ARMOR PLATE AND HIGH-EXPLOSIVE SHELLS.

Commencing with the "Maine" class, all future battleships of the United States navy will be protected with face-hardened armor treated by the Krupp process, which produces a plate about as much superior to the Harveyized plate as that was to the armor which it superseded. The objects sought in the manufacture of armor plate are great toughness of body to resist cracking and breaking up of the plate, and extreme hardness of the face, with the object of smashing the projectile before it can effect penetration. In the Harveyized plate great toughness is secured by using a certain percentage of nickel in making up the composition of the steel. This toughness is further secured by a very thorough furnace and mill treatment. Face-hardening is done by placing the plate, face upward, in a furnace, covering it with a layer of crushed bone and other carbonaceous material, and exposing it for the proper length of time to a predetermined temperature. The face of the plate takes up a large percentage of carbon, and after tempering with cold water becomes extremely hard. The Krupp process is similar in principle. Nickel is used in making up the composition, and the steel after being taken from the furnace is subjected in the fluid state to enormous pressure in a hydraulic press, which squeezes out the gas and various impurities. The compressed ingot is heated and forged into plate in a 14,000-ton hydraulic press, and then undergoes various processes of annealing to take out initial strains. The face-hardening is done in a furnace where gas is substituted for the carbonaceous material of the earlier process. By this method the face-hardening is carried into the plate about twice as deeply as in the Harvey process.

We present two photographs showing the Proving Ground tests of two plates, representing armor for the new battleships "Maine" and "Missouri." The 12-inch Carnegie plate for the "Missouri" was attacked by one Carpenter and two Wheeler uncapped shells, with striking velocities of 1,675, 1,669, and 1,664 feet per second. In each case the shells broke up after penetrating from 3½ to 4⅜ inches only. The plate in each case was dished only one-eighth of an inch, and no further damage was done than the flaking of the face-hardened surface. No cracks whatever were developed in the plate. In the case of the Bethlehem 12-inch plate for the "Maine," one Carpenter and two Wheeler uncapped shells were used; the striking velocities were 1,616, 1,692, and 1,723 feet per second. The shells broke up after penetrating 6½, 4½, and 4½ inches without developing any cracks in the plate, the only injury beyond the penetration being a flaking of the surface and a slight dishing of the plate in the first round to the extent of a quarter of an inch. The foregoing results indicate that the side, barbette, and turret armor of our latest battleships will be secure against the 12-inch shells of the enemy, except at close range.

12-Inch Kruppized Armor Plate Representing Armor for the "Missouri," After Attack by Three 12-Inch Shells. Projectiles Smashed on Plate. Penetration, 4⅜ Inches, 4¼ Inches, and 3⅛ Inches.

12-Inch Kruppized Armor Plate, Representing Armor for the "Maine," After Attack by Three 12-Inch Shells. Projectiles Smashed on Plate. Penetration, 6⅛ Inches, 4⅛ Inches, and 4⅛ Inches.

OUR POWERS OF DEFENSE.

The complete wrecking of the finest and heaviest modern armor plate by high-explosive shells, as shown in the accompanying illustrations, was the culmination of a very thorough investigation carried out by the Army Board of Ordnance at Sandy Hook, in the search for a high-explosive shell-filler that would meet all the ideal conditions as to safety, certainty, fragmentation and destructive effects. From the first appearance of high explosives artillerists have recognized how greatly they would increase the destructiveness of shell-fire, if they could be used as a shell-filler and rendered sufficiently insensitive to shock to be carried through armor plate and burst by a suitable time fuse in the interior of a fort or a battleship. The desiderata in such a high explosive are: It should be reasonably safe in manufacture; it must withstand the shock of discharge from the gun and the shock of impact when the shell struck and was passing through armor plate; it must be uniformly and completely detonated by a suitable fuse; it must possess the elements of stability—that is to say, it must not decompose under test, it must be non-hygroscopic, and it must not attack the metal of the projectiles and fuses. Lastly, it must not be attended with danger in loading into shells, and the explosive should be readily manufactured, and in large quantities, at a reasonable cost. Among the high explosives tested were black musket powder, the Rendrock Company's No. 400 explosive, picric acid, wet guncotton pellets, maximite, and explosive "D." Of these, the last two fulfilled in every particular the conditions laid down. Their exact composition is, of course, a secret; but it is known that maximite is a picric acid compound consisting mainly of a picrate. Its products of combustion are almost entirely gaseous, and as the heat developed on detonation is very great it possesses, as the result of its high gravity, an unusually high explosive value. "Dunnite," the other explosive is the invention of Capt. Dunn, of the army, and in its qualities and action it is very similar to maximite.

The plate which is shown in the accompanying illustration so completely smashed to pieces was one of two identical plates built under an appropriation by Congress, which was granted for the purpose of testing the regular 12-inch gun, firing service projectiles, against an 18-inch gun which was built especially for throwing the Gathmann, guncotton, torpedo shell. The Gathmann idea is to deliver a large amount of high explosive against the outside of a battleship, under the expectation that the detonation of the charge on impact will result in the bursting in of a large section of the ship's side. The Gathmann test plate and the armor service projectile plate were backed up with steel framing representing a section of the side of the battleship "Iowa." In these tests three of the Gathmann shells, each containing about one-quarter of a ton of wet guncotton, cracked the plate from top to bottom, but otherwise did it no material injury. The plate with its backing, however, was driven 8 feet into the sand backing, and the whole mass was swung around 8 feet to the left of its original position. However, in view of the great striking energy of 52,000 foot-tons of the 1,800-pound

An 11½-inch Kruppized Plate After Attack by Three of Our 12-Inch Armor-Piercing High-Explosive Projectiles. Plate and Backing Completely Wrecked.

Rear View of Same Target, Showing Complete Destruction Wrought by 12-Inch Armor-Piercing Shot Loaded with 20 Pounds of the New Government High-Explosive.

OUR POWERS OF ATTACK.

Gathmann shell, it was considered that the results on the plate itself were very inadequate. In the test of the service armor-piercing projectiles three rounds were fired, the first two being with armor-piercing shot filled respectively with 20 pounds of maximite and 20 pounds of dunnite, the last being an armor-piercing shell filled with 60 pounds of maximite. The projectiles burst as they were passing through the plate, which was completely broken up, and the flying fragments of plate and shells tore the steel backing literally to shreds, cut to pieces the heavy oak struts at the rear, and blew away several hundred tons of the sand backing.

As far as we know, large-caliber, high-explosive shells have never before been carried through heavy armor. Had this been done, it could scarcely have been kept a secret, and would surely have become known to the world at large. It is, therefore, evident on comparing the upper with the lower pair of photographs that, while our heaviest armor is impervious to attack at ordinary ranges by 12-inch shells, we are in the possession of a high-explosive shell which can penetrate and burst behind the best armor employed in foreign navies.

Armored Cruisers.

ARMORED CRUISERS OF THE "MARYLAND" CLASS—"CALIFORNIA."

The development of the cruiser during the past few years has been in two widely divergent directions. On the one hand we have the large armored cruiser of from 12,000 to 14,000 tons displacement, with a complete waterline belt; and well-protected positions for a main battery of two or four heavy 8, 9 or 10-inch guns, and full broadside or casemate armor for a numerous battery of broadside rapid-fire guns. On the other hand, we see the protected cruiser tending to lower speed, less protection and lighter battery. The line of division between the battleship and the armored cruiser, furthermore, is becoming less distinct; and the six magnificent ships of the "Maryland" class will be so well armored and protected that they would not hesitate to take their place in line of battle against second-class battleships, while their large coal capacity and high speed will enable them to fulfill all the requirements of the first-class cruiser.

The six fine vessels of the "California" class will be 502 feet long, or longer by 90 feet than the next largest ships in our navy; and they will be but little shorter on the waterline than ocean liners like the "St. Paul" and "New York."

The fighting positions and the "vitals" will all of them be sheltered behind walls of Kruppized steel, and the arrangement of armor protection will be as follows: First, a waterline belt 7 feet 6 inches wide extending from bow to stern, which carries its maximum thickness 4½ feet from the top down, whence it tapers to the armor ledge. For a distance of 244 feet amidships, the belt will have a maximum thickness of 6 inches and a minimum of 5; thence to the bow and to the stern the belt will have a uniform thickness, top and bottom, of 3½ inches. For a distance of 232 feet amidships, above the waterline belt and up to the main deck, the sides will be reinforced by 5-inch armor; transverse bulkheads, turning inboard at the ends of this side armor, will complete the central casemate, housing the ten 6-inch guns. These transverse bulkheads will be 4 inches thick. The protective deck will be continuous from bow to stern; on the flat it will be 1½ inch thick and on the slopes 4 inches thick. Above this protective deck, a cellulose belt 3 feet thick will be worked along the sides, from one end of the ship to the other. It is required that the water-line armor belt be so placed that at least a foot of it will be out of water at deepest load draft.

The armament will consist of: A main battery of four 45-caliber, 8-inch, breech-loading rifles and fourteen 50-caliber, 6-inch, rapid-fire guns; and a secondary battery of eighteen 14-pounders, twelve 3-pounders, eight 1-pounders, two 3-inch field guns, two machine guns, and a half a dozen small-caliber pieces for boat service. There will be two submerged torpedo-tubes, to be placed on the broadsides pretty well forward. The 8-inch guns are to be mounted in two balanced elliptical turrets on the main deck forward and aft of the superstructure. These turrets will be generally 6 inches thick with slanting faces ½ inch thicker. The turrets are to be controlled electrically, and are to fire through arcs of 270 degrees. The rate of ammunition supply is one complete round of powder and projectile to each electric hoist every fifty seconds.

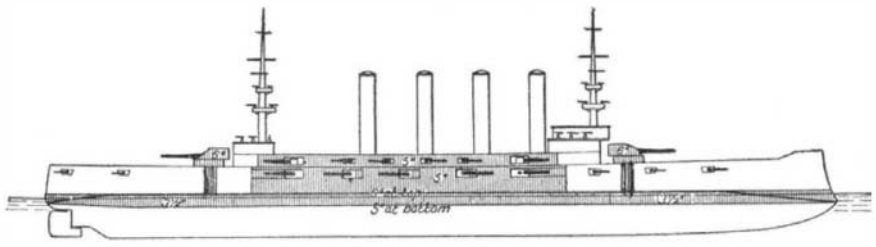
The four 6-inch guns mounted on the main deck are to be placed in sponsons at the four main corners of the superstructure, and are to fire through arcs of 145 degrees—the forward ones from dead ahead aft, and the after ones from dead astern forward. These guns are protected by 5-inch armor. The ten other 6-inch guns, five on each broadside, are to be placed amidships on the gun deck—the forward ones firing dead ahead, while all the other guns on each side will have arcs of fire of 110 degrees, and will be arranged to house within the side line. These guns will be separated by 2¼-inch splinter bulkheads. The ammunition hoists will be run by electricity, and are to supply each 6-inch gun with three complete rounds every minute. The 14-pounders will be mounted on the gun deck and up in the superstructure, three forward and two aft of the 6-inch battery on each side, and four on each broadside between the 6-inch guns up in the superstructure. The 3-pounders are to be mounted on the superstructure deck and on the bridges, while most of the 1-pounders are to fill the military tops. Each 14-pounder is to be supplied six rounds a minute, while the 3-pounders are to have ten.

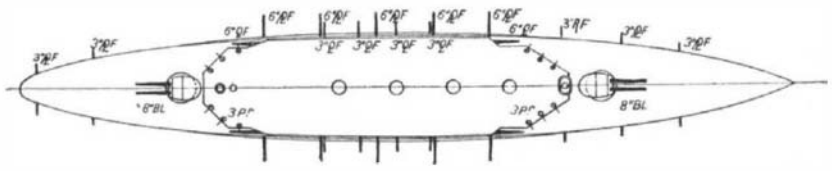
The firing stations for the torpedoes will be sheltered from the reach of 6-pounders and lighter pieces, and are to be located above the torpedo tubes. The conning-tower, located at the fore end of the superstructure, will be of steel 9 inches thick, and the signal tower, located at the after end of the superstructure, will be of steel 5 inches thick. The pilot house will be of bronze. All magazines are to be carefully insulated, and certain of them are to be chilled by the refrigerating plant. All are also to be easily susceptible of instant flooding.

The ships will be driven by twin triple-expansion engines of 23,000 horse power, which are calculated to give them a speed of 22 knots an hour. As the displacement is 13,680 tons, these vessels in respect of their motive power afford an interesting comparison with the British armored cruisers of the "King Alfred" class, which on a displacement of 14,100 tons are to make 23 knots an hour with 30,000 horse power. The boiler rooms of the "California" will contain 30 water-tube boilers placed in 8 water-tight compartments.

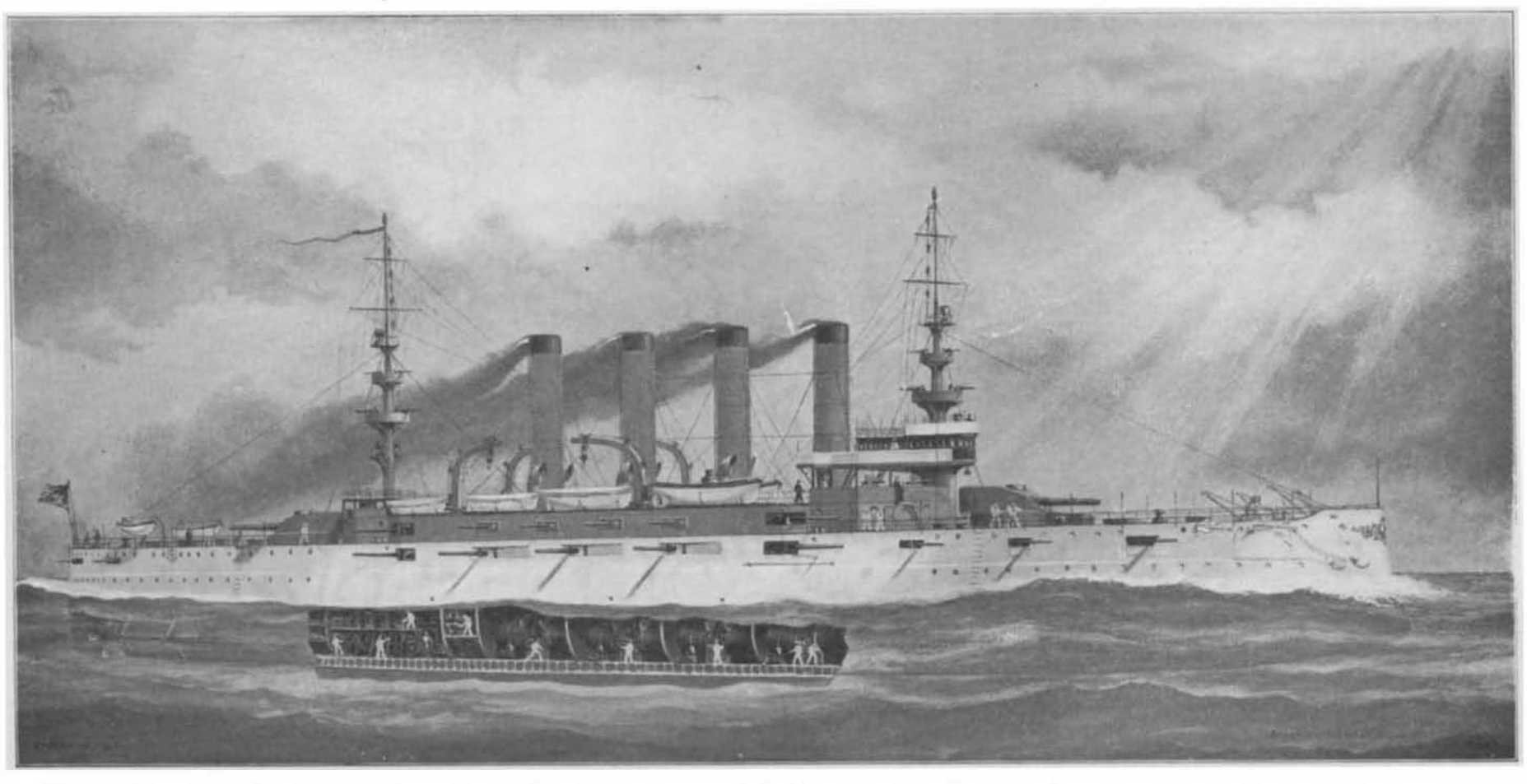
The ships will carry ammunition enough to put up a good long fight; 500 rounds being allowed the 8-inch guns, 2,800 rounds for the 6-inch guns, 4,500 rounds for the 14-pounders, 6,000 rounds for the 3-pounders, and a pretty liberal supply for the rest. Provision is to be made for closing many of the water-tight doors automatically, i. e., from a single controlling station, and every care has been taken to localize the effects of damage by shell-fire or torpedo.

In closing, we would draw attention to the protection afforded to the broadside battery, which, compared with separate casemate protection, as used on the English cruisers of the "Drake" class, is we think superior. The casemate carries 6 inches of armor on the front and 2 inches at the rear. The stretches of the ship's side between casemates are unarmored, and an enemy's shells might pass between casemates, and, bursting on the 2-inch armor of the opposite casemates, wreck them. No such damage could be suffered by the off-side battery of the "Pennsylvania," as all 5-inch and most 6-inch shells would be burst on the unbroken front wall of 5-inch armor.





Gun and Armor Plan; "California" Armored Cruiser Class. "California," "Colorado," "Maryland," "Pennsylvania," "South Dakota," "West Virginia."



Displacement, 13,680 tons. **Speed,** 22 knots. **Bunker Capacity,** 2,000 tons. **Armor:** Belt, 6 inches to 3½ inches; turrets, 6½ inches to 6 inches; barbettes, 6 inches; deck, 1½ inch to 4 inches. **Armament:** Four 8-inch, 45-caliber B. L.; fourteen 6-inch, 50-caliber R. F.; eighteen 3-inch R. F.; twelve 3-pounders; eight 1-pounders; two 3-inch field guns; two machine guns; six automatic guns. **Torpedo Tubes,** 2. **Complement,** 822.

ARMORED CRUISER "CALIFORNIA."