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ENGINEER DEPARTMENT, UNITED STATES ARMY.

STUDIES

ON

COAST DEFENSE

APPLIED TO

THE GULF OF SPEZIA

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BY

CÆSAR GUARASCI,

COLONEL OF ENGINEERS.

(Traduit de la Rivista Marittima.)

TRANSLATED BY

FIRST LIEUT. G. McC. DERBY,

CORPS OF ENGINEERS, U. S. ARMY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

ENGINEER DEPARTMENT, UNITED STATES ARMY.

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OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., June 18, 1884.

SIR: The Board of Engineers has submitted a translation of an article from the Rivista Marittima, entitled "Studies on Coast Defense applied to the Gulf of Spezia."

The paper contains valuable information for the officers of the Corps of Engineers and for the Army generally, and I respectfully recommend that authority be granted to have it printed, with its accompanying plates, at the Government Printing Office, and that 800 copies be obtained for the use of the Engineer Department, upon the usual requisition.

The paper, with its accompanying plates, is submitted herewith.

Very respectfully, your obedient servant,

JOHN NEWTON,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. ROBERT T. LINCOLN,
Secretary of War.

[Indorsement.]

Approved.

By order of the Acting Secretary of War:

JOHN TWEEDALE,
Chief Clerk.

WAR DEPARTMENT,
June 19, 1884.

UNITED STATES ENGINEER OFFICE,
New York, May 22, 1884.

SIR: I have the honor to return herewith the pamphlet entitled "Considérations sur la Défense des Côtes appliqués au Golfe de la Spezia," with the translation of it that I was requested to make.

Very respectfully, your obedient servant,

GEO. MCC. DERBY,
Lieutenant of Engineers.

Col. J. C. DUANE,
Corps of Engineers, U. S. A.,
President of the Board of Engineers.

[Indorsement.]

OFFICE BOARD OF ENGINEERS,
New York, May 27, 1884.

Respectfully forwarded to the Chief of Engineers, together with the translation herein referred to, and with the recommendation that it be published for the information of officers of the corps.

On behalf of the Board:

J. C. DUANE,
Colonel of Engineers, Bvt. Brig. Gen. U. S. A.,
President of the Board.

STUDIES ON COAST DEFENSE APPLIED TO THE HARBOR OF SPEZIA.

A well organized and complete defense by means of fortifications cannot be made at any point whatever of a coast; but only where special hydrographic conditions permit the location of a series of works which, collectively, shall, under all circumstances, have a preponderating defensive value over the means of attack. To attain this end two conditions must be fulfilled, one independent of, the other dependent upon, the work of man. Only when the hydrographic conditions of the coast impose a limit to the development of the attack, and hence to its importance, is it possible to fix the defense so that it may have the superiority demanded.

The hydrographic conditions alluded to are found where shoals prevent the free movement and concentration of vessels, or where the coast line forms sinuosities sufficiently narrow into which the enemy's vessels must necessarily enter to use their means of attack efficiently; in such cases the arrangements necessary for a successful defense are easily determined, the only absolute condition controlling the location of the works being to provide the necessary concert of action, so that the burden of resisting an attack may not fall upon a single work.

A disregard of the principle of concentrating the fire of the greatest possible number of guns upon all points where the attacking vessels may present themselves, would neutralize such naturally favorable hydrographic conditions, and permit the attack to overcome the various works in succession. The results of this method of attack are certain and infallible, and are confirmed by many instances, amongst which, to cite a single one, it will be sufficient to recall the attack upon San Juan d'Ulloa, made by a small French squadron composed of three frigates, a corvette, and two gun-boats, which, from its ability to reconnoiter and select a good position at 1,100 meters, not exposed to the principal front of the fortified lines, succeeded in half a day in silencing the armament of 193 pieces and in forcing the place to capitulate.

It is often said as an aphorism in regard to coast defense that this duty should be intrusted exclusively to the fleet, which it is claimed ought to defend its own shores at a distance and on the open sea. For when by a

bold initiative the war can be carried to the coast of an enemy's country, doing serious damage to his dock-yards, arsenals, forts, &c., thus paralyzing his naval power by action against the fundamental bases of operations of his fleet, it is highly improbable that similar attempt on the part of the enemy will be made.

But a bold initiative of this nature may, however, be unsuccessful, in consequence of innumerable and unforeseen contingencies to which naval operations are liable; furthermore, for the very reason that a timely initiative may be so fruitful in great results, it must be expected on the part of the enemy. It may be readily conceived, then, that a victory in a naval engagement, won in distant waters, may be decisive, and in such case the one that remains in control of the seas can select at pleasure his objective on the enemy's shores where he will do the greatest damage to the seaboard cities, and bring ruin to the more important establishments, dock-yards, arsenals, &c., so that the one that has met with reverse finds himself, in consequence, exposed to extreme disaster.

The action of fleets should be prompt, free, and very mobile; and for that reason it would be absurd to claim that fortified works, which are fixed defenses, could resist all the operations that might be attempted against an extended shore line; and it would be no less absurd to deprive the fleet of its mobility to protect certain fixed points on its own coast by obliging it to hold itself in readiness to defend them even against operations which the enemy could complete in a short time.

It is the general opinion, and unquestionably true, that the Gulf of Spezia, with its grand dock-yards and arsenal, should be defended by powerful fortifications, leaving to the fleet entire freedom of action, either to assume a bold initiative or to contend with a superior naval force, and it would be unwise to weaken it by withholding a number of vessels for the defense of the arsenal. Whatever may be the arguments of those who are in favor of a naval defense alone for these waters they cannot succeed in disproving the value of sea-coast defenses. Moreover, the outlay required to provide the necessary fortifications for Spezia, if applied to the navy, would at the very most increase its strength by but one or two vessels.

The necessity of defending the Gulf of Spezia by means of fortifications has therefore been rightly maintained, and, admitting the wisdom and necessity of such defense, it will be useful to examine in what way the principles enunciated for the execution of an efficient defense can be satisfied.

For that purpose it is important to consider, first, what may be the objective of the attack which the works should resist.

Spezia is, without doubt, an important objective for the attack of an enemy, who would wish to paralyze our fleet by depriving it of the indispensable means of holding the seas to defend our coast. We must therefore

admit that he might propose to attain his end either by an attack from the land side or an attack by sea or finally by a combination of both.

Now, leaving aside the land defenses, the importance of which depends upon the number of troops that can be assigned to their support, it is evident that the sea-coast works, that is to say those to which the defense against a naval attack is intrusted, should have a maximum defensive power sufficient to withstand any attack that can be made upon them, for the use of troops could not be depended on to compensate for an inadequate or inferior defensive system. Finally, we must absolutely free ourselves from all idea of receiving any assistance from our fleet if we wish to leave it free from all obligation of guarding the arsenal and give to it the liberty of action necessary for the defense of our extended sea-coast.

Admitting the foregoing, the works for the defense of the arsenal from an attack by sea should be of such a character as to prevent an hostile fleet from freely approaching near enough to the works to destroy them either by its artillery or by landing a few bold men; and provision should be made for preventing the landing of boat parties supplied with the means of rapidly destroying the structures and material.

Indeed, the work of a few men landed at the arsenal and supplied with the necessary explosives might cause a greater destruction than would be feared from near bombardment. It need only be considered what enormous damage could be done the most important structures in the arsenal, such as the docks, by means of a torpedo exploded in the filling and emptying sluices, to realize that several thousand cannon shots would not suffice to do the same damage. It is therefore easy to conceive that the fortifications of Spezia should be studied with the double purpose of preventing bombardment and the approach of the enemy's vessels to the neighborhood of the arsenal; but that of the two the second point should be given absolute importance.

Among the various projects for the defense of the Gulf of Spezia, preference has always rightly been given to the idea of closing the entrance with a dike. While at first the prevention of bombardment was considered the main object, it is none the less true that it is essential we should keep in view its more important object, that of preventing access to the arsenal. Although concerning the position of the dike several opinions have been discussed at length, and though the necessity of placing it as far as possible from the arsenal to prevent bombardment is generally admitted, there is yet a difference of opinion regarding the precise location which will attain at the same time the double result of preventing bombardment and access to the arsenal.

An exterior dike situated on the extreme chord of the gulf, drawn between Points Maralunga and Scuola, would at first sight appear the most suitable as placing an obstacle at the greatest possible distance from the ar-

senal. But this extreme location, which primarily appears the most rational, would have a serious disadvantage; for a dike whose openings could not be securely defended by guns would answer the purpose but poorly; and the exterior dike cannot be otherwise defended than by works situated on one of the extreme points of the shore, together with others erected on the dike itself; all of which being exposed to the open sea would fail to satisfy the condition which, as we have shown, is indispensable to insure a superior defense. The attack being able to develop itself freely, would always have the means of choosing favorable positions from which to silence the exterior works one after the other; and this being done, what obstacle would prevent the enemy from passing beyond the dike and bombarding at his pleasure, or, what is still worse, taking possession of the arsenal?

If we neglect the objection of exposing the works to the open sea, a line of works on the extreme chord from Scuola to Maralunga and a dike a little in rear would constitute a less defective solution. Of course, the advanced works in this case would be neither more nor less efficient in keeping the bombardment at a distance than in the first case, for we should not admit that the enemy would try to pass through the intervals between the works. For if armored vessels can, and even ought to, venture a great deal when they have a fortified channel to force, it is none the less true that such an operation would be unnecessarily hazardous, when, after having forced the passage, instead of finding space to escape from the persistent action of the guns of the defense, they would run upon an obstacle like the dike situated a little in rear of the fortified lines.

The second solution would therefore present the same difficulties to the bombardment as the first; with this difference, however, that after having reduced to silence the works of the defense in the first case, the exterior dike would be powerless to prevent either the entrance to the arsenal or the bombardment which would subsequently be made even at a very short range when the vessels had passed the dike; whereas, in the second case, the dike being behind, with its openings still well defended, narrower, and situated in a re-entering, could still effectively prevent access to the arsenal and limit the distance to which the vessels could approach to effect the bombardment.

The foregoing considerations appear to prove conclusively that the system of the dike a little withdrawn and defended more in front by fortifications placed on the extreme chord of the gulf is more effective than the exterior dike defended by works established on the same line; provided, of course, the immediate defense of the openings is secured by other coast works located on the flanks.

This solution, however, although better than the first, is still open to

criticism, because the advanced works being still exposed to the offing would be deprived of the conditions necessary to insure the superiority of the defense, which, as has already been demonstrated, can only be obtained in the single case when the attack is crowded into a limited space where it can be swept from all sides by the converging fire of the defense. It is therefore of the first importance that the works placed in advance of the dike should also be in a re-entering position imposing a necessary limit to the development of the attack.

Now, it is evident that to execute the project of the defense under the best possible conditions the dike ought to be placed at a greater distance from the arsenal than that of bombardment; but the dike itself and the more advanced works should be situated in a re-entering with respect to the extreme chord of the gulf. As the length of the axis of the Gulf of Spezia will not permit this disposition, it is clear, as we have demonstrated, that the only possible solution to satisfy the principle insuring the superiority of defense, consists in seeking to always hold the works in a re-entering position, and to so manage that their efficiency shall extend to the limit necessary to prevent bombardment. In this way access to the arsenal will be prevented absolutely, and the bombardment will be opposed by the preponderating fire of the defensive batteries.

In a word, the best solution would be obtained if the dike were placed beyond bombarding range, and if it were defended in front by works established in a re-entering position. As this cannot be obtained, the best remaining solution is that which places the dike as far as possible from the arsenal, protecting it by works located and armed in such a way as to extend their effective action beyond the limit necessary to prevent bombardment; but always with the condition that the works shall be located on a re-entering line, that they may surround and sweep effectively with converging fire the zone of water into which the enemy must necessarily advance to be able to attack them.

To make these principles clearer it will be well to examine them more closely and for the special case of the defense of Spezia.

Plate I represents the case in which the works in front of the dike are placed on the extreme chord of the gulf; that is to say, one at Maralunga, one at Scuola, and three in the interval between these two points.

It is assumed that the dike placed between points Santa Maria and Santa Teresa, where it is at present being constructed, has its openings defended near at hand by work situated on each of the points mentioned. In this way the defense by batteries for horizontal fire would be intrusted to seven works, which we will suppose armed with guns mounted in revolving turrets, or, if preferred, on platforms allowing a sector of fire of 360°. We will also leave out of consideration other works with great elevations whose fire, while always useful, will not constitute the funda-

mental basis of the defense. It will further be supposed that the zone of effective fire for the guns constituting the armament of the water batteries extends to 2,500 meters.

With these data the zone in front of the dike effectively defended would be limited by the line *m g* at a mean distance of 8,700 meters from the arsenal. In this zone the fire of the works would be combined according to the diagram shown on the plate, in which the numbers that mark the different sectors indicate the number of batteries having simultaneous action in each of them.

Now, it is easy to see that, with the arrangement indicated, there are still large zones of water, swept only by the fire of two batteries, in which vessels could take up positions to attack, at quite short range, and from which it would be sufficient for the enemy to silence one of these batteries to render its task with the other much easier. It is thus shown by the diagram how a concentration of fire would clear the way, step by step, rendering successive attacks possible and more and more easy.

But if, on the contrary, we suppose the defense made up as in the diagram, Plate II, the task of the attack would be much more severe, for, in this case, excepting in a few very narrow and most distant sectors, where vessels could take position exposed to the fire of two batteries only, in all the rest they would always be under the simultaneous fire of several batteries. In the latter diagram it is important to notice that the two batteries Scuola and Maralunga are supposed to have their fields of fire limited towards the offing, as indicated by the lines in *m n* and *m′ n′*, respectively, in order that they shall not be left exposed to attack in that direction from sectors where the co-operation of other batteries would be wanting. It is, therefore, supposed that these batteries would be so located that they would be protected by the coast from the sea outside the lines mentioned which constitute the limits of their fields of fire in that direction.

A comparison of the conditions of defense presented by the two diagrams shows clearly that while in the first the effective fire of the defense reaches as far as 8,700 meters from the arsenal, on the other hand the safety of the works cannot be well assured; whereas in the second diagram effective action is much better secured. Consequently if we could assume that a bombardment from a distance of not less than 7,500 meters is not dangerous and of but little effect, the superiority of the second solution would be evident. It may be objected, however, that if we cannot with the present arrangement of guns afloat attain a range of 7,500 meters, we must expect at any time that greater ranges will be obtained. This objection is certainly serious, but after all it can only arise from a new arrangement of guns on board ships, and we may assume that in such case we also might have such guns with ranges exceeding even 8,700 meters, and in that event

the arrangement in the first diagram would not only have no advantage over the second, but would be in every respect inferior. Beyond a doubt if we were to succeed in obtaining such long ranges it would become a very serious matter to protect the arsenal from all danger of bombardment, which could then be made from such distances that our batteries could not offer a certain and effective opposing fire. However, the use of such guns on board ships is a question of the future, and if it should be realized we would then have to adopt other measures for the defense, which could perhaps be no longer intrusted exclusively to fortifications, but should then be assisted by the fleet. In any event it is certain that if neither of the two solutions should succeed in preventing bombardment, the second would always be the more effective in preventing access to the arsenal.

Besides the two foregoing solutions there would also be a third, shown in Plate III, in which we assume the batteries situated at two chosen points on the body of the dike itself. This solution would have the advantage of a defense situated in a re-entering; but, on the other hand, it would lessen the distance to which vessels could approach to bombard and it would still have the objection of exposing the works to successive attacks, they being so placed that the assistance of the other works would be of but little advantage to them.

To improve the diagrams of the field of fire it would evidently be proper to add other batteries on the points of the coast in front of the dike, and then we would fall anew into the solution of Plate II, without having the advantage of pushing farther off the limit to which vessels could approach to effect a bombardment.

Having discussed the considerations on which we should depend to determine the defense of a coast, and having made a special application of them to the Gulf of Spezia, it is well to examine and discuss the best type for works of such great importance. It would be superfluous to repeat here all the arguments so often presented on the advantages and disadvantages of the three known types, namely, barbette batteries, armored casemates, and revolving turrets.

Barbette batteries have already demonstrated their capabilities. It is not lack of experience that will prevent our discussing their real value. We know that even with parapets of extreme thickness the men and the pieces are very imperfectly protected, for the gunners must necessarily be exposed while serving the piece and the *matériel* cannot be sufficiently protected by the parapet. These disadvantageous conditions are further aggravated by the greater precision in firing, which is constantly increasing, and by the growing use of explosive shells and shrapnel. The dangers to be feared from the above causes reach a maximum in the case of low batteries like sea-coast water batteries, particularly if armed with heavy guns, which stand a greater chance of being damaged by direct fire, or even by large

fragments of shells capable of injuring the mechanism of the carriage. It may therefore happen that even if the water batteries are armed with the most powerful artillery, they may be silenced by an attack made with cannon of smaller caliber.

We must also consider how dangerous a combined naval and land attack might be for the water batteries if the enemy should succeed in taking up a position commanding them, a possibility which, although very hazardous on account of the presence of other defensive works, should not be entirely forgotten.

Evidently armored batteries with casemates or revolving turrets are exempt from the above disadvantages, and as long as we can rely on the thickness of the armor and on the possibility of reducing to a minimum the probability of the embrasures being entered by direct fire, these batteries will be found unquestionably superior. At any rate the objections made to them can be removed or sensibly diminished. On the contrary, with barbette batteries the difficulty is special and peculiar to their type.

But barbette batteries have in their favor a quality which, from a financial point of view, is satisfactory at first sight; they cost much less than batteries with armored casemates or turrets. We must not deceive ourselves on this subject. The economic question is of such an important character that we must take it seriously into consideration, for it marks the limits of possibility independently of technical considerations which are found by inevitable laws. It does not therefore seem out of place before examining the three types in question and making a comparative discussion of them to establish their relation as regards expense. However, for the special case of the Gulf of Spezia, taking into consideration the extent to be given the fields of fire to obtain the combination shown in the diagrams already discussed, we must necessarily omit the system of batteries with armored casemates, whose field of fire is far too limited. Consequently we should compare turret batteries and barbette batteries, and to establish the data closely it is assumed—

a. That the armament is to be of Italian 100-ton guns.*

* The 45-centimeter (Rosset) breech-loading gun of the artillery throws a projectile weighing 1,000 kilograms.

At a distance of 2,500 meters, the velocity of the projectile being 413 meters, it follows that the total striking energy of the projectile is 8,697 meter-tons, or 61.5 meter-tons per centimeter of its circumference. This energy is that necessary to pierce squarely 51 centimeters of iron armor in a single thickness.

The side of the Inflexible being protected by two iron plates of a total thickness of 61 centimeters (sandwich armor), requires that the projectile shall have a striking energy of 44 meter-tons per centimeter of its circumference to pierce it squarely.

Under the present hypothesis it is clear that the works armed with 45-centimeter guns would defend the entrance to the Gulf of Spezia very efficiently, since at the extreme distance of 2,500 meters the projectiles would have an energy about once and a half greater than that necessary to pierce the side of the most powerful iron-clad of the English fleet, the Inflexible.

b. That the armor plates are to be 55 centimeters thick, and of Schneider steel like the specimen presented by the house of Schneider & Co. for the experiments made at Spezia with the naval 100-ton gun.

c. That when mounted in turrets it is always proper to have two guns in each turret, whereas if mounted in barbette it is preferable to have an isolated battery (*batterie á puits*) for each cannon, which is necessary both to enable us to give the piece an extended field of fire and in order not to expose more than one piece to the same shot from the direction of the sea.*

d. That the parapets necessary for the barbette batteries, as well as those which in the turret batteries cover the lower part of the turret, should preferably be constructed of masonry at least 7 meters in thickness, rather than of earth or sand.

e. That however the cannon be mounted, the magazines for the shelter of the ammunition, machinery, and equipment should in general be placed underneath the platform.

f. Finally we assume 300,000 francs as the cost of the 100-ton gun, including the carriage and the mounting of the piece.

With the preceding data as a basis we have briefly calculated the net cost of a 100-ton gun mounted either in barbette or in a turret, and according to whether the battery is constructed isolated in the bay, on the dike, or on shore. The results of these calculations are shown in Table A, hereto annexed, from which it follows that everything included, cost of cannon, and accessories—

The outlay per piece in a barbette battery is—

	Francs.
Isolated	665,000
On the dike	615,000
On shore	460,000

The outlay per piece in a turret is—

Isolated	1,140,000
On the dike	1,090,000
On shore	947,000

Hence, if *i*, *d*, and *s* represent respectively the cost of the barbette gun according to the three situations of the battery, that is, isolated, on the dike, or on shore, the corresponding cost of the turret gun would be—

Turret gun—

Isolated	1.71 *i*†
On the dike	1.77 *d*
On shore	2.06 *s*

* We exclude *á priori* the supposition that the barbette guns should be mounted on revolving platforms, which would permit their being placed in pairs as in turrets. The platforms would be too feebly protected, for even the detached débris from the parapet that might happen to fall on them would suffice to prevent their being revolved.

†If we take into consideration the cost of the interior revetment with armor,

We may therefore remember that in the single case when the battery is situated on shore the cost of the turret gun exceeds by very little twice the cost of the barbette gun ; and since for the other locations, that is on the dike and on foundations isolated in the bay, the cost of the turret gun is sensibly less than twice that of the barbette gun, it will be readily conceded that, under the conditions of the Gulf of Spezia, where we must have at least two batteries isolated in the bay, if we take for a mean the cost of a turret gun as equal to twice the cost of a barbette gun we shall be making an hypothesis altogether favorable to this latter method of mounting.

But are two cannons in barbette equivalent from a defensive point of view to a single cannon in a turret? This is the important question which deserves to be all the more attentively discussed, since, from its nature, it is very complex; and, moreover, we lack elements of comparison to do it with any accuracy.

However, if we cannot have a rigorous solution it is at least possible to reach some conclusions of practical use.

For this purpose it is desirable to examine the diagram in Plate II, and to suppose that the various sectors of fire correspond to the same number of pieces, whether mounted in barbette or in turrets.

Now, to make an hypothesis favorable to the barbette batteries, let us assume that while armed with 100-ton guns they are attacked by vessels armed with less powerful pieces; or, in other words, let us suppose that they have to resist vessels of the type the most common in existing navies. It is evident that the 100-ton guns will have effective action at a distance greater than the 2,500 meters assumed in the diagram, and even greater than prudence exacts our fixing to preserve a sufficient probability of hitting the mark. But whatever be that distance it is beyond doubt that the vessels would also have effective action upon the batteries.

Consequently, if we take as a radius the distance in question, and describe the sectors of fire as in the diagram, Plate II, we will have a new diagram similar to the preceding one, in which there will be towards the extreme edge of the total zone of fire spaces scarcely swept by two batteries at the same time, and the greater the radius of effective fire the larger will be the surface of these feebly-swept spaces.

On the contrary, if the batteries had turrets with armor 55 centimeters thick it would be necessary primarily that the attacking vessels should also be armed with 100-ton guns. Besides, they would be obliged to come within close range of the batteries in order to attack them effectively; and

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either for the bottom of the turret or the interior scarp of the parapet, as mentioned in the note to the table, these ratios become 1.28*i*, 1.30*d*, and 1.41*s*; much more favorable to mounting in turrets, but which we will not consider, in order to demonstrate our proposition with abundance of proof.

they would therefore be obliged to place themselves in zones of water swept at the same time by four or five batteries at least. Hence, the presence of the turrets with 55-centimeter armor, in the case shown in the diagram, Plate II, is equivalent to more than doubling the simultaneous action of the batteries on the zone that is useful to the attack; or, in other words, this means that a cannon in a turret can surely be considered as equivalent at least to two cannons in barbette, with this much more, however, that it suffices to employ for the attack on barbette batteries cannon of ordinary caliber, whereas against turret batteries with armor 55 centimeters thick we must have at least 100-ton guns.

If, finally, we suppose that the vessels, in addition to their armaments of 100-ton guns, are at the same time protected by armor of the defensive power of that adopted for the vessels of the type of the Duilio, Dandolo, Italia, &c.,* then the barbette batteries will always be exposed to being attacked by these vessels remaining in the offing, and hence their number, whatever it might be, could not compensate for the inefficiency of the fire; whereas turret batteries would always oblige the vessels to make their attack by placing themselves in quite restricted zones, where the defense would have not only efficient action, but also the possibility of being superior in number of pieces.

The conclusions thus deduced from the comparison of the introduction of cannon in barbette and in turrets are, we must repeat, neither general nor rigorous; but for the special case that we have considered, that is, for the defense of the Gulf of Spezia, they constitute an element sufficiently certain to make us give the preference to batteries with revolving turrets.

As to the particular structure of the turrets, the experiments made at Spezia with the naval 100-ton gun (Armstrong, 43 centimeters) have proved that if protected with plates of Schneider steel, 55 centimeters thick, they would be capable of resisting the 100-ton gun; for in these experiments the Schneider plates were not entirely pierced by the 908-kilogram projectile fired by the 100-ton gun with an initial velocity of 455.40 meters and a striking velocity of 451.80 meters, giving a total striking energy of 9,333 meter-tons, and of 69.36 meter-tons per centimeter of circumference of the projectile.

Consequently plates that have given such satisfactory results under the favorable conditions of firing in a polygon can leave no doubt as to the superior results they will give in practice, the more so if we take into consideration the small probability of the projectiles striking the armored sides of the turret normally. Such conditions can only obtain in experimental firing done with deliberation and at very short range.

It is known that in connection with the batteries of the Gulf of Spezia,

* Armor of Schneider steel from 55 to 70 centimeters thick.

Grüson & Co. have presented several projects for armored batteries and revolving turrets with armor of chilled cast-iron. In a general way the types of both seemed acceptable, but there were differences of opinion as to the propriety of using for the defense of Spezia armored casemated batteries or only batteries with revolving turrets. It is certain that a turret of the Grüson type for two 90-ton guns, with a thickness of cast-iron sides capable of resisting the 32-centimeter gun,* would cost 1,400,000 francs, and the total weight of the turret, without guns, would be about 1,616 tons. On the contrary, a turret of the Duilio type, with armor of Schneider steel, 55 centimeters thick, would be capable of resisting the 100-ton gun, and, taking into account also the cost of a ring of armor 45 centimeters thick on the interior revetment of the glacis of the turret for the sectors exposed to fire only, would cost, in all, about 1,446,000 francs, reducing the weight of the turret alone to 600 tons.

It is therefore seen under how much better conditions we can now obtain turrets capable of resisting the 100-ton gun by abandoning the idea of constructing them of chilled cast-iron, and adopting, on the contrary, armor of Schneider steel.

But what is the number of turrets, each with two 100-ton guns, necessary to insure the defense of the gulf? To answer this question it will suffice to find how many vessels can, while preserving the liberty of action necessary for the attack, present themselves at the same time in the zone of water where they must necessarily advance to be able to act effectively against the turrets. If we take into consideration that this zone can also be made dangerous by torpedoes, it seems improbable that more than three vessels (Duilio type) would be able at the same time to attack the works, bearing in mind the dangers the torpedoes would present at the distance they should have to multiply the objective points of the defense.

It would therefore appear sufficient to make sure of the safety of the defense, that each of the seven batteries shown in the diagram should consist of a single turret with two 100-ton guns.

The question being reduced to this, the necessary outlay would be the following:

	Francs.
For two turrets on foundations isolated in the bay, including two cannons, machinery, &c., and including the interior revetment of the glacis (see table), each 2,506,000 francs	5,012,000
For five turrets on shore, including the two cannons, machinery and tools, and including the revetment as above, each 2,120,000 francs	10,600,000
Total	15,612,000

* The 32-centimeter gun (Rosset) throws a projectile weighing 350 kilograms, which, at a distance of 500 meters, has the energy necessary to pierce squarely an iron plate 43 centimeters thick; that is, 35 meter-tons per centimeter of its circumference.

If from this sum we deduct the cost of the fourteen 100-ton guns, we will have merely for the fortifications intended for coast defense with horizontal and armor-piercing fire, the sum of 11,412,000 francs.

The defense being established in the manner indicated, we believe that it can be considered final from a general point of view. We admit readily that it can be subjected to modifications in details, which, however, become matters of estimation, and may be judged in different ways. The proposed armament of fourteen 100-ton guns only, may perhaps be considered too feeble; and it may be called in question whether the defensive power of the works will attain the necessary limit, or whether it will be excessive with superflous expense; these objections or others may be raised; but we do not believe, however, that they can constitute a vital question, for it will certainly be easy to study the details of the subject so as to reach a practical solution.

The only really serious point is that to carry out the propositions under discussion, even within the restricted limits in which we have proposed them, not only a considerable expenditure of money is necessary, but the period of time required is too long to provide for an urgency already too much neglected; consequently we realize that prudence demands that we should provide at once for the defense of our arsenal and as thoroughly as possible, and at the same time that the structures necessary for the permanent defense should be undertaken, beginning with those that will require the longest time. During the construction of the works, we should proceed with that of the 45-centimeter guns, that the defense may be completely finished within a delay of about five years.

We also think that it would not be difficult to establish at short notice a provisional defense; for the dike already closes the Gulf, and it only remains for us to defend the waters in front to prevent bombardment, which would not be difficult to accomplish with torpedoes and provisional batteries, managing, however, to locate these batteries so as not to permit an attack upon them from the offing, and so as to oblige the enemy's fleet to develop itself in a re-entering, and be subject to the enveloping and converging fire of the defense.

TABLE A.

Barbette battery for a 45-centimeter G. R. C. breech-loading gun.

Battery isolated in the bay.		Battery on the dike.		Battery on shore.	
	Francs.		*Francs.*		*Francs.*
Riprap and foundations	245,000	Riprap for foundation, enrockments and surcharge	195,000	Excavation for installation and foundation	40,000
Masonry	105,000	Masonry above for shelters and magazines, &c	105,000	Masonry	105,000
Cost of 45-centimeter gun, including carriage	300,000	45-centimeter gun, including carriage	300,000	Cost of gun and carriage	300,000
Machinery	15,000	Machinery for raising projectiles, cartridges, &c	15,000	Machinery	15,000
Total	665,000	Total	615,000	Total	460,000

TABLE A—Continued.

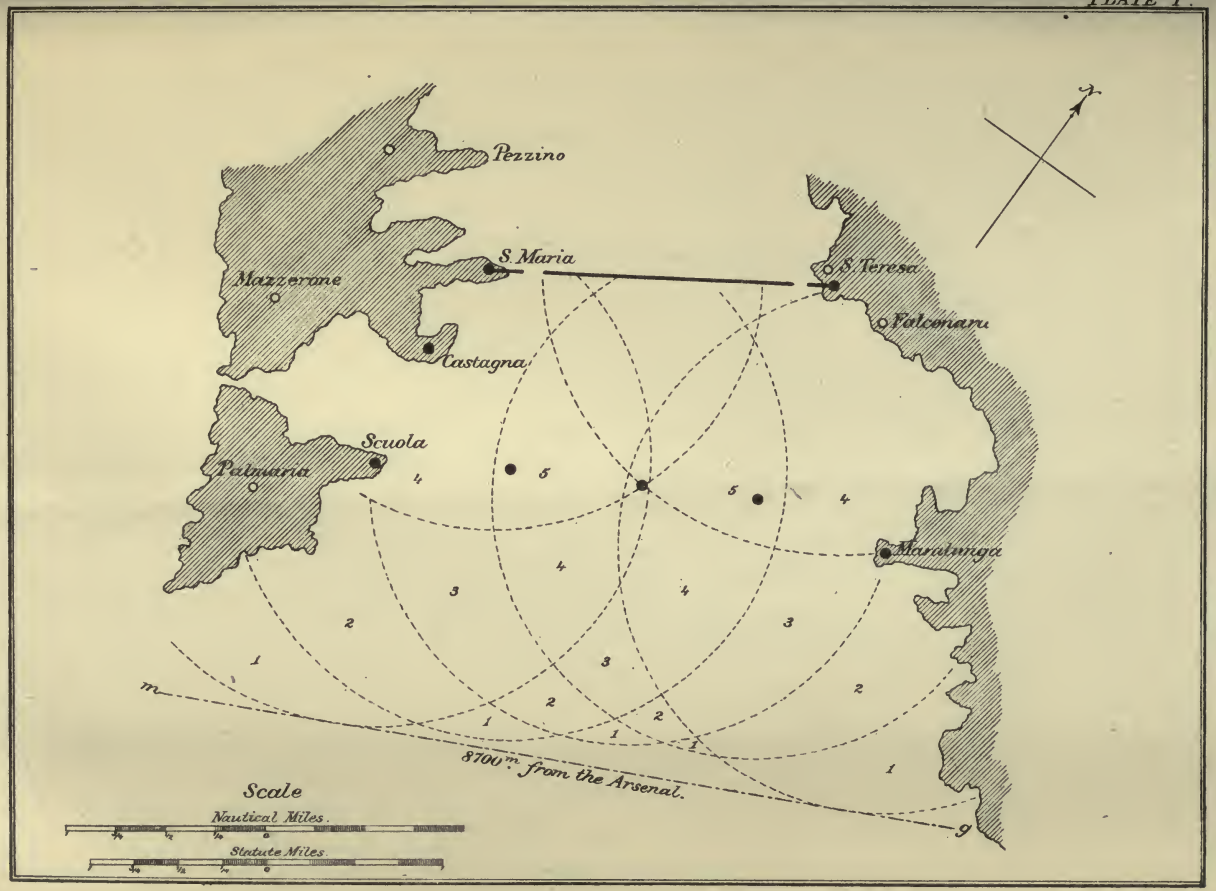
Battery of one turret (with Schneider 55-centimeter armor) for two 45-centimeter G. R. C. breech-loading guns.

Battery isolated in the bay.	Francs.	Battery on the dike.	Francs.	Battery on shore.	Francs.
Riprap and foundations	426,000	Riprap for foundation, enrockments and surcharge	326,000	Excavation and foundation	40,000
Masonry	174,000	Masonry above for shelters, magazines, &c.	174,000	Masonry	174,000
Turret for two guns	1,055,000	Machinery and steam-engines	25,000	Turret for two guns	1,055,000
Machinery and 10-horse power steam-engines	25,000	Turret for two guns	1,055,000	Machinery and steam-engines	25,000
Two 45-centimeter guns	600,000	Two 45-centimeter guns	600,000	Two 45-centimeter guns	600,000
Total	2,280,000	Total	2,180,000	Total	1,894,000

NOTES.

1. The surcharge, considered under the head of enrockments, is intended to insure thorough settling of the foundations, and is supposed to be formed of rocks making a weight not less than that of the structures to be placed upon the same foundations.

2. In the total cost of the turrets we have not included the cost of the annular revetment with armor of the interior of the parapet. This revetment which is certainly necessary for the parapets of the turrets is not less so for the interior scarps of the parapets of the barbette batteries. This revetment when limited in either case, to the sector exposed only, and when made of 45-centimeter armor would increase the expense about 226,000 francs.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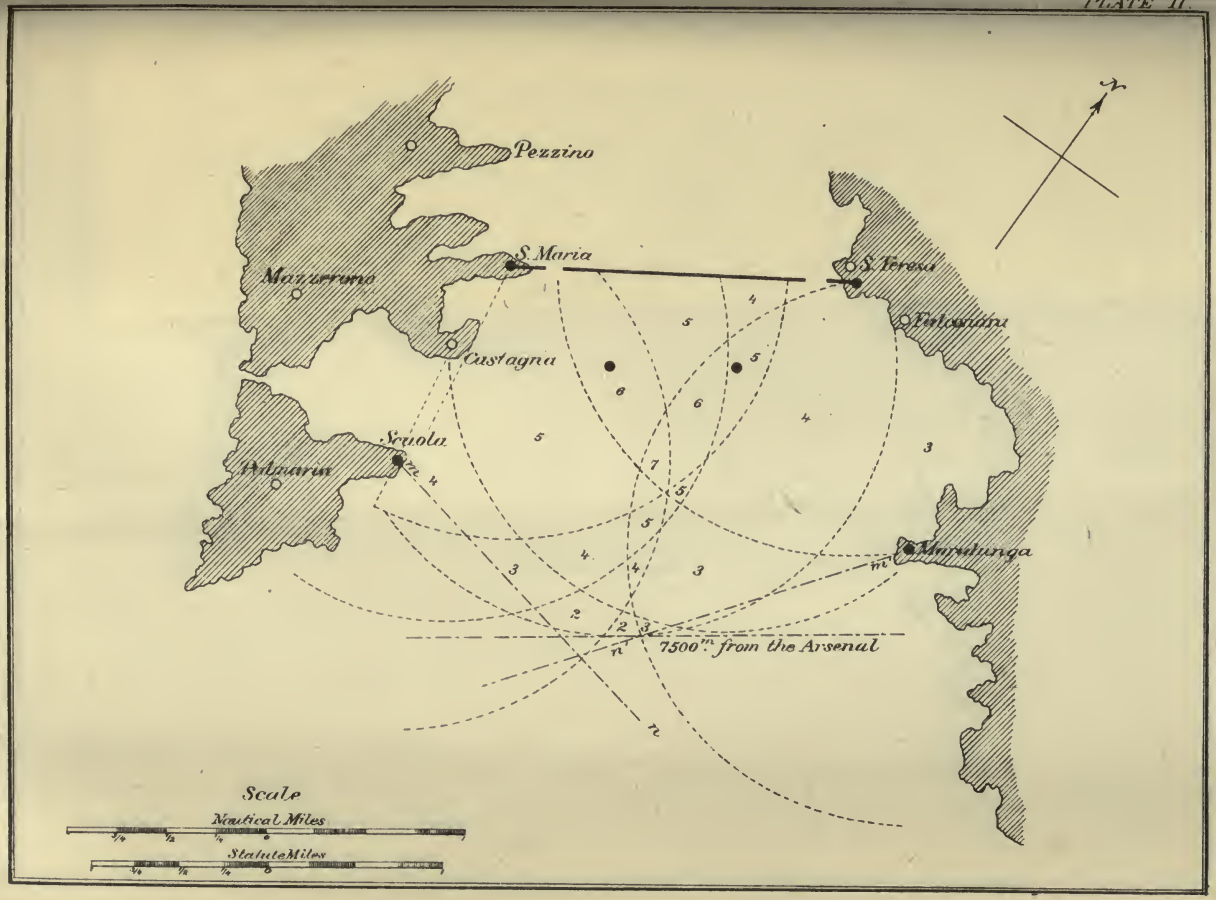
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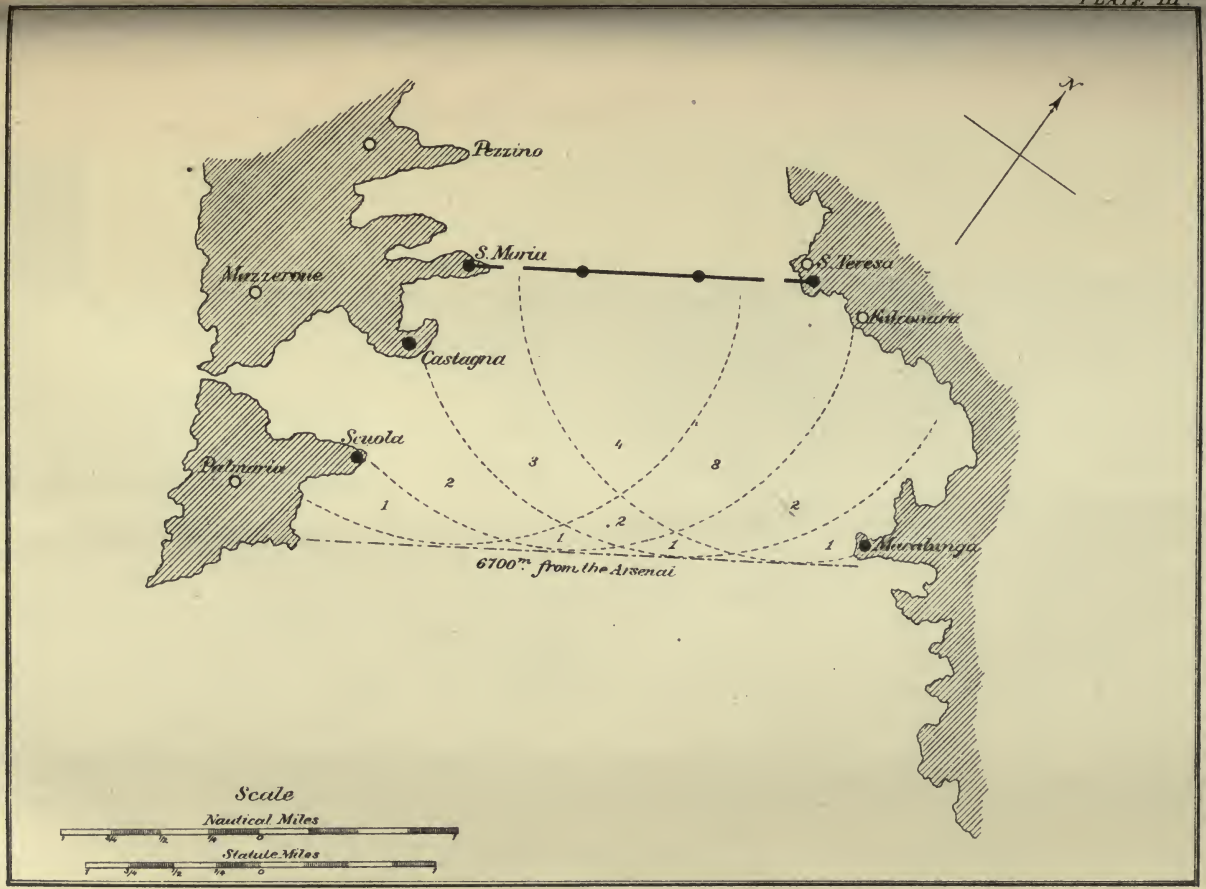
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