be entirely on the side of the fortifications. Large numbers of such guns should be mounted in land batteries, to neutralize the enemy's fire; to discourage his sharp-shooters; to riddle the unarmored portions of his ship; to pour a stream of projectiles through every gun-port; to repel boat attacks; to assist in protecting the torpedo lines; and to defend our works from land attacks in flank and rear. As they are comparatively inexpensive, easily moved, and only auxiliaries to the main defence, they will not require such secure cover as the heavier guns. They should be so concealed from the enemy that he can only locate them by their fire, and may be mounted in earthern sunken batteries outside of, but not in line with the main works, keeping always in view the special purposes above mentioned and the advantage of a concentrated fire on the hostile fleet.

* The Italia and Lepanto are each to carry twenty-two 6-inch rifles.

In view of the important part destined to be taken by machine guns in future sea-coast warfare, the following brief description of these weapons may not be without interest.

1. RAPID-FIRING GUNS.—Strictly speaking these are not machine guns, but occupy a position midway between machine guns proper and small-calibred breech-loading rifled cannon. For naval purposes they are mounted on fixed stands permitting practically no recoil; are loaded by hand with fixed ammunition similar to that used with small-arms; are pointed rapidly and easily by aid of shoulder rests; and are provided with pistol grips and triggers for firing.

The first seventy-seven Hotchkiss guns of this class were delivered to the British Admiralty last month (April). They are 2.24-inches calibre; weigh 1,000 pounds each; and fire either chilled, common, or shrapnell shell, or case shot. The initial velocity is 1,900 feet per second; the projectile weighs 6 pounds, and will penetrate 4 inches of steel at 300 yards. Two men are required to serve each gun, and 12 aimed rounds can be fired to the minute.

The Nordenfeldt gun is similar to the Hotchkiss; and both manufacturers are prepared to supply much heavier weapons, whenever they may be required.

2. HOTCHKISS REVOLVING CANNON.—These are of three sizes—1.46-in., 1.85-in., and 2.09-in.; have five barrels each; and fire steel projectiles weighing respectively 1 pound, 2½ pounds, and 4 pounds. The barrels are revolved by a handle, one shot being fired at each revolution of the handle. About twenty aimed shots can be fired to the minute.

3. NORDENFELDT VOLLEY GUNS.—These are of several patterns, the heaviest being the two-barrelled 1½-inch calibre, weighing 450 pounds. This gun fires 22-ounce steel shot or shells at the rate of 40 volleys or 80 shots per minute. The initial velocity is 1,600 f. s., and the penetration 1½ inches of iron at 300 yards. The four-barrelled 1-inch guns used in the British navy weigh, with the mounting, 700 pounds, and fire 8-ounce projectiles at the rate of 65 volleys or 260 shots per minute.

4. GATLING GUN.—Number of barrels, 10; calibre, .65 inches; weight, 725 pounds; weight of lead projectile, 3¼ oz.; muzzle velocity, 1,427 f. s.; rapidity of fire, 1,200 shots per minute.

5. MAXIM GUN.—In some respects this is still an experimental weapon, but it bids fair to supersede all other varieties of

machine guns. The empty cartridge case is extracted, a new cartridge inserted, and the gun fired, all by the force of recoil from the preceding explosion; so that if one round be fired by hand, the gun will go on firing by itself so long as the supply of cartridges remains unexhausted. With a single barrel, it is said that this gun will fire 600 rounds per minute. The rapidity of fire is easily regulated by proper mechanism.

6. GARDNER GUN.—Number of barrels, 2; calibre, .45 inches; initial velocity of lead projectile, 1,280 f. s.; rapidity of fire, 357 shots per minute. Like the Gatling, this gun is fired by turning a hand crank, all the barrels being fired at each revolution of the handle.

No floating obstruction offers so serious an obstacle to the enemy as fixed electrical torpedoes. These should be planted by grand groups and skirmish lines so as to cover a wide area and render countermining, under the close fire of the batteries, a difficult and fruitless labor; and should be placed so close together as to make it an absolute impossibility for any ship to pass the lines without striking one or more torpedoes. A single touch would mean destruction. Electrical torpedoes have this advantage, that a single movement of the firing-battery switch renders the channel safe for our own vessels, and a similar reverse movement will close it in the face of an enemy. The electrical operating rooms must be placed in the most sheltered and secure positions in the works.

Mechanical torpedoes may be used to block one of several channels, or even the only channel in cases of emergency or in unimportant harbors, but such torpedoes, once planted, close the channel to friend and foe alike.

The torpedo lines must be well flanked, for protection against counter-mining and to prevent the enemy from removing the torpedoes or cutting the cables at night. This may sometimes be done by the works previously described, but in general, special flanking defences will have to be constructed. Such works should be placed in sheltered positions, protected from the enemy's distant fire, and should be armed with smooth-bores—firing grape and canister—and machine-guns. The former may be so arranged as to be fired automatically by any one disturbing the torpedoes in the line along which the gun is trained. Earthen parapets will generally suffice for such batteries.

The boat-houses and dynamos for the fish torpedoes, sunken and floating channel obstructions of a passive nature, and electric lights and apparatus are component parts of the third line of defence.

The arrangements for the auxiliary defences would include boat-houses and air-compressors for torpedo boats; gun-boats; torpedo launches and pinnaces; guard and picket boats; and all the numberless details of a similar nature. Many of these could be improvised after the declaration of war; others would require previous and careful preparations; and all are of great importance to a vigorous defence.

To recapitulate: The defences of our important harbors should consist of three lines and a reserve.

1st line—War ships.

2d line—Torpedo boats.

3d line—Channel obstructions and land batteries.

Reserve—War ships, and auxiliary defences.

The land batteries of the third line are of six classes:

1. Revolving armored turrets, used where all-round fire is essential, containing the heaviest guns, and so placed as to ensure the destruction or serious injury of the strongest iron-clads which may attempt to force the line.

2. Iron casemated forts, used when all-round fire is not essential, containing guns of smaller calibres, and so placed as to thoroughly command the channels of approach, and to assist in maintaining the preponderance of fire necessary for a secure defence.

3. Earthen barbette batteries, to be used in connection with the foregoing works or as substitutes for them.

4. Mortar batteries, armed with 12-inch rifled mortars.

5. Machine-gun batteries, containing large numbers of modern rapid-firing and machine guns.

6. Torpedo flank defences, armed with smooth-bores and machine guns.

The extent, character, and locations of the fortifications, and the size and number of the guns constituting their armaments, will depend upon the circumstances and requirements of the defence, and will so vary with each locality that extended and detailed study will be essential for the proper application of this system to any particular harbor.

"If the water is so shoal as to permit the approach of light-draught vessels only, barbette batteries may suffice. Where the channel is deep, but so narrow as to compel the ships to move up in single file and attack bow on, heavy guns should be mounted in iron casemates, supported by batteries of lighter guns mounted in barbette; but when the channel is both broad and deep, with ample room for the development of the attack, every available means of defence must be employed." * The full complement of torpedoes should be provided in all cases.

The advantage of all-round fire which armored turrets possess is so great that it has been estimated that when such fire is required two guns in a turret are equivalent to six guns in shielded or casemated batteries. Turrets may be advantageously placed on commanding points when such positions fulfil the conditions before given.

Iron-fronted batteries restrict the lateral range to 70° or less, and are very costly. Nevertheless they are essential in positions where suitable elevated sites cannot be obtained, and under any circumstances in important harbors where dependence should not be placed on open batteries alone. If properly constructed they can only be silenced by direct embrasure shots.

Open batteries possess manifest disadvantages. They are exposed to distant curved and vertical fire, and to small-arm and machine-gun fire at closer range. If depressing carriages be used, they will probably not suffer severely from the latter fire, but the long-range medium-sized rifled guns of the attack may do great execution. On the other hand, barbette batteries have the great advantages of limited cost and an unrestricted field of fire.

Table V.† gives the nature and estimated cost of the defences proposed for eight of our important harbors, the armament of these works, the value of the destructible property thus covered, and the ratio of the cost of defence to the value of the property protected.

NEW YORK HARBOR.

The defences of New York Harbor, as proposed by the Board of Engineers, are to consist of two revolving armored turrets on the site of old Fort Lafayette, and two similar turrets on the Staten Island side, each mounting two 100-ton guns; two casemated batteries, each pierced for ten 50-ton guns; two earthen barbette batteries, each armed with ten 20- or 30-ton guns mounted on disappearing carriages; and two mortar batteries mounting

* Report, Board of Engineers, 1884. † Proposed Harbor Defences, page 33.

TABLE V.

PROPOSED HARBOR DEFENCES.

Harbor.	100-ton guns mounted in revolving turrets.	50-ton guns mounted in iron casemates.	50-ton guns mounted in barbette batteries.	30-ton guns mounted in barbette batteries.	20-ton guns mounted in barbette batteries.	12-inch rifled sea-coast mortars.	Cost of iron turrets	Cost of iron-casemated batteries.	Cost of barbette batteries.	Cost of mortar batteries.	Total cost of gun emplacements.	Cost of armaments.	Total cost of forts and armaments.	Total cost of defence. Add 25 per cent. for cost of torpedoes and flanking defences, modifications of existing works and of sites.	Total value of destructible property protected.	Ratio of cost of defence to value of property protected.
Portland . .			20		20	48			$1,400,000	$96,000	$1,496,000	$2,120,000	$3,616,000	$4,520,000	$33,145,454	.136
Boston . . .	8	10		10	15	100	$2,400,000	$1,000,000	550,000	200,000	4,150,000	3,250,000	7,400,000	9,250,000	531,470,398	.017
Newport . .			10		10	48			700,000	96,000	796,000	1,420,000	2,216,000	2,770,000	24,241,660	.114
New York .	14	30		15	15	144	4,200,000	3,000,000	900,000	288,000	8,388,000	5,660,000	14,048,000	17,560,000	2,574,490,678	.007
Philadelphia .		10			10	16		1,000,000	300,000	32,000	1,332,000	940,000	2,272,000	2,840,000	789,265,391	.004
Baltimore . .		5			10	16		500,000	300,000	32,000	832,000	690,000	1,522,000	1,902,500	219,114,914	.009
New Orleans .	8		20		10		2,000,000		1,100,000		3,100,000	2,000,000	5,100,000	6,375,000	176,397,116	.036
San Francisco	10		20	71	5	96	3,000,000		3,080,000	192,000	6,272,000	5,670,000	11,942,000	14,927,500	180,991,633	.082
Totals .	40	55	70	96	95	468	$11,600,000	$5,500,000	$8,330,000	$936,000	$26,366,000	$21,750,000	$48,116,000	$60,145,000	$4,529,117,144	.013

forty-eight mortars each, The batteries are to be constructed on either bank in the vicinity of Forts Hamilton and Wadsworth.

This defensive line is distant about six miles from the Battery, and the works would command all approaches in the lower bay north of Sandy Hook. The channel is narrow, permitting the effective use of torpedoes and compelling hostile ships to pass within close range of the works on either bank. It is believed that these fortifications, together with the channel torpedoes, would make the line impregnable, but where so much is at stake every means of defence should be exhausted, and every possible auxiliary in the shape of war ships, monitors, torpedo boats, movable torpedoes, etc., should be provided.

Ships could not maintain a bombardment from any position within three or four miles' range of these works, and this would place them beyond reach of New York City. The extreme range of modern ordnance is not so great as is popularly supposed.

TABLE VI.

EXTREME RANGES OF MODERN HEAVY ORDNANCE.

Gun.	Elevation, 45°. Range in miles. Héliés' formula.	Elevation, 38°. Range in miles. Héliés' formula.	Elevation, 35°. Range in miles.		Elevation, 20°. Range in miles.	
			Bashforth's formula.	Héliés' formula.	Bashforth's formula.	Héliés' formula.
119-ton Krupp	10.184	9.990		9.779	7.407	7.642
110-ton Armstrong . .	10.331	10.134	9.592	9.929		7.746
100-ton Armstrong . .	9.487	9.300		9.105	6.817	7.042
80-ton Woolwich . . .	8.546	8.372		8.191	6.102	6.279
63-ton Woolwich . . .	10.405	10.208	9.536	10.003		7.816

Table VI. gives the ranges of some of the heaviest guns at different angles of elevation.* Many of the smaller guns have nearly equal ranges, but those given are sufficient to indicate a probable limit of less than eleven miles.

It will be noticed that the extreme range in the table (10.4 miles) is obtained with the 63-ton Woolwich gun when fired at an elevation of 45°. Such an elevation would, however, be impossible with naval guns of great weight, for even should the carriage permit, the deck could not be subjected to such a strain. An ele-

* Computed by Lieut. Bruff, Ordnance Department, U. S. A., by Bashforth's and Hélié's formulas. Ranges can only be approximately determined by computations; these are doubtless correct within a fraction of a mile.

vation of 20° is probably an extreme limit for heavy guns mounted on ships-of-war. This angle gives a range of 7.8 miles with the 63-ton gun, and 6.8 miles with the 100-ton gun. New York and Jersey City would therefore be completely protected from naval bombardment by the proposed defences, and Brooklyn to a great extent. There are, however, positions off Coney Island from which the suburbs and southern portion of the latter city could be reached.

But the enemy's fleet must enter the upper bay before he is in position to demand a ransom from these great cities. As has been shown, this would present no great difficulty in the present condition of our fortifications, but with the proposed system of defences it would be an impossibility.

The entrance from Long Island Sound is of scarcely less importance: it would not be necessary for a fleet to pass Hell Gate in order to have New York City at their mercy, and ships of any draught could proceed as far as Ward's Island without difficulty. It is proposed to construct revolving turrets (three), iron casemated batteries, barbette and mortar batteries, near the present forts at Willets Point and Trogg's Neck, mounting in all six 100-ton guns, ten 50-ton guns, ten 20- or 30-ton guns, and forty-eight 12-inch rifled mortars. These works, with the channel torpedoes, would effectually close this passage to any enemy.

Referring again to the question of ranges, the following data in reference to actual long-range firing may be found interesting, as practice is always more convincing than theory.

July, 1880. Italian 100-ton gun. Weight of projectile, 1,000 kilos; initial velocity, 451 metres; elevation, 15° 48′; range, 8,000 metres (5 miles).

August 17, 1883. Krupp's 30.5 c. m. gun (35 calibres). Charge, 162 kilos; weight of projectile, 455 kilos; elevation, 14°; range, 10,146 metres (6.3 miles).

July 31, 1883. Krupp's 26 c. m. gun (35 calibres). Charge, 87 kilos; weight of projectile, 275 kilos; elevation, 20°; range, 11,526 metres (7.2 miles).

French 34 c. m. gun. Elevation, 38°; range, 12,918 metres (8 miles). [Hélié.]

Woolwich 80-ton gun. Charge, 445 pounds; weight of projectile, 1,760 pounds; muzzle energy, 33,710 ft.-tons; elevation, 10°; range, 6,251 yards (3.5 miles).

Report of Sept., 1884. Krupp's 24 c. m. mortar. Charge, 5.4 kilos; weight of projectile, 136 kilos; for elevation of 30°, range equal 3,314 metres (2.1 miles); for elevation of 60°, range equal 3,119 metres (1.9 miles). Five shots were fired at each angle. At 30° the mean divergence was 11.9 metres in range, and 0.5 metres laterally; at 60° the mean divergence was 6.6 metres in range and 5.8 metres laterally.

PART IV.—THE QUESTION OF ARMOR.

For land defence the question is simply how to obtain secure cover at a minimum expense. Any one of the various forms of armor will afford complete protection if sufficient thickness be used, but the cost will vary within wide limits. For naval purposes, the weight of the armor must be the ruling consideration, and the question of expense is subsidiary thereto. Discussions and conclusions concerning the use of armor for war ships do not therefore of necessity apply to land batteries.

The four principal varieties of armor plates may be briefly described as follows:

1. Steel Plates.—These are principally manufactured by Henri Schneider & Co., of Le Creusot, France. Strictly speaking the material is not steel but semi-steel, steely iron, homogeneous metal, or soft steel, as it is variously designated; the proportion of carbon being about .45 %. The plates are forged under heavy hammers, which operation reduces the thickness as much as 77 %, then tempered by immersion in colza oil, and afterwards annealed. They combine great resisting power with great tenacity.

2. Compound Plates.—These consist of wrought-iron foundation plates with steel faces. The iron gives the requisite tenacity, and the steel the hardness which determines the resistance to penetration. The steel face comprises about one third of the total thickness, and is applied in two ways, by the Ellis and Wilson patents. The principal manufacturers of the Wilson plates are Charles Cammell & Co., Sheffield, England. Molten steel is poured on the wrought-iron plate, and after cooling the combined plate is rolled down to the requisite thickness. In the Ellis plate, manufactured by Sir John Brown, of Sheffield, the face consists of a thin plate of rolled steel, which is welded to the wrought iron by molten steel, the combined plate being afterwards rolled as before. Hard steel is used, the proportion of carbon being from .65 to .80 %.

3. Wrought-Iron Armor.—This consists of either single or multiple rolled wrought-iron plates. When more than one plate is used, the degree of resistance is greatly influenced by the intervals between the plates.

4. Chilled Cast-Iron Plates.—These are cast in curved form, generally with double curved surfaces, and are principally manufactured by Grüson, of Buckau, near Magdeburg, Prussia. The exterior is chilled to a depth depending on the thickness of the plate, and a cross-section shows all varieties of cast iron, from the hardest and most brittle white variety on the exterior, to the softest and most ductile gray iron on the interior.

The value of any plate, whatever be the material, depends greatly upon the quality of the metal and the skill and care bestowed upon its manufacture. Large plates are proportionally more liable to defects than small ones, and the remarkable differences developed in the official trials are doubtless largely due to differences in manufacture.

EFFECT OF PROJECTILES UPON ARMOR PLATES.

The wrought-iron plate yields locally, being cleanly perforated when the striking energy is sufficient, or penetrated to a greater or less depth when the striking energy is insufficient for perforation. Beyond the shot-hole but little injury is done to the plate.

The compound plates, being harder, offer greater resistance, and are smashed or split open rather than punched. Both radiating and concentric cracks are formed around the point of impact, the latter being frequently very destructive. When the energy is not sufficient to destroy the plate, these cracks are limited to the steel face, which, in imperfectly welded plates, sometimes separates from the wrought iron in large pieces.

The steel plate also opposes great resistance, perhaps even more than the compound in some cases, though the face being softer, the projectile may penetrate a little deeper. The metal swells up around the point of impact, and radiating cracks are formed, which under continuous fire extend through the plate, breaking it in pieces. Concentric cracks are never observed.

Steel and compound plates are considered to offer a resistance to perforation approximately the same as a wrought-iron plate of 20 to 25 % greater thickness.

Chilled cast-iron plates oppose greater resistance to penetration than any other variety of armor, but this hardness is attained at the expense of tenacity, and they are far more susceptible to racking effects than either the steel or compound armor. Up to the present time, no projectile has ever penetrated a Grüson chilled-iron plate to a greater depth than 2.8 inches.

Armor is classified as hard or soft according to its degree of resistance. Under the first head are included steel, compound, and chilled-iron armor, while wrought iron is the only form of soft armor.

The number of bolts required to hold the plates to the backing depends upon the kind of armor. While wrought iron only requires one bolt for about every ten or twelve square feet of surface, hard armor requires one bolt for every four square feet. So far it has not appeared that the bolt-holes weaken the plates appreciably, or determine the direction of the cracks. Cast-iron plates require no bolts; their shape makes them mutually supporting, like the stones of an arch or dome, and they are bonded by zinc solder.

With hard armor, a large plate has somewhat greater resistance proportionally than a small one, as the shock is distributed throughout the entire mass.

A recent method of measuring the force of blows upon hard armor is by the amount of energy per ton of plate. For penetration in soft armor the measure is the amount of energy per inch of circumference of the projectile.

USE OF ARMOR FOR SEA-COAST DEFENCES.

Grüson's chilled-iron armor has been used for coast defences by most of the continental European powers. It was originally adopted by France, but subsequently rejected.

In studying the recorded trials of Grüson's shields, we find the tests to which they have been subjected quite inferior to those which steel and compound plates have undergone. In no instance has a cast-iron plate been struck by a projectile having even 15,000 ft.-tons of energy, while steel and compound plates have been subjected to blows of 20,000, 34,000, and even 44,000 foot-tons. A casting may stand an indefinite number of light blows, yet be easily broken by a few heavy blows, and the total energy necessary to cause fracture will diminish rapidly with the number of blows into which it is divided. In 1873, a Grüson shield with a maximum thickness of thirty-three inches, withstood nineteen blows of 14,432 foot-tons each, or in all about 274,208 foot-tons. This was a remarkable result, but it may be asked how the plate would have fared had this energy been put into ten shots of 27,421 foot-tons each, or eight shots of 34,276 foot-tons each. It is true that land batteries must be assailed at longer ranges than will characterize purely naval engagements, but we must expect our armored defences to be frequently struck by projectiles having at least 34,000 foot-tons of energy, and to resist such a blow, according to Grüson's own formula, would require a maximum thickness of 47.7 inches of cast iron, while a 28-inch wrought-iron plate would suffice. Moreover, since turret guns on armored ships, and even broadside guns, are fired by electricity from the conning tower, it is far from improbable that a land turret should be struck by two of these heavy projectiles at the same instant, and in such a case, even though the points of impact may be well separated, the effect would undoubtedly be very disastrous to cast-iron armor.

In the fall of 1883, a Grüson turret plate with a maximum thickness of 43 inches, and a mean thickness of 35 inches, was subjected to 4 shots from Krupp's 12-inch rifle (30.5 c. m. 25 cal.). Each projectile weighed 981 pounds, and the striking energy in each case was 14,490 foot-tons, sufficient to penetrate about 20 inches of wrought iron. The fourth shot breached the shield, and rendered the gun chamber untenable. It is only fair to say that this result was partially attributed to the lack of firmness in the masonry bracing. A 43-inch plate should offer "thorough resistance" to a projectile with a striking energy of 22,000 foot-tons. Col. Inglis, R.E., says of this trial: "To help in forming an opinion as to whether this result may be fairly considered favorable or otherwise to cast-iron defence, it may be stated with confidence that for the cost of this cast-iron plate a shield affording equal cover could be made of good wrought-iron armor, which would stand four rounds similar to those fired at Buckau without being breached, and it is equally certain that if such a wrought-iron plate were to be subjected to further trial until ultimately pierced, the resulting injury would be of a much less serious character than that which was done to the cast-iron target. No doubt there is a great advantage on the side of the cast iron in the roundness of the form which may be given to it, which makes it very difficult to hit it at any but very oblique angles of incidence; but on the other hand there is the great disadvantage that a cast-iron structure cannot be afterwards strengthened by applying additional thicknesses, as can be done with ease in the case of other kinds of armor."

The immense loss of energy due to the failure of the projectile to bite into this hard armor at oblique angles, lends great importance to the above-mentioned advantage. Moreover, no projectile has yet been found which gives entirely satisfactory results against chilled iron. The most perfect forged steel shots are shivered to atoms on impact, and it now seems probable that solid shot instead of shell will have to be used against such armor for battering purposes. No projectile can get through Grüson's plates without first shattering them to pieces.

There is another great advantage in the roundness of form, which has been strikingly exemplified in different trials. The planes of weakness are normal to the surface, and this being curved it follows that when the plate breaks, the pieces will have approximately the shape of frustums of pyramids, with the smaller bases on the interior. No piece can be driven in by any blow, however severe, so long as the other pieces retain their positions. In the trial of 1873 before referred to, the plate was broken in two at the fourth shot, and into several pieces by succeeding shots, yet the plate stood nineteen rounds and still afforded complete cover.

In consequence of the unexpected result of the trial of 1883, Grüson has recently modified the shape of his turrets by giving the front plates a greater slope or inclination to the horizontal, so that it is now practically impossible for a projectile having great energy, and hence a flat trajectory, to strike normal to the surface. The interior space is of course diminished by this turtle-back form.

Grüson's armor costs from $150 to $200 per ton for large-sized plates.

The heaviest cast-iron turret now in process of construction is that at the Helder in Holland. The armor weighs 580 tons, and the total load on the rollers will be 773 tons. The plates are 39 inches thick at the bottom, 43 inches at the level of the gun, and 10 inches where they join the top cover plate.

Steel and compound armor are principally used for naval purposes, and there are no existing fortifications armored with either class. In the severe competitive trials to which these plates have been subjected, each has scored complete victories, the results having been greatly influenced by the quality of the individual plate, its mounting, backing, etc. From the recorded results, however, it would seem that under similar conditions they offer about equal resistances; that a projectile will get its point rather deeper into the steel than into the compound armor; that the racking effect is more severe on the compound plates; and that the result of complete perforation is far less destructive to the steel than to the compound armor.

In the Spezia trials of last October, Brown, Cammell, and Schneider plates, 18.89 inches in thickness, were perforated by 100-ton gun projectiles, with striking energies in each case of 44,340 foot-tons. One shot was fired at each target. The Brown plate was divided into four pieces and the steel face torn off all around the point of impact, showing some evident defect in manufacture; the Cammell plate was broken into six large pieces hanging by the bolts; while in the case of the steel armor "the projectile pierced the plate neatly, like a punch, forming a circular hole 580 m.m. (22.9 in.) in diameter." The plate was divided into three large pieces by radial cracks. As a result of this competition the Italian Government ordered steel plates for the armor of the *Lepanto.*

Krupp's hollow steel projectiles (forged and tempered) were used in each case. When loaded with sand they weighed 1,841 pounds, and undoubtedly possessed great tenacity and cohesion, but while the energy was sufficient to drive them through the plates, they were invariably broken into many pieces. The fragments were smaller in the case of the Cammell plate than in that of the steel plate, which the advocates of the former attributed to its greater resistance. There was no question, however, as to the fact that the Schneider plate had suffered far less than its rivals.

The impact of such heavy projectiles with such great energies invariably bends the plate more or less. The homogeneous steel adapts itself to this change of form far better than the compound armor, and the concentric cracks of the latter may be due to this cause. Even in the Shoeburyness experiments of 1883, the bending of the plate was noticeable, although the backing was solid granite, and the concentric cracks were deep and wide, and far more serious than those radiating from the point of impact. For this reason compound armor needs better backing than does armor of other kinds.

Neither steel nor compound plates can be readily manufactured with double-curved surfaces as can the cast-iron plates.

Compound plates of the largest size weigh about fifty tons, the dimensions being 20′ x 10′ x 10″, or varying with the thickness, the weight remaining the same. The price ranges from $425 to $450 per ton. Schneider produces forty-ton plates at about $386 per ton.*

In the Spezia trials of 1882, Cammell, Brown, and Schneider plates, each 18.9 inches in thickness, were subjected to the fire of the 100-ton gun. The first round on each plate was with a striking energy of about 21,000 foot-tons, and the second round with an energy of about 34,000 foot-tons. Both compound plates were destroyed on the second round, and the steel plate succumbed on the fourth round. Referring to this trial, Col. Inglis says: "To give some idea of the merits and disadvantages of steel and compound armor as compared with wrought-iron plates, it may be mentioned that in the first three rounds [one shot at each target—E. G.] of the above trial, the projectile used would have pierced about 19 inches of ordinary rolled-iron armor, and in the remaining rounds about 25 inches of the same material. Further, a target composed of two thicknesses of wrought-iron plates, each 14 inches thick, would not only have offered complete protection against the gun used in this trial, but if it had been made of two such plates, and of the same length and breadth as the targets in the trials, it would have stood three rounds from the gun far better than either the Schneider steel or the Sheffield compound plates did, for the injuries would have been confined to the localities of the shot-marks, and would not have involved the general destruction of the target. In fact, the target would have been quite fit to receive, if not another round from the 100-ton gun, at any rate several rounds more from lighter natures of ordnance. Again, a target composed of two 14-inch wrought-iron plates would cost considerably less than one of a single compound plate 18.98 inches thick, the other dimensions being the same, and very far less than a target of steel armor of the same size. In this view, therefore, while for naval purposes, where the consideration of the saving of weight is one of paramount importance, the use of steel or steel-faced armor becomes almost a necessity; for fortifications on land, where increased weight has generally no disadvantage, there appears to be nothing in this experiment to warrant the adoption of either steel or compound

* These prices are taken from General Abbot's "Hasty Notes," and are those prevailing in the fall of 1883.

armor, except, perhaps, in certain special cases, such as in that of revolving turrets and cupolas, where there may be advantage in keeping down the weight of the total moving load."

Wrought iron has been exclusively used for sea-coast defences in England; for turrets, iron-fronted and shield batteries. Experience has shown that there is no appreciable loss in resistance by using two or three plates instead of putting all the metal in a single plate, while there is a considerable gain in economy. In the sandwich armor, the plates must not be separated by too great or too small intervals; five inches has been adopted as the proper distance whatever the other conditions may be. This distance is sufficient "to prevent the two pieces of metal from coming together, while at the same time it does not give room for the point of the shot to clear itself of the front plate before coming to the second plate." The present practice is to separate the plates by two layers of wood, each 2½ inches thick, one placed vertically and the other horizontally. There seems also to be a practical limit to the number of plates, and not more than three or, at the most, four separate plates can be used without appreciably diminishing the resistance over that of the equivalent single plate.

Oblique fire is much more effective on soft than on hard armor, as the point of the projectile encounters less resistance and bites more readily. In Krupp's experiments of 1882, a target composed of two wrought-iron plates with thicknesses of 7.9 inches and .98 inches, respectively, separated by 9.84 inches of wood, was penetrated at an angle of 35° with the normal, or 55° with the front of the target. The shot "went through the entire target and passed on up the range 328 yards uninjured."

The projectile was from the 5.9-inch rifle, and struck with a velocity of 1750 feet. Capt. Orde Browne, R.A., says: "It had sufficient work to have penetrated 9½ inches at the striking angle, supposing the projectile to 'bite' properly; but at so oblique an angle it has been found that the projectile has to be more than a match for the plate, generally speaking, to bite, and therefore the penetration was unusually good."

While, therefore, considerable advantage would be derived from the general curved shape of wrought-iron turrets, this advantage would not be nearly so great as in the case of cast-iron armor.

Wrought-iron plates cost from $220 to $330 per ton.

The heaviest wrought-iron turret in existence is that at Dover, England. The total weight is about 1,000 tons, resting on thirty-six conical steel rollers.

PROJECTILES.

The resistance of armor varies greatly with the character of the projectiles used against it.

In 1882–3, experiments were conducted at Shoeburyness with 18-inch compound plates for the purpose of ascertaining the best kind of projectile for the attack of steel-faced armor. Col. Inglis gives the following as the results of this trial (1883).

"First, that forged steel shot, which have shown such marked superiority over every other kind of projectile in the attack of wrought-iron armor at all velocities, and which promised so well in shot up to the 9-inch calibre (weight 275 lbs.), against compound armor at moderate velocities, have failed to maintain that superiority in the case of heavier shot (12-inch calibre, and upwards of 700 lbs. weight), employed at higher velocities against very thick masses of compound armor. Next, that the cast-steel shot with chilled-iron head has shown itself to be scarcely, if at all, better than the service chilled cast-iron projectile for the attack of compound armor. The present trial further shows that little or no advance has been made of late in the manufacture of projectiles for the attack of hard armor. It has been found hitherto to be impossible to produce masses of steel of sufficient hardness to act upon steel and steel-faced armor without change of form, and at the same time to stand the effect of the shock on impact without breaking up. In fact, that which was done with projectiles of Whitworth steel against wrought-iron armor, when the same 9-inch shell was fired three times through 10 or 12 inches of wrought iron, has not been approached in the case of steel-faced armor. * * * In the existing state of things it is quite hopeless to expect that any kind of shell will be found to carry a bursting charge through a considerable thickness of steel or steel-faced armor."

In February, 1884, in a lecture before the Royal United Service Institution, Capt. Orde Browne said: "There is some reason to fear that our chilled projectiles are unsuitable ones to attack it (Grüson's chilled armor). In 1879, Krupp attacked a chilled shield made to represent Grüson's, with chilled shot. He wished it to be beaten by a wrought-iron shield of his own. In a few rounds he was disappointed at the effect of chilled shot and replaced them by steel ones, which, in a measure, broke the chilled iron.

"In 1882 I believe the French made some experiments against chilled-iron shields for inland fortifications. They had adopted them, but they found the effect of steel shot so much greater than that of chilled shot against chilled iron that they rejected this material for inland works. At Magdeburg the chilled-iron shield was broken by the blows of steel shot."

The London *Engineer*, Oct. 24, 1884, says: "The new forged steel projectiles, such as those of Krupp's make, possessing tenacity and great cohesion, require, in order to break them, an effort and space of time infinitely greater than that of cast-iron or brittle metal, so that the effort of penetrating or punching the material of the plates has time to develop itself before the pieces of the projectile become separated."

Whatever be their deficiencies, there seems to be no doubt about the superiority of the present forged-steel projectiles against *every* kind of armor, and their great cost is the only obstacle to their general adoption.

Steel shells are now made of great length to carry heavy bursting charges, and Capt. Browne mentions a "torpedo" shell only 8.27 inches in diameter, but which carries a bursting charge of 106 pounds. What effect would be produced by the explosion of such a shell when buried in a wrought-iron plate? I have found no record of such an experiment, but I doubt whether the result would be very serious to the plate. The hole caused by the penetrating shell would probably act like the bore of a mortar, and the main effect of the explosion would be outwards, enlarging the hole but little and developing but a slight tendency to increase the penetration. Should the time come, however, when nitro-gelatine shells can be fired with sufficient charges to give good penetration, and means can be found to prevent explosion upon impact, the effect will undoubtedly be disastrous.

Summing up these results, we are called upon to decide whether we shall use hard armor, which must be smashed to pieces, or soft armor, which cannot be smashed, and which may be made so thick that it cannot be perforated. Once before, we had the same problem presented, when our granite forts succumbed to the increased power of heavy ordnance. We solved it then by adopting earthen walls of far less resistance, and by making them so thick that they could not be perforated we obtained secure cover. Shall we follow the same course now?

Grüson will make cast-iron turrets of any desired size and set them up in place for $200 per ton. We could not manufacture them ourselves, as the "trade secrets" of mixing the ores and controlling the chill are unknown to our iron-founders. Our chilled-iron work, however, is equal if not superior to any in the world in every other respect, and I believe that with proper inducements, our manufacturers would soon penetrate these secrets and rival Grüson in his own specialty. The objections to cast-iron turrets, however, are quite serious. In addition to those given, the turtle-back form now adopted will require much larger foundations, and in many localities this would entail considerable extra expense.

I would place steel before compound armor because of the greater cost of the latter as well as for other reasons. The price of steel armor is about double that of cast iron, but the greater thickness of the latter would make the ratio of cost of completed turrets much nearer unity.

The advantages of wrought iron have been set forth in some detail, and the choice seems to lie between this metal and low steel. The iron will probably be selected for casemated batteries, but for turrets the choice is not so evident, though at the present time, considering the difference in cost, I should say the advantage was with the iron. Soft steel has the requisite toughness together with superior resisting powers; and when the price of such steel approximates sufficiently to that of wrought iron the former will be used.

APPENDIX.

TABLE III.

FOREIGN ARMORED SHIPS AVAILABLE FOR OFFENSIVE OPERATIONS AGAINST THE UNITED STATES.

[Compiled chiefly from information furnished by the Office of Naval Intelligence, U. S. Navy Department.]

ABBREVIATIONS.

M. L. R. . .	Muzzle-loading rifle.	B. . .	Bulkhead.
B. L. R. . .	Breech-loading rifle.	S. . .	Steel armor.
S. B.	Smooth-bore.	C. . .	Compound armor.

The absence of any abbreviation indicates that the armor consists of wrought iron. The second column under "Thickness of Armor" includes *barbette towers*, *casemates*, and *citadels*, as well as TURRETS.

ENGLAND.

Name.	Date.	Displacement.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Warrior	1860	9,210	27	0	14.8	Broadside.	4½		28 7-in., 6½-ton; 4 8-in., 9-ton M. L. R.
Black Prince . .	1861	9,210	27	0	13.6	"	4½		4 8-in., 9-ton; 24 7-in., 6½ ton M. L. R.
Defence	"	6,250	26	7	11.6	"	4½		2 8-in., 9-ton; 14 7-in., 6½ ton M. L. R.
Resistance . . .	"	6,250	26	8	11.6	"	4½		2 8-in., 14 7-in. M. L. R.
Hector	1862	6,710	26	0	12.3	"	4½		2 8-in., 16 7-in. M. L. R.
Minotaur	1863	10,690	27	0	14.4	"	5½		15 9-in., 12-ton M. L. R.; 2 6-in. B. L. R.
Achilles	"	9,820	27	4	14.3	"	4½		12 9-in., 12-ton; 2 7-in. M. L. R.; 2 6-in. B. L. R.
Wivern	"	2,750	17	0	10.6	2 Turrets.	4½	5	4 9-in. M. L. R.
Valiant	"	6,710	26	7	12.7	Broadside.	4½		2 8-in., 16 7-in. M. L. R.

ENGLAND [*Continued*].

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches. Side.	Turret.	Armament.
		Tons.	ft.	in.	Knots.				
Scorpion	1863	2,750	17	0	10.5	2 Turrets.	4½	5	4 9-in. M. L. R.
Prince Albert	1864	3,880	20	4	11.7	4 "	4½	5½–10	4 9-in. M. L. R.
Lord Warden	1865	7,840	27	6	13.5	Broadside.	5½		2 9-in., 14 8-in., 2 7-in. M. L. R.
Agincourt	"	10,690	27	9	15.4	"	5½		1 9-in. M. L. R.; 2 6-in. B. L. R.
Bellerophon	"	7,550	26	0	14.2	"	6		11 8-in., 2 6-in. B. L. R.
Viper	"	1,230	11	7	9.6	"	4½		2 7-in. M. L. R.
Northumberland	1866	10,580	27	9	14.1	"	5½		5 9-in., 20 8-in. M. L. R.; 2 6-in. B. L. R.
Vixen	"	1,230	11	10	8.9	"	4½		2 7-in. M. L. R.
Penelope	1867	4,470	17	7	12.8	"	6		8 8-in. M. L. R.; 3 40-pdr. 35-cwt. B. L. R.
Hercules	1868	8,680	26	5	14.7	Central battery.	9		8 9.2-in., 18-ton; 6 6-in. B. L. R.
Monarch	"	8,320	26	7	14.9	2 Turrets and central battery.	7	8–10	4 12-in., 25-ton; 2 9-in., 12-ton; 1 7-in. M.L.R.
Repulse	1868	6,190	26	2	12.3	Broadside.	6		12 8-in. M. L. R.
Cerberus	"	3,340	15	2	9.7	2 Turrets.	8	10–9	4 10-in., 18-ton M. L. R.
Audacious	1869	6,010	23	3	13.6	Central battery.	8		10 9-in. M. L. R.; 8 4-in. B. L. R.
Invincible	"	6,010	23	0	14.0	" "	8		10 9-in. M. L. R.; 4 64-pdr. 71-cwt. B. L. R.
Magdala	"	3,340	15	2	10.6	2 Turrets.	8	10	4 10-in. M. L. R.
Iron Duke	1870	6,010	23	0	13.6	Central battery.	8		10 9-in. M. L. R.; 4 64-pdr. B. L. R.
Triumph	"	6,640	26	2	13.5	" "	8		10 9-in., M. L. R.; 4 5-in. B. L. R.
Swiftsure	"	6,040	26	1	13.8	" "	8		10 9-in. M. L. R.; 8 4-in. B. L. R.
Abyssinia	"	2,900	14	6	9.6	2 Turrets.	7	10	4 10-in., 18-ton M. L. R.
Sultan	"	9,290	27	6	14.0	Central battery.	9		8 9.2 in., 6 8-in. B. L. R.
Hotspur	"	4,010	21	8	12.7	1 Turret.	11	10–8½ C.	2 12-in. M. L. R.; 2 6-in. B. L. R.
Devastation	1871	9,330	27	1	13.8	2 Turrets.	12	14	4 12-in. M. L. R.
Glatton	"	4,910	19	3	12.1	1 Turret.	12	14	2 12 in. M. L. R.
Cyclops	"	3,480	16	4	10.0	2 Turrets.	8	10	4 10-in. M. L. R.
Hecate	"	3,480	16	4	10.9	2 "	8	10	4 10-in. M. L. R.
Hydra	"	3,480	16	4	11.2	2 "	8	10	4 10-in. M. L. R.

ENGLAND [*Continued*].

Name.	Date.	Dis-place-ment.	Draught. ft.	Draught. in.	Speed.	Class.	Thickness of Armor in Inches. Side.	Thickness of Armor in Inches. Turret.	Armament.
		Tons.	ft.	in.	Knots.				
Gorgon	1871	3,480	16	4	11.1	2 Turrets.	8	10	4 10-in. M. L. R.
Thunderer	1872	9,330	27	1	13.5	2 "	12	14	4 $12\frac{1}{2}$-in., 38-ton M. L. R.
Rupert	"	5,440	23	6	13.6	1 Turret.	12	14	2 9.2-in., 2 6-in, B. L. R.
Alexandra	1875	9,490	26	6	15.0	Central battery.	12		10 10-in., 2 11-in., 25-ton M. L. R.
Dreadnought	"	10,820	26	9	14.0	2 Turrets.	14	14	4 $12\frac{1}{2}$-in. M. L. R.
Shannon	"	5,390	23	0	12.5	Belted cruiser.	9		2 10-in., 7 9-in. M. L. R.
Temeraire	1876	8,540	27	2	14.7	2 Barbette towers and central battery.	11	10–8	4 11-in., 4 10-in. M. L. R.
Inflexible	1876	11,400	26	4	14.8	2 Turrets.	24	17–16C.	4 16-in., 80-ton M. L. R.
Nelson	"	7,620	25	9	14.0	Belted cruiser.	9	$10\frac{1}{4}$B.	4 10-in., 8 9-in. M. L. R.
Northampton	"	7,620	25	9	13.2	" "	9	$10\frac{1}{4}$B.	4 10-in., 8 9-in. M. L. R.
Superb	1875	9,100	26	5	13.2	Central battery.	12		16 10-in. M. L. R.
Neptune	1874	9,170	26	1	14.2	2 Turrets.	12	13–11	4 $12\frac{1}{2}$-in. M. L. R.; 2 8-in. B. L. R.
Orion	1879	4,830	21	4	12.8	Central battery.	12		4 12-in. M. L. R.
Belle Isle	1876	4,830	21	4	12.8	" "	12		4 12-in. M. L. R.
Agamemnon	1879	8,490	24	0	13.0	2 Turrets.	18	16–14C.	4 $12\frac{1}{2}$-in. M. L. R.; 2 6-in. B. L. R.
Ajax	1880	8,490	24	0	15.5	2 "	18	16–14C.	4 $12\frac{1}{2}$-in. M. L. R.; 2 6-in. B. L. R.
Conqueror	1881	6,200	24	0	13.0	1 Turret.	12 C.	12C.	2 12-in., 43-ton ; 4 6-in. B. L. R.
Collingwood	1882	9,150	26	3	16.8	2 Barbette towers.	18 C.	$11\frac{1}{2}$–10C.	4 12-in., 43-ton ; 6 6-in. B. L. R.
Edinburgh	"	9,150	26	3	17.2	2 " "	18 C.	16C.	4 12-in., 43-ton ; 5 6-in. B. L. R.
Colossus	"	9,150	26	3	16.5	2 " "	18 C.	16C.	4 12-in., 43-ton ; 5 6-in. B. L. R.
Imperieuse	1883	7,390	25	5	16.0	4 " "	10 C.	8C.	4 9.2-in. 6 6-in. B. L. R.
Warspite *	1884	7,390	25	5	16.0	4 " "	10 C.	8C.	4 9.2-in. 6 6-in. B. L. R.
Howe *	1885	9,600	27	3	16.0	2 " "	18 C.	$11\frac{1}{2}$–10C.	4 $13\frac{1}{2}$-in., 63-ton ; 6 6-in. B. L. R.
Anson *		10,000	27	3	16.0	2 " "	18 C.	14–12C.	4 $13\frac{1}{2}$-in., 63-ton ; 6 6-in. B. L. R.
Rodney *	1884	9,600	27	3	16.0	2 " "	18 C.	$11\frac{1}{2}$–10C.	4 $13\frac{1}{2}$-in., 63-ton ; 6 6-in. B. L. R.
Camperdown *		10,000	27	3	16.0	2 " "	18 C.	14–12C.	4 $13\frac{1}{2}$-in., 63-ton ; 6 6-in. B. L. R.
Benbow *		10,000	27	3	16.0	2 " "	18 C.	14–12C.	2 $16\frac{1}{4}$-in., 110-ton ; 10 6-in. B. L. R.

* Not completed.

ENGLAND [*Continued*].

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Renown *		10,470	27	3	15.5	Turret.	18 C.	18 C.	2 110-ton, 1 9.2-in., 12 6-in. B. L. R.
Sanspareil *		10,470	27	3	15.5	"	18 C.	18 C.	2 110-ton, 1 9.2-in., 12 6-in. B. L. R.
Orlando *		5,000	22	6	17.5	Belted cruiser.	10 C.		2 9.2-in., 10 6-in. B. L. R.
Undaunted *		5,000	22	6	17.5	" "	10 C.		2 9.2-in., 10 6-in. B. L. R.
Australia *		5,000	22	6	17.5	" "	10 C.		2 9.2-in., 10 6-in. B. L. R.
Narcissus *		5,000	22	6	17.5	" "	10 C.		2 9.2-in., 10 6-in. B. L. R.
Galatea *		5,000	22	6	17.5	" "	10 C.		2 9.2-in., 10 6-in. B. L. R.

* Building.

FRANCE.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament. All breech-loading rifles (B. L. R.).
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Couronne	1861	6,428	28	6	12.7	Broadside.	5.6		8 $9\frac{1}{2}$-in., 4 $7\frac{1}{2}$-in.
Heroine	1863	6,007	27	5	13.0	"	5.6		8 $9\frac{1}{2}$-in., 3 $7\frac{1}{2}$-in., 2 $5\frac{1}{2}$-in.
Provence	"	5,815	27	4	13.9	"	5.9		8 $9\frac{1}{2}$-in., 3 $7\frac{1}{2}$-in., 2 $5\frac{1}{2}$-in.
Flandre	1864	5,964	27	7	14.3	"	5.9		8 $9\frac{1}{2}$-in., 5 $7\frac{1}{2}$-in.
Savoie	"	5,896	28	0	13.5	"	5.9		8 $9\frac{1}{2}$-in., 3 $7\frac{1}{2}$-in., 4 $5\frac{1}{2}$-in.
Surveillante	"	6,220	28	10	13.2	"	5.9		8 $9\frac{1}{2}$-in., 4 $7\frac{1}{2}$-in., 4 $5\frac{1}{2}$-in.
Valeureuse	"	5,984	28	0	13.8	"	5.9		8 $9\frac{1}{2}$-in., 1 $7\frac{1}{2}$-in., 4 $6\frac{3}{8}$-in.
Revanche	"	5,790	27	2	13.3	"	5.9		8 $9\frac{1}{2}$-in., 3 $7\frac{1}{2}$-in., 2 5.5-in.
Belliqueuse	1865	3,447	21	10	11.8	"	5.9	$4\frac{3}{4}$	4 $7\frac{1}{2}$-in., 4 $6\frac{3}{8}$-in., 4 $5\frac{1}{2}$-in.

FRANCE [*Continued*].

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches. Side.	Thickness of Armor in Inches. Turret.	Armament. All breech-loading rifles (B. L. R.).
		Tons.	ft.	in.	Knots.				
Alma	1867	3,788	24	0	11.9	2 Barbette towers and central battery.	5 7/8	4 3/4	6 7½-in.
Ocean	1868	7,749	29	10	13.7	4 Barbette towers and central battery.	7 7/8	5 7/8	4 10⅝-in., 4 9½-in., 2 5½-in.
Montcalm	1868	3,889	23	8	11.7	2 Barbette towers and central battery.	5 7/8	4 3/4	6 7½-in.
Atalante	1868	3,825	23	3	11.8	2 Barbette towers and central battery.	5 7/8	4 3/4	6 7½-in.
Reine Blanche . .	1868	3,845	23	9	11.8	2 Barbette towers and central battery.	5 7/8	4 3/4	6 7½-in.
Marengo	1869	7,172	27	9	13.5	4 Barbette towers and central battery.	7 7/8	5 7/8	4 10⅝-in., 4 9½-in., 7 5½-in.
Suffren	1870	7,604	29	10	14.3	4 Barbette towers and central battery.	7 7/8	5 7/8	4 10⅝-in., 4 9½-in., 6 6½-in.
Gallissoniere . .	1872	4,487	23	10	13.1	2 Barbette towers and central battery.	5 7/8	4 3/4	6 9½-in., 6 3⅝-in.
Friedland . . .	1873	8,916	29	11	13.3	Central battery.	7 7/8		8 10⅝-in., 8 5½-in.
Richelieu . . .	"	8,790	27	10	13.1	4 Barbette towers.	8 3/8	6.3	6 10⅝-in., 5 9½-in., 7 5½-in.
Colbert	1875	8,617	28	6	14.5	Central battery.	8 7/8	6 3/8	8 10⅝-in., 2 9½-in., 6 5½-in.
Victorieuse . . .	"	4,576	22	8	12.8	2 Barbette towers and central battery.	5 7/8	4 3/4	6 9½-in., 1 7½-in., 6 5½-in.
Tonnerre	1875	5,584	21	4	14.0	1 Turret.	14 1/4	13 1/4	2 10⅝-in.
Redoubtable . .	1876	8,854	24	10	14.7	Central battery.	14	9.5	8 10⅝-in., 6 5½-in.
Trident	"	8,814	29	1	14.2	2 Barbette towers and central battery.	8 5/8	6 3/8	8 10⅝-in., 2 9½-in., 6 5½-in.
Tempête	1876	4,523	16	9	12.8	1 Turret.	13	11 3/4	2 10⅝-in.
Triomphante . .	1877	4,127	22	8	12.9	2 Barbette towers and central battery.	5 7/8	4 3/4	6 9½-in., 1 7½-in., 6 5½-in.

FRANCE [*Continued*].

Name.	Date.	Displacement.	Draught.		Speed.	Class.	Thickness of Armor in Inches. Side.	Turret.	Armament. All breech-loading rifles (B. L. R.).
		Tons.	ft.	in.	Knots.				
Fulminante . . .	1877	5,584	21	4	13.2	1 Turret.	$14\frac{1}{4}$	$13\frac{1}{4}$	2 $10\frac{5}{8}$-in.
Thétis	1867	3,621	21	10	12.0	2 Barbette towers and central battery.	$5\frac{7}{8}$	$4\frac{3}{4}$	6 7.5-in., 4 $3\frac{5}{8}$-in.
Vengeur	1878	4,523	16	9	13.8	1 Turret.	13	$13\frac{3}{4}$	2 $13\frac{1}{2}$-in.
Ad. Duperré . .	1879	10,486	26	0	14.5	4 Barbette towers.	21.6	12	4 13.5-in., 14 5.5-in.
Devastation . . .	"	9,639	24	11	15.2	Central battery.	15		4 13.5-in., 4 $10\frac{5}{8}$-in., 6 5.5-in.
Turenne	"	5,881	24	10	14.0	4 Barbette towers.	$9\frac{7}{8}$	$7\frac{7}{8}$	4 9.5-in., 2 7.5-in., 6 5.5-in.
Bayard	1880	5,881	24	10	14.5	4 " "	$9\frac{7}{8}$	$7\frac{7}{8}$	4 9.5-in., 2 7.5-in., 6 5.5-in.
Tonnant	"	4,523	16	9	12.8	1 Turret.	$17\frac{3}{4}$	$14\frac{5}{8}$	2 13.5-in.
Requin	1881	7,184	24	9	14.5	1 "	$20\frac{7}{8}$ S.	19 S.	2 $16\frac{1}{2}$-in., 4 4-in.
Terrible	"	7,184	24	9	14.5	1 "	$20\frac{7}{8}$ C.	19 C.	2 $16\frac{1}{2}$-in., 4 4-in.
Vauban	1882	5,869	24	10	14.0	4 Barbette towers.	$9\frac{7}{8}$	8	4 9.5-in., 1 7.5-in.
Foudroyant . . .	"	9,639	24	11	14.2	Central battery.	15		4 13.5-in., 4 10-in., 6 5.5-in.
Duguesclin *. . .	1883	5,869	24	10	14.0	4 Barbette towers.	$9\frac{7}{8}$	8	4 9.5-in., 1 7.5-in., 6 5.5-in.
Formidable * . .	1885	11,441	26	0	16.0	3 " "	$21\frac{5}{8}$ S.	$15\frac{3}{4}$	3 16.5-in., 12 5.5-in.
Caiman *	"	7,239	24	9	14.5	1 Turret.	$20\frac{7}{8}$ C.	$17\frac{3}{4}$ S.	2 16.5-in., 4 4-in.
Furieux *	1883	5,695	21	4	13.0	1 "	19.6	$17\frac{3}{4}$ S.	2 13.5-in.
Ad. Baudin * . .	"	11,441	26	0	16.0	3 Barbette towers.	$21\frac{5}{8}$ S.	$16\frac{1}{2}$	3 16.5-in., 12 5.5-in.
Indomitable * . .	"	7,184	24	9	14.5	1 Turret.	$20\frac{7}{8}$ C.	19 C.	2 16.5-in., 4 4-in.
Hoche *	1885	9,864	27	2	16.0	4 Barbette towers.	$17\frac{3}{4}$ C.	$15\frac{3}{4}$	2 13.5-in., 2 $10\frac{5}{8}$-in., 20 5.5-in.
Marceau * . . .	1884	9,864	27	2	16.0	4 " "	$17\frac{3}{4}$ C.	$15\frac{3}{4}$	2 13.5-in., 2 $10\frac{5}{8}$-in., 20 5.5-in.
Neptune * . . .	1885	9,861	27	0	16.0	4 " "	$17\frac{3}{4}$ C.	$15\frac{3}{4}$	3 15.5-in., 18 5.5-in.
Magenta * . . .	"	9,864	27	2	16.0	4 " "	$17\frac{3}{4}$ C.	$15\frac{3}{4}$	2 13.5-in., 2 $10\frac{5}{8}$-in., 18 5.5-in.
Charles Martel * .	"	9,780	28	0	15.0?	4 " "	$17\frac{3}{4}$ S.		4 $13\frac{1}{2}$-in., 8 5.5-in.
Brennus *. . . .	"	9,780	28	0	15.0?	4 " "	$17\frac{3}{4}$ S.		4 $13\frac{1}{2}$-in., 8 5.5-in.

* Not completed.

GERMANY.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament. All breech-loading rifles (B. L. R.).
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Arminius	1864	1,583	12	5	10.5	2 Turrets.	4½	7½	4 8¼-in.
Friedrich Carl	1867	6,007	24	0	13.6	Central battery.	5		16 8¼-in.
Kronprinz	"	5,568	24	3	14.3	" "	5		16 8¼-in.
Konig Wilhelm	1868	9,757	26	6	14.7	" "	8		18 9½-in., 5 8¼-in.
Hansa	1872	3,610	21	7	12.0	" "	6¼		8 8¼-in.
Preussen	1873	6,770	24	9	14.0	2 Turrets.	9¼	8¼	4 10¼-in., 2 6.7-in.
Friedrich du Grosse	1874	6,770	24	9	14.0	2 "	9¼	8¼	4 10¼-in., 2 6.7-in.
Kaiser	"	7,676	26	0	14.6	Central battery.	10	8	8 10¼-in., 1 8¼-in.
Deutschland	"	7,676	26	0	14.5	" "	10	8	8 10¼-in., 1 8¼-in.
Sachsen	1877	7,400	19	8	14.0	Central battery and 1 barbette tower.	17¼	10	6 10¼-in. (2-in T. and 4-in C.).
Bayern	1878	7,400	19	8	14.0	Central battery and 1 barbette tower.	17¼	10	6 10¼-in. (2-in T. and 4-in C.).
Würtimberg	1878	7,400	19	8	14.0	Central battery and 1 barbette tower.	17¼	10	6 10¼-in. (2-in T. and 4-in C.).
Baden	1880	7,400	19	8	14.0	Central battery and 1 barbette tower.	17½	10	6 10¼-in. (2-in T. and 4-in C.).
Oldenburg	1884	5,200	19	6	14.0	Central battery.	12.8		8 9.36-in., 4 5.85-in.

RUSSIA.

Name.	Date.	Displacement.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament. All breech-loading rifles (B. L. R.).
							Side.	Turret.	
	·	Tons.	ft.	in.	Knots.				
Prevenetz . . .	1864	3,277	15	0	9.0	Broadside.	4½		14 8-in.
Sevastopol . . .	1862	6,209	26	4	14.0	"	4½		16 8-in., 1 6-in.
Netzonmeña . .	1864	3,840	17	0	8.0	"	5½		14 8-in.
Kreml.	"	3,812	18	0	8.5	Central battery.	6		14 8-in.
Petropavloski . .	1865	6,175	26	0	11.0	Broadside.	4½		21 8-in., 1 6-in.
Knaz Pojarskoi . .	1867	4,509	22	0	10.0	Central battery.	4½		8 8-in., 2 6-in,
Ad. Lazereff . .	"	3,753	20	0	10.0	3 Turrets, monitor.	4½	6	6 9-in.
Ad. Greigh . . .	1868	3,841	21	0	10.0	3 " "	4½	6	3 11-in.
Ad. Cicagoff. . .	"	3,692	18	6	10.7	2 " "	6	6	2 11-in.
Ad. Spiridoff . .	"	3,744	18	6	10.7	2 " "	6	6	2 11-in.
Peter the Great . .	1872	9,665	24	9	13.0	2 "	14	14	4 12-in,
General Admiral .	1873	4,603	23	0	14.0	Belted cruiser.	6		4 8-in., 2 6-in.
Duke of Edinburgh	1875	4,602	23	0	14.0	" "	7		10 6-in.
Novgorod . . .	1873	2,505	13	2	7.0	Popoffka, 1 barbette tower.	11	11	2 11-in.
Ad. Popoff . . .	1875	3,590	13	5	8.3	" " "	18	18	2 12-in.
Minin	1878	5,740	25	7	12.5	4 Barbette towers.	8		4 8-in., 8 6-in., 4 4-in.
Vladimir Monomach	1882	5,754	25	0	17.0	4 " "	6 C.	12	4 8-in., 12 6-in., 4 4-in.
Dimitri Douskoi .	1883	5,893	25	0	16.0	4 " "	6 C.	12	2 8-in., 14 6-in., 16 4- and 3-in.
Tchesmé * . . .	"	10,181	25(m.)		16.0	3 " "	15–10	12	6 12-in., 7 6-in,
Sinope *	"	10,181	"		16.0	3 " "	15–10	12	6 12-in., 7 6-in.
Catherine the Great*	"	10,150	"		(?)	3 " "	18	14	6 12-in., 7 6-in.
Ad. Naphimoff * .		7,781	25	9	16.0	Belted cruiser, 4 barbette towers.	8	14	4 9-in., 10 6-in.
Moskwa * . . .									
Alexander the II.*		7,712	25	9	16.0	Belted cruiser, 4 barbette towers.	6	14	4 9-in., 10 6-in.

* Not completed.

ITALY.

Name.	Date.	Displacement.	Draught. ft.	Draught. in.	Speed.	Class.	Thickness of Armor in Inches. Side.	Thickness of Armor in Inches. Turret.	Armament.
		Tons.	ft.	in.	Knots.				
Terrible	1861	2,700	17	9	10.0	Broadside.	$4\frac{1}{2}$		8 $7\frac{7}{8}$-in. M. L. R.
Formidabile . . .	"	2,700	17	9	10.0	"	$4\frac{1}{2}$		8 $7\frac{7}{8}$-in. M. L. R.
Castelfidardo . .	1863	4,250	22	0	12.0	Central battery.	$4\frac{5}{8}$		2 9-in., $12\frac{1}{2}$-ton ; 9 8-in., 9-ton M. L. R.
Maria Pia . . .	"	4,250	22	0	$11\frac{1}{2}$	" "	4.7		2 9-in., 9 8-in. M. L. R.
San Martino . .	"	4,250	22	0	$11\frac{1}{2}$	" "	4.7		2 9-in., 9 8-in. M. L. R.
Ancona	1864	4,250	22	0	13.0	" "	4.7		2 9-in., 9 8-in. M. L. R.
Roma	1865	5,800	25	3	13.0	" "	$4\frac{3}{4}$		11 10-in. M. L. R.
Affondatore . . .	"	4,370	21	6	13.0	2 Turrets.	5	$5\frac{1}{8}$	2 10-in. B. L. R.
Varese	"	2,000	15	9	9.0	Central battery.	$4\frac{3}{4}$		4 $7\frac{7}{8}$-in. M. L. R.
Palestro	1871	6,161	26	10	12.9	" "	$8\frac{5}{8}$		1 11-in., 6 10-in. M. L. R.
Principe Amedeo .	1872	5,854	26	2	12.4	" "	$8\frac{5}{8}$		1 11-in., 6 10-in. M. L. R.
Duilio	1876	11,570	28	7	15.0	2 Turrets.	21.7 S.	17.7	4 17.72-in., 100-ton ; 4 4.7-in. M. L. R.
Dandolo	1878	11,434	28	7	15.5	2 "	21.7 S.	17.7	4 17.72-in., 4 4.7-in. M. L. R.
Italia	1880	13,851	30	3	16.0	2 Turrets and oval central battery.		18.9C. †	4 17-in., 100-ton.; 9 6-in. B. L. R.
Lepanto * . . .	1883	13,551	30	3	16.0	2 Turrets and oval central battery.		18.9S. †	4 17-in., 9 6-in. B. L. R.
Ruggiero-di-Lauria*	1884	10,045	25	11	17.0	1 Barbette turret.	17.72S		4 103-ton, 12 6-in. B. L. R.
Francesco Morosini*	1881	10,045	25	11	"	" "	17.72S		4 103-ton, 12 6-in. B. L. R.
Andrea Doria * . .	1882	10,045	25	11	16.0	" "	17.72S		4 103-ton, 12 6-in. B. L. R.
Re Umberto * . .	1885	13,251			16.0				

* Not completed. † Citadel.

TURKEY.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Azizyeh	1864	6,400	27	0	12.0	Broadside.	5½		14 8-in. Arm. 1 9.5 Krupp, 2 6-in. Krupp.
Mahmondiyeh . .	"	6,400	27	0	12.0	"	5½		14 8-in. Arm. 1 9.5 Krupp, 2 6-in. Krupp.
Osmanyeh . . .	"	6,400	27	0	12.0	"	5½		14 8-in. Arm. 1 9.5 Krupp, 2 6-in. Krupp.
Orkaniyeh . . .	1865	6,400	27	0	12.0	"	5½		14 8-in. Arm. 1 9.5 Krupp, 2 6-in. Krupp.
Assar-i-Tirfix . .	1868	5,687	21	0	13.0	2 Barbette towers and central battery.	6	8	8 9-in. M. L. R.
Avni Illah . . .	1869	2,380	16	6	12.5	Central battery.	6		4 9-in. M. L. R.
Mooyini Zaffar . .	1868	2,380	16	6	12.5	" "	6		4 9-in. M. L. R.
Nidj-un-Shefket .	1869	2,046	16	6	11.0	1 Barbette tower and central battery.	6	4½	1 9-in., 4 7-in. M. L. R.
Hufzi Rhaman . .	1868	2,500	19	5	12.0	2 Turrets.	4½	5	2 9-in., 2 7-in. M. L. R.
Assar-i-Shefket . .	1869	2,046	16	6	11.0	1 Barbette tower and central battery.	5½		1 9-in., 4 7-in. M. L. R.
Feth-i-Bulend . .	1869	2,760	18	0	12.5	Central battery.	9		4 9-in. M. L. R.
Idjlaliyeh . . .	1870	2,228	17	6	11.0	1 Barbette tower and central battery.	6	4½	2 9-in., 2 7-in. M. L. R.
Mookademi Khair .	1872	2,760	18	0	12.0	Central battery.	9		4 9-in. M. L. R.
Mesoodiyeh . . .	1874	8,950	26	5	13.1	" "	12		12 10-in., 2 7-in. M. L. R.
Hamidiyeh . . .	1878	7,920	25	6	13.0	" "	10		10 9-in., 2 7-in. B. L. R. (Krupp).

AUSTRIA.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Salamander * . .	1861	3,040	20	10	11.4	Broadside.	4¾		10 7-in. M. L. R. 6 light guns.
Ferdinand Max. .	1865	5,170	25	7	10.0	"	5		14 7-in. M. L. R. 6 light guns.
Hapsburg . . .	"	5,170	25	7	10,0	"	5		14 7-in. M. L. R. 6 light guns.
Lissa	1869	6,030	28	6	13.3	Central battery.	6¼		12 9½-in. M. L. R. 6 light guns.
Custoza	1872	7,090	26	9	14.0	" "	9		8 10¼-in. B. L. R. 8 light guns.
Erzherzog Albrecht	"	6,020	25	4	13.4	" "	8		8 9½-in. B. L. R. 8 light guns.
Kaiser	"	5,840	26	0	12.7	" "	6¼		10 9-in. M. L. R. 8 light guns.
Don Juan D'Austria	1875	3,540	20	9	12.7	" "	8		8 8¼-in. B. L. R. 6 light guns.
Kaiser Max . . .	"	3,540	20	9	12.7	" "	8		8 8¼-in. B. L. R. 6 light guns.
Prinz. Eugen . .	1877	3,570	20	9	12.7	" "	8		8 8¼-in. B. L. R. 6 light guns.
Tegethoof	1878	7,450	26	7	14.0	" "	14½		6 11-in. B. L. R. 8 light guns.
Erzherzog Rudolf †	1884	6,900	25	0		1 Turret.	12S.		2 12-in., 6 3½ in. B. L. R.
——— †		6,900	25	0		"	12S.		2 12-in., 6 3½ in. B. L. R.

* Rebuilding † Not completed.

DENMARK.

Name.	Date.	Displacement.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Denmark	1864	4,747	19	0	8.1	Broadside.	$4\frac{1}{2}$		12 8-in. M. L. R., 12 6-in. S. B.
Peder Skram	"	3,373	20	0	11.7	"	$4\frac{1}{2}$		8 8-in. M. L. R., 8 6-in. S. B.
Lindormen	1868	2,076	15	9	12.0	2 Turrets.	5	5	2 9-in. M. L. R.
Gorm	1870	2,344	14	0	12 2	1 Turret.	7	8	2 10-in. M. L. R.
Odin	1872	3,083	15	1	12.4	1 Turret and central battery.	8	8	4 10-in. M. L, R.
Helgoland	1878	5,347	18	0	13.5	" " "	12	10	1 12-in., 4 $10\frac{1}{4}$-in., 5 5-in. B. L. R.
Iver Hvitfeldt *		3,260							

* Not completed.

HOLLAND.

Name.	Date.	Displacement.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Prince Henry of the Netherlands	1865	3,375	18	9	12.0	Central battery and 2 turrets.	$4\frac{1}{2}$	5.5	4 9-in., 4 4.7-in. M. L. R.
Schorpionen	1868	2,275	15	10	12.8	1 Turret.	6	8	2 9-in. M. L. R.
Stier	"	2,069	15	7	12.3	"	6	8	2 9-in. M. L. R.
Buffel	"	2,198	15	6	12.7	"	6	8	2 9-in. M. L. R. 4 30-pdrs. S. B.
Guinea	1870	2,378	15	9	12.0	"	6	8	2 9-in. M. L. R.
King of the Netherlands	1874	5,400	19	0	12.0	2 Turrets.	8	12	4 11-in., 4 5-in. M. L. R.
Matador	1878	1,650	9	11	7.0	1 Turret.	$4\frac{1}{2}$	9	2 11-in. M. L. R.

SPAIN.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Numancia	1863	7,300	26	7	8.0	Broadside.	5½		8 9-in., 7 8-in., 8 small calibre M. L. R.
Vitoria	1865	7,200	27	4	11.5	"	5½		8 9-in., 3 8-in., 6 small calibre M. L. R.
Zaragoza	1867	5,400	24	10	8.0	"	5		4 9-in., 3 7-in., 10 6¼ in., M. L. R.
Sagunto	1869	7,300	25	11	8.0	Central battery.	6		8 9-in., 3 7-in. M. L. R.
Mendez Nuñez . .	1861	3,350	22	0	6.5	" "	4½		4 9-in., 2 8-in. M. L. R.

One armored vessel building.

BRAZIL.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Ad. Barroso . . .	1864	1,354	8	10	9.0	Central battery.	3⅞		2 7-in., 3 32-pdrs. M. L. R.; 2 68-pdrs. S. B.
Solimoës	1876	3,700	11	6	12.0	2 Turrets.	12	11–13	4 10-in. M. L. R.
Javary	"	3,700	11	6	12.0	"	12	11–13	4 10-in. M. L. R.
Sete-de-Setembro .	1874	2,145	12	6	11.0	Broadside.	4½		4 9¼-in. M. L. R.
Riachuelo . . .	1883	5,791	20	0	16.0	2 Barbette towers.	11C.	11	4 9.2-in., 20-ton ; 6 ——, 5½-ton B. L. R.
Aquidaban * . .	1885	5,791	18	0	15.5	2 Turrets.	11C.	10	4 9.2-in., 20-ton ; 4 ——, 5½-ton B. L. R.

* Not completed.

JAPAN.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Foo-So	1877	3,718	18	3	14.0	Central battery.	9		4 $9\frac{1}{2}$-in., 2 $6\frac{1}{2}$-in. B. L. R.
Kongo	"	2,200	17	6	14.0	Belted cruiser.	$4\frac{1}{2}$		6 6-in., 3 $6\frac{3}{4}$-in. B. L. R.
Ki Yei	"	2,200	17	6	14.0	" "	$4\frac{1}{2}$		6 6-in., 3 $6\frac{3}{4}$-in. B. L. R.

The Tsukushi having only a protected deck is not included.

CHILI.

Name.	Date.	Dis-place-ment.	Draught.		Speed.	Class.	Thickness of Armor in Inches.		Armament.
							Side.	Turret.	
		Tons.	ft.	in.	Knots.				
Huascar	1866	2,032	15	6	11.0	1 Turret.	$4\frac{1}{2}$	$5\frac{1}{2}$	2 8-in. B. L. R.; 4 20-pdrs.
Almirante Cochrane	1874	3,500	19	8	12.8	Central battery.	9		6 8-in. B. L. R.
Blanco Encalada .	1875	3,500	19	8	12.8	" "	9		6 9-in. M. L. R.

The Esmeralda, having only a protected deck, is not included.