THE BATTLESHIP OF THE FUTURE.—I.

BY FORREST E. CARDULLO.

An unusual interest has been taken in the new British ship "Dreadnought," not only by those whom we might expect to find professionally interested in all naval affairs, but also by the average layman, who reads nothing more technical than the columns of the Sunday paper. To the latter she is interesting simply as the biggest and most powerful warship afloat, but to the man who concerns himself with naval affairs, she is even more interesting as the forerunner of the new type of battleship.

In most respects, the "Dreadnought" is simply a further advance along those same lines in which battleship design has been progressing for the past fifteen years. Her armor is of Krupp steel, similar to that carried by the present-day type of ship, being, however, a trifle thicker than is usual in British ships. Her speed is high for a battleship, being 21½ knots. She is driven by steam turbines, instead of reciprocating engines. The hull is subdivided into separate watertight compartments to an unusual extent, as a protection against torpedoes. To make all these improvements possible, the ship is of great size, being of about 18,000 tons nominal displacement. There are many other unusual features in her construction, adopted with the idea of making her more seaworthy, more comfortable for her crew, or more convenient to operate, but none of them materially affect her fighting efficiency.

In one respect, however, the "Dreadnought" is a radical departure from the type of battleship that has been the accepted standard for the past fifteen years. Her main battery consists of ten 12-inch guns, in place of the four 12-inch guns usually carried. She is without any intermediate battery whatever, while the present type of ship carries an intermediate battery of from twelve to twenty guns, varying in caliber from 6 to 8 inches. All the weight generally devoted to this battery, its ammunition, mountings, armor, etc., in the case of the "Dreadnought" is devoted to the primary battery. The reason for this change is as follows:

Let us suppose that the "Dreadnought" engages our own "Connecticut." The "Connecticut" carries an intermediate battery of unusual power, and is therefore an especially good representative of the present type of ship. If the vessels fight at long range, the 12-inch guns of the "Dreadnought" will soon destroy the "Connecticut's" intermediate battery, since they can easily penetrate the 7 inches of armor defending it, even at 10,000 yards range. While at this range the "Connecticut's" guns can inflict a tremendous amount of damage on the "Dreadnought's" upper works, they can do nothing which will impair her fighting ability in the least, since all of the heavy guns, machinery, magazines, and other vitals of the British ship are protected by armor 12 inches thick.

If, on the other hand, the vessels close in till the heavy guns of each can inflict serious damage on the other, the four guns in the "Connecticut's" primary battery would be overwhelmed by the ten guns of the "Dreadnought," while the American's intermediate battery would be powerless to affect the result. Twenty of her guns would be ruled out of the battle through lack of penetrating power. Although they might be trained against the upper works of the British ship, where they could destroy perhaps a million dollars' worth of property, the effort would not have the slightest effect on the result of the battle. Neither would the intermediate battery effect any injuries of this character which the main battery of another "Dreadnought" could not inflict. At all ranges, and for any service, the plan of having two calibers of heavy guns aboard ship is inferior to the new plan of making all these guns of the same caliber.

In the course of this paper the writer purposes to develop in a general way the lines along which battleship design may be expected to progress in the future. Our deductions will be based on several fundamental propositions, the first of which is that all her heavy guns will be of the same caliber. The second is that invention and discovery will in the future, as in the past, permit of continual improvements in the material and mechanism of warships. The third is that individual ships will continue to increase in size and power, provided that there is a corresponding gain in efficiency. The fourth is that the designer must seek to obtain the most powerful fleet possible with a given annual money cost. It costs money to build warships, and it costs even more money to maintain them ready to perform effective service. The first cost of a ship of a given type is very nearly proportional to her displacement. The cost of maintenance of a ship is nearly proportional to her displacement, being, however, less per ton in the case of the larger ships. A large ship is more powerful in proportion to its size than is a small ship, and therefore more powerful in proportion to its cost. The limit to the size of a ship is reached at that point where an increase in the number of guns carried does not produce a proportionate increase in the power of the ship, on account of interference between them. It is not possible to arrange a very large number of heavy guns on a ship in a satisfactory manner, since either each gun will have only a small arc of fire, or else the blast from one gun will prevent another from being properly served and aimed. It is next in order, therefore, that we investigate the probable distribution of guns on our battleship of the future.

Of the possible arrangements of heavy guns, the most usual is to mount them in pairs in turrets. This arrangement combines a maximum arc of fire and a very thorough protection with a minimum weight of armor and mountings. A number of arrangements of guns so mounted are shown in Figs. 1 to 4. Fig. 1 is the arrangement to be used on the United States battleship "Michigan." It will be noted that there are eight guns, so mounted that all of them may be fired on either broadside, four of them may be fired ahead, and four of them may be fired astern. Assuming that broadside fire is twice as valuable as bow or stern

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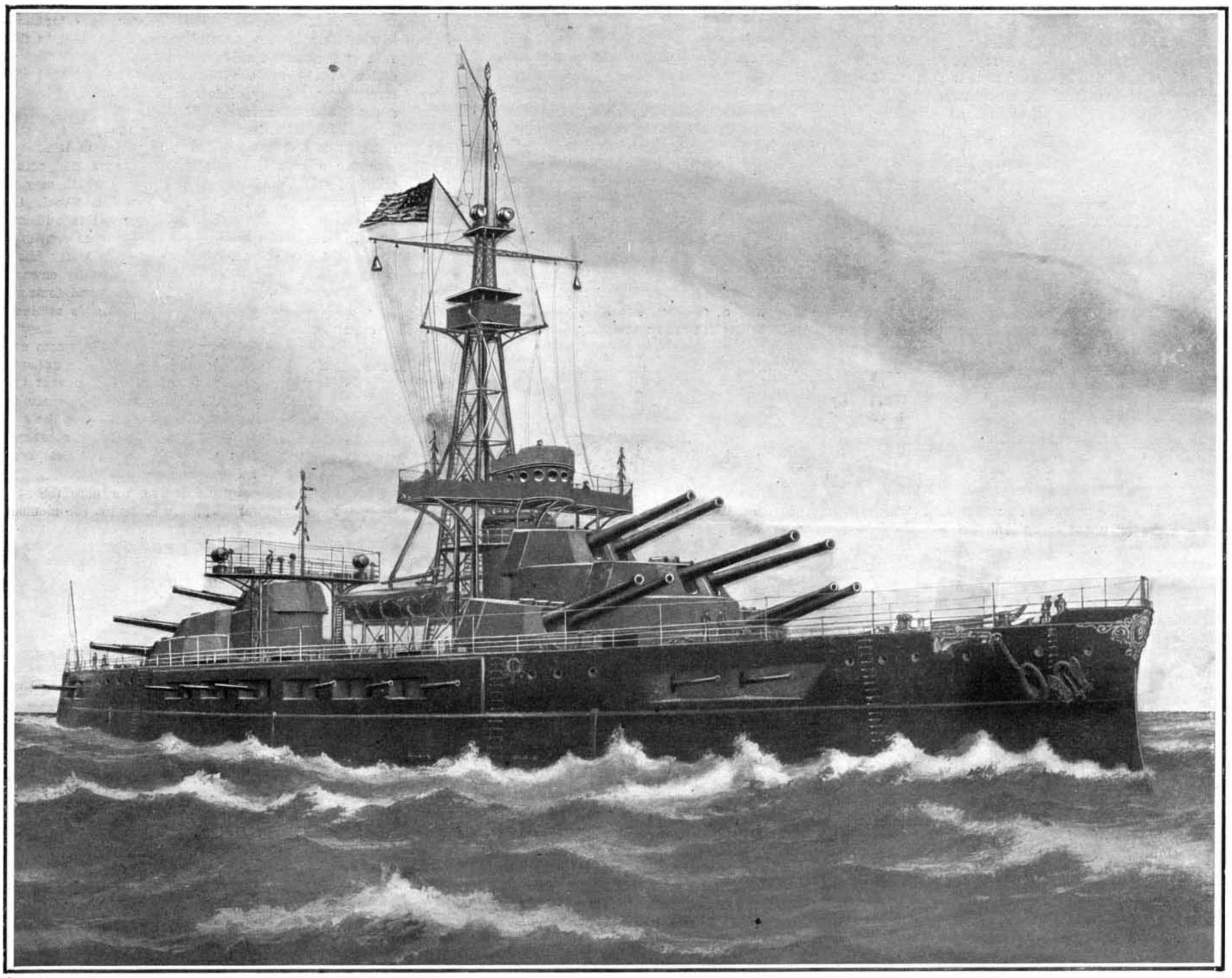

Displacement, 26,000 tons. **Speed with producer-gas engines,** 22.5 knots. **Cruising radius,** 13,000 miles. **Armor:** Belt, 12 inches; barbettes, 16.4 inches; turrets (face), 16.4 inches. **Armament:** Sixteen 12-inch, 50-caliber, 75-ton guns, firing 1,200-pound shell with 3,300 foot-seconds velocity. Torpedo boat defense, twenty 4.7-inch, 60-caliber guns, firing 50-pound shell with 4,000 foot-seconds velocity. **Note the absence of smokestacks. The main battery emplaced in two diamond-shaped barbettes at each end of central armored redoubt, as in diagram Fig. 5.**

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fire, we may estimate roughly the power of this arrangement as $2 \times 8 + 4$, or 20 gun units. In like manner we may say that its comparative efficiency is $20 \div 8$, or 2.5.

Fig. 2 represents the arrangement of the guns of the "Dreadnought." In this case, although there are ten guns, only eight of them can fire on either broadside, and six of them can fire ahead. While theoretically six guns may be fired astern, also, as a matter of fact there is a large space to the rear of the ship on each side of the center line, on which only four guns can be brought to bear. In this design, none of the guns fire over the turrets of other guns, it being different in this respect from all the others shown. The power of the "Dreadnought" is $2 \times 8 + \frac{6+4}{2}$, or 21 gun units, and the efficiency of the arrangement is $21 \div 10$, or 2.1.

Fig. 3 is a distribution of twelve guns after the arrangement in use on our own "Connecticut." Eight guns can be fired on either broadside, and six guns ahead or astern. The power of the arrangement is 22 gun units and the efficiency is 1.83. Fig. 4 is another arrangement of twelve guns. No similar arrangement is in use on any ship at the present time. Ten guns may be fired on either broadside, and eight ahead or astern. The power is 28 gun units, and the efficiency is 2.33.

In each of the arrangements so far discussed, each turret is presumed to be mounted on a barbette, or circular armored tower, rising from the armored deck at the water line to the base of the revolving turret. The armor of this barbette comprises more than half the weight of the whole structure. If we arrange the turrets in groups, each group mounted as close together as possible, and all mounted on an armored citadel, instead of several separate barbettes, there is a possibility of a considerable saving in weight. In Fig. 5 is shown such an arrangement, where the armament is gathered into two groups of four two-gun turrets each, each group of turrets being mounted on an armored citadel, diamond-shaped in plan. For the same thickness of armor, the weight of the citadel is but two-thirds of the weight of four barbettes. The power of this arrangement is 32 gun units, since twelve guns can be fired on either broadside, and eight guns ahead or astern. Since the efficiency, on the plan we have been considering, depends on the number of guns carried in two-gun turrets, each mounted on a separate barbette, we may estimate the comparative efficiency of the proposed arrangement in the following manner: Assuming that the weight of the barbette is 50 per cent of the weight of the whole structure, we have reduced the total weight by 1-3 $\times$ 50 per cent, or 16 2-3 per cent. For the same number of guns, the total weight of the structures is but 83 1-3 per cent of that of eight separate turrets, each with its own barbette. The efficiency of the arrangement is accordingly $32 \div (16 \times 83$ 1-3 per cent), or 2.40.

It is possible to mount guns in threes as well as in pairs, provided that the turrets be suitably enlarged. The turret would become circular instead of elliptical, a slightly greater distance between the guns would be desirable, and the three guns would be trained and elevated as a unit in the same manner as the two guns of a turret now are. The disadvantages of such a scheme are that it makes the turret more complicated and crowded, that the larger turret is a better target, and that an accident to a turret will put three guns out of action instead of two. The advantages are that a ship of a given size may in this way carry more guns, since the weight of the entire structure is not increased in the same proportion as the number of guns, that the guns may be so arranged as to interfere less with each other's fire, and that given the same number of guns and the same displacement, the ship having three-gun turrets will be more speedy, more heavily armored, and more powerful in point of gun fire than her opponent with two-gun turrets. In the writer's opinion, the advantages of the system very much outweigh its disadvantages. Accordingly, we will consider the following possible arrangements of guns.

Fig. 6 is an arrangement of twelve guns in four three-gun turrets. The entire twelve may be fired on either broadside, and six may be fired ahead or astern. The power of the arrangement is therefore 30 gun units. The efficiency may be estimated as follows: In the case of the two-gun turret, the weight of the turret and barbette together is very nearly 75 per cent of that of the whole structure, while the weight of the guns comprises the remaining 25 per cent. To allow of three guns in a turret, the area of its ground plan must be increased 50 per cent. This will necessitate an increase of 23 per cent in the circumference of its walls, or an increase of 75 per cent $\times$ 23 per cent, or 17 per cent, in the total weight of the structure. The extra gun will increase the total weight by $\frac{1}{2} \times 25$ per cent, or $12\frac{1}{2}$ per cent. The whole increase in weight will be $17\frac{1}{2}$ per cent plus $12\frac{1}{2}$ per cent, or 30 per cent. It therefore follows that the weight per gun is 2-3 $\times$ 130 per cent, or 87 per cent of its former value. The efficiency of this grouping is therefore $30 \div (12 \times 0.87)$, or 2.88.

The three-gun turrets may be arranged in any of the groupings that have already been found possible with two-gun turrets. Combinations may also be arranged of two-gun and three-gun turrets on the same ship. What seems to be the most powerful practicable arrangement of guns is shown in Fig. 7. Twenty guns are here gathered in two groups, one at each end of the ship. Each group consists of four turrets mounted upon a diamond-shaped citadel. Of these turrets, the two on the center line of the ship are three-gun turrets, while the other two are two-gun turrets. Sixteen guns can be fired on either broadside, while ten can be fired ahead or astern. The power of the arrangement is 42 gun units, and since the weight of all the gun structures may be shown to be but 75 per cent of that required to mount twenty guns in ten separate turrets, the efficiency of the arrangement is 2.8.

Fig. 1.—Eight 12-Inch (Michigan).

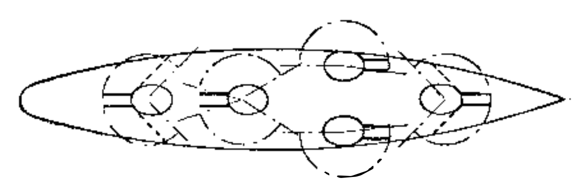

Fig. 2.—Ten 12-Inch (Dreadnought).

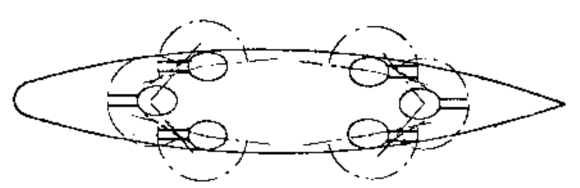

Fig. 3.—Twelve 12-Inch.

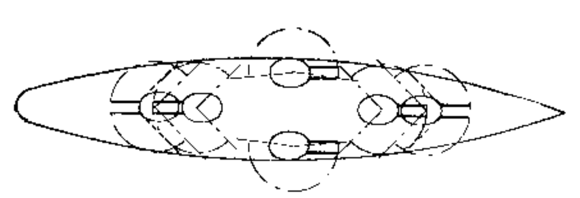

Fig. 4.—Twelve 12-Inch.

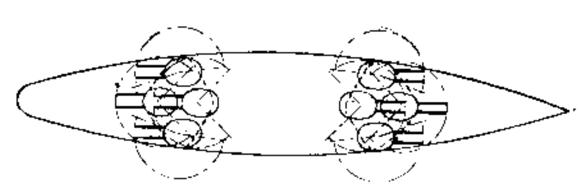

Fig. 5.—Sixteen 12-Inch in Two Groups of Four 2-Gun Turrets.

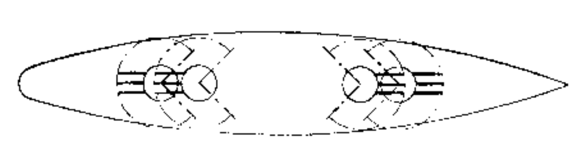

Fig. 6.—Twelve 12-Inch in Four 3-Gun Turrets.

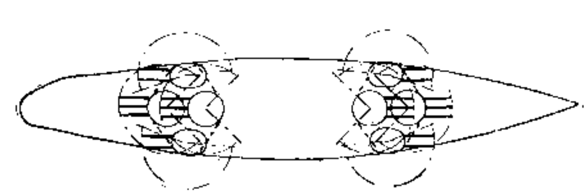

Fig. 7.—Twenty 12-Inch in Four 3-Gun and Four 2-Gun Turrets.

The few arrangements which have been here presented do not by any means exhaust the list of desirable combinations. They are to be taken simply as representative of what may be done, and the comparison of them is interesting because it affords us an idea of the principles by means of which their relative value may be estimated. What will be a very serious objection in the minds of many naval authorities to some of the plans proposed is the fact that they involve an extraordinary concentration of guns in a small space. It will be argued that in the case of the arrangement shown in Fig. 7, for instance, a single shot could put out of action ten guns, or half the power of the ship. On the other hand, it is to be noted that the great size of ship required to carry so heavy an armament, together with the saving in weight effected by the arrangement, permits of the application of armor so thick as to make its penetration impossible except at very short range. The argument that it is poor policy to put all your eggs in one basket is met by the answer that one basket in this case may be more carefully guarded and thoroughly protected.

The type and caliber of gun carried is second only to the number and arrangement, in determining the size and general construction of the ship. The type of gun will affect the thickness and distribution of armor, and indirectly, the size and speed of the vessel. It is of paramount importance that a battleship shall be armed with guns of such caliber and power as will enable her to fight on equal terms with any ship of approximately equal tonnage, and all other considerations are of secondary importance. That the guns of the future will be more powerful and effective than those of the present day goes without saying, but it is not so easy to see in what way this increased power will be gained.

The power of a gun of a given caliber may be increased in one of two ways. Either the length of the gun may be increased, or the pressure of the explosion may be raised by increasing the powder charge. The limit to the length of the gun is about sixty calibers, since when this length is reached, it is found to be better to enlarge the caliber of the weapon and diminish the ratio of length to bore. The limit to the explosion pressure is about 17 tons per square inch, and this limit is set, not by lack of strength on the part of the walls of the gun to resist a greater pressure, but by the fact that greater gas pressures produce too great erosion in the bore of the gun. Guns have been built and tested which successfully endured a pressure of 32 tons per square inch, and if sufficient improvement can be made in powders, and in the material of inner tubes, so that heavier pressures may be sustained without too serious erosion, we may expect great advances in the power of guns.

The value of a gun as a naval weapon depends on two things, first on its ability to penetrate armor, and second on the weight of shot thrown in a given time. Given two guns of equal penetration at battle ranges, their relative values are as the weight of metal thrown per minute by each. When, however, we are called upon to compare two guns of different penetration, it is more difficult to get an idea of their relative value. The writer is inclined to estimate their relative value by comparing the range at which they will penetrate the armor to which they will probably be opposed. If this principle be correct, it will appear from the tables of gun penetrations and probable thickness of armor that the power of a gun varies as the cube of its caliber, for a given muzzle velocity and form of projectile; but when the caliber has become so great that the gun is able to penetrate any armor to which it will be opposed, at battle ranges, a further increase is useless, and the law given above no longer holds. If we consider that the weight of metal thrown per minute by a gun is independent of its caliber (since the smaller it is the faster it can be fired), which is nearly true for guns of 6-inch caliber and over, we have 1 twelve-inch gun equal to 1.7 ten-inch guns, or 3.4 eight-inch guns, or 8 six-inch guns, or 0.63 of a fourteen-inch gun.

Facilities for rapidly leading, sighting, and firing naval guns are of very great importance when applied to guns of sufficient penetration. A more rapid rate or fire demands a larger supply of ammunition, better and more powerful ammunition hoists, and greater space and weight for magazines and loading machinery. Were it not for this fact, we might expect to see the displacement per gun continually decreasing, as improvements are introduced which tend to cut down weights, but the probabilities are that the extra weight demanded by the improved rate of fire will just about balance any saving that may be had from other sources.

(*To be continued.*)

Death of Sir Michael Foster.

One of England's most noted surgeons, Sir Michael Foster, K.C.B., died January 30, 1907. He held at various times the posts of professor of practical physiology at University College, London; prælector of physiology, Trinity College, Cambridge; president of the British Association; professor of physiology, Cambridge; and secretary of the Royal Society. He represented London University in the House of Commons, 1900-06. He was joint editor of "Scientific Memoirs of Thomas Henry Huxley."

A landslide occurred in October on the Thompson ranch at Scott's Valley at Santa Cruz, Cal., which uncovered a bed of whalebone which apparently has been there since the antediluvian period. The place where the prehistoric bones were uncovered is fully 600 feet above the sea level and six miles from the shores of Monterey Bay. Other discoveries of the kind have been made in various sections of the county, and scientists who have made a study of the geological formation of the soil at different times claim that the present site of Santa Cruz, extending as far back as the Santa Cruz Mountains, was once covered by an immense body of water.