# THE PROTECTION OF HEAVY GUNS

FOR

# COAST DEFENCE.

[CONFIDENTIAL.]

FOR USE OF BOARD ON FORTIFICATIONS OR OTHER DEFENCES.

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The following paper has been drawn up by my directions with the view of throwing light upon the various questions relating to the mounting of guns for coast defences in the immediate future. It is possible that a considerable amount of coast fortification may shortly have to be undertaken, and it seems desirable to attempt to set forth the general principles which will have to be taken into consideration. These principles deserve to be subjected to a wide and searching discussion. In my opinion it is undesirable in the highest interests of the country that questions of defence should be dealt with as the special prerogative of a handful of Officers in a single office, and I strongly hold that the more minds brought to bear upon them the better. It is, I consider, of special importance that Naval and Artillery Officers should have an opportunity of hearing and expressing opinions upon matters relating to coast defence. Their views cannot fail to act as a wholesome corrective to those of Engineers. The opinions advanced in this paper may not, therefore, receive universal acceptance. They are merely put forward as suggestions open to discussion and criticism.

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# The Protection of Heavy Guns for Coast Defence.

The science of coast defence may be defined as that of mounting for heavy guns to the best advantage, the latter depending on two sometimes antagonistic conditions:—1st, the offensive power of the gun must have its fullest scope; 2nd, the protection given to the gun and detachment must be the maximum, compatible with the first condition, and with reasonable economy. Great coast forts, such as South Hook, Popton, Hubberstone, Carlisle, and Camden, covering a considerable area, and provided with barrack accommodation of every kind, will be more rare. Future coast defences will, probably, take the form of powerful batteries, either provided with comparatively slight gorge defence, or protected by a field or provisional redoubt commanding their dispersed emplacements. Even in the case of a ring of land defences with flanks resting on the sea, as at Plymouth, it is unlikely that the heavy guns which might be required for the sea defence of those flanks would be placed in the forts themselves, but rather in independent open batteries commanded by them or within their protective circle. The reasons for the change are mainly three:—1st, the breech-loading rifle, aided by the machine gun, has rendered comparatively slight earthworks eminently defensible against a ship's landing party; 2nd, the modern war ship has few men to spare, and risky operations ashore are now less likely to be undertaken than formerly; 3rd, the reduction of depth to a minimum is desirable in the case of works exposed to the fire of the heaviest guns. Coast batteries can rarely be required to stand a land attack of the nature of a siege, and have, in fact, seldom been so designed. A force provided with siege guns would have made short work of South Hook, even when it was new. In any case, it will probably be admitted that the gorge of an independent coast battery must either be defended, directly or indirectly, against the attack of a mere landing party unprovided with siege artillery, but possibly disposing of light field guns; or it must be made as strong as the front of a land work. No intermediate measure of protection appears logical. Large and important harbours which it is decided to protect, must have land defences, permanent or provisional, and their sea defences would stand or fall with the latter. Islands and analogous sites offer special conditions of their own.

It may probably be taken, therefore, that the coast battery of the future will, as a rule, have comparatively little permanent gorge defence, and less barrack accommodation. In this there is a simplification of the problem of coast defence, which is much more apparent than real. It is now less a question of pure fortification than of technical detail. But in the many complications of that detail, yearly increasing with the weight of guns, and in the adjustment of the delicate compromise between mutually incompatible advantages, there remains an ample field for genius. Moreover, with the increase of range in attack and defence, and the great diversity in draught, armour, armament, and general capabilities of modern vessels of war, there has come increased difficulty in siting coast guns to the best effect. The chart must be studied more carefully, and it is more than ever necessary for the engineer to be able to look at questions of coast defence from the purely naval point of view.

These questions are particularly important at the present moment. After a gradual advance, dating from the introduction of rifled guns, artillery has now taken a decided leap in the introduction of the long breech-loader. Moreover, it is possible that the defence of our commercial harbours and coaling stations may shortly be undertaken, while the time has certainly arrived for a re-armament, combined with revision, or reconstruction, of our present first line works. It will not therefore be out of place to consider the question of the protection of heavy guns in the light of such experience as is forthcoming.

All methods of protection, existing or proposed, may be divided into three groups :—

1. Complete material protection, limited only by the size of a port, to gun and detachment.
2. Varying protection against direct fire. No bomb-proof overhead cover. Detachment more or less protected from machine gun and shrapnel bullets in various ways.
3. Gun completely protected during loading by being lowered.

The following is a brief statement of the advantages and disadvantages of the methods severally included in the above groups. Examples of the practical application of these methods are also noted :—

### Group I.

a. *Shielded Casemates.*—Two tiers, Picklecombe, Garrison Point; one tier, Bovisand, Thames and Medway defences.

*Advantages.*

Complete protection against the heaviest projectiles, limited only by the thickness of shield adopted and the size of the port. Complete protection against vertical and high angle fire. Perfect protection against machine gun fire and shrapnel, except at the port.

*Disadvantages.*

Effect of a heavy shell near junction of shield and masonry not yet fully ascertained, possibly very great. Hit in crown of arch above shield possibly disastrous. Hit below sill probably fatal in some existing cases. Cost entails crowding of guns, which is unadvisable in several respects. Merlons liable to be destroyed. Always offers a large target, especially in a two-tier work. Liable to cumulative damage at long range. Port usually limits elevation of guns. (At Garrison Point the heavest guns have the least range.) Lateral range of individual guns limited. Field of view restricted for aiming purposes.

b. *Curved Front Shielded Casemates.*—King's Bastion, Gibraltar.

*Advantages.*

*See* above. Large field of fire; curved form unfavourable to penetration except to nearly direct hits.

*Disadvantages.*

*See* above. The port which is not in use is a source of weakness. A single shell entering there would probably disable the gun. Time is lost in traversing from port to port and, consequently, there is difficulty in following a moving object.

c. *Continuous Iron Front.*—Two tiers, Horse Sand and Nomans Land, Spithead; one tier, Plymouth and Portland Breakwater.

*Advantages.*

Complete protection, except at port, against projectiles of all sorts, limited only by thickness of armour adopted. Overhead protection. Closest approximation to a broadside ironclad.

*Disadvantages.*

Costly; crowding of guns therefore inevitable. Usually a conspicuous target. Elevation and training limited. Field of view restricted for aiming purposes. If penetrated, it is possible that two guns could be disabled by a single projectile.

d. *Gruson Battery.*.—Langlütjensand, German defences on Baltic and North Sea.

*Advantages.*

Protection very complete. Curved form favorable to deflection of projectiles. Economy over wrought-iron or compound armour claimed, but possibly not sufficiently established. Requires the occurrence of several hits in a small area to produce much result.

*Disadvantages.*

Guns necessarily crowded, thus giving to the attack a considerable margin in direction of fire. Individual segments proved to be capable of being broken up by repeated hits. Probably somewhat cramped. Lateral range of individual guns limited. Field of view restricted.

e. *Non-recoil Gun.*—System tried by Krupp in 1877–'78 with guns of 15 and 15.5 cm.

*Advantages.*

Perfect protection (except to muzzle of gun) limited only by thickness of armour adopted.

*Disadvantages.*

Probably inapplicable to heavy guns. A single hit at or near muzzle might jam gun. Whole weight has to be lifted or lowered in aiming. Training limited.

f. *Turret.*—Dover, sole English example; Fort Milutine at Kronstadt.

*Advantages.*

Complete protection, limited only by thickness of armour and size of port. Curvature unfavorable to penetration. Relatively small target. All-round fire. Two guns combined in one protection. Overhead protection against shrapnel and splinters. Conning tower affords wide field of view for aiming purposes. Proved to work satisfactorily on board ship.

*Disadvantages.*

Excessively costly. Steam or hydraulic power required. Possibility of jamming, perhaps not yet fully realized. Small difficulties in fine laying, unless turret is completely under control of No. 1. Not well suited to colonial conditions generally. Somewhat conspicuous.

g. *Compound Armoured Cupola.*—Not yet ready for experiment.

*Advantages.*

*See* Turret. Additional conical curvature unfavourable to penetration. May possibly be worked by hand power with smaller natures of gun. (Two 9-inch guns of 12 tons constitute the greatest armament which has at present been worked by hand power alone.) Lends itself well to dispersion.

*Disadvantages.*

*See* Turret. Some difficulty in rapid fine laying may be experienced, if traversing is done by men at a distance. Interior space much cramped. Somewhat conspicuous as a target. Untried at present.

h. *Gruson Turret.*—German defences in the Baltic and North Sea.

*Advantages.*

*See* Turret. Cast-iron allows any curvature of form. Economy claimed.

*Disadvantages.*

*See* Turret. A segment several times hit will break up; the destruction of a segment would possibly seriously affect whole turret.

(N. B.—The Gruson system of mounting with a muzzle pivot is probably applicable to any form of turret or cupola, and is a matter altogether apart from the question of chilled cast-iron armour.)

Group 2.

a. *Open Battery with Shields.*—New Tavern Fort. Some batteries at Gibraltar and Malta.

*Advantages.*

Great front protection, as merlon can have unlimited thickness of earth. No exposed masonry required. Can be rendered fairly inconspicuous.

*Disadvantages.*

Difficulty in affording adequate support to the shield, since the latter can have only side and bottom abutments, and the top is unsupported. Probable points of weakness at the sides of the shield, where the earth cannot be very thick unless the shield is excessively long. In some existing cases there is another weak point below the sill. Angle of training limited. Elevation to some extent restricted. No proper overhead cover, since the latter, if extemporized with timber, &c., is probably useful against shrapnel and splinters only, and positively adds to the danger from heavy common shell.

b. *Open Battery with Earth Embrasures.*—South Hook. All the heavy gun batteries at Alexandria except Meks. Defences of Marseilles.

*Advantages.*

Cheap. Lends itself to dispersion. Can be rendered very inconspicuous as a target. Fair protection against machine gun fire, at least till much of embrasure is destroyed. Protection easily capable of repair. Great flank protection can be given.

*Disadvantages.*

Embrasure necessarily weak at the neck. If gun is on a low carriage, detachment exposed to shrapnel and machine gun fire after neck is destroyed. Horizontal angle of fire limited.

c. *Barbettes.*—With bonnettes, Isle of Grain Fort; without bonnettes, Inchkeith, Harding's Fort, and Europa Hutment Gibraltar.

*Advantages.*

Angle of fire unlimited unless bonnettes are required. Lends itself well to dispersion. Can be rendered inconspicuous as a target.

*Disadvantages.*

Gun itself necessarily more or less exposed. If not bonnetted, specially exposed on flanks, where it offers a broadside target. In the case of low sites under-cover loading almost absolutely essential, in order to give protection to detachments against machine gun fire, but very difficult to obtain with larger natures of M. L. guns unless chain rammer* proves successful. In side-loading, there is a considerable expenditure of power in traversing the gun, and when traversed the latter proffers a broadside target.

d. *Light Cupolas.*—Practically a barbette with a turntable and shrapnel and machine gun protection. Doubtful if at present existent.

*Advantages.*

All round fire. Good protection against shrapnel, splinters, and machine gun fire.

*Disadvantages.*

Cupola probably sufficient to catch and burst common shell which would otherwise be harmless. Glacis plates equal to those of a turret probably required to lessen risk of jamming. Cramped interior space. Applicable only to B.L. guns. Possible difficulties as to sighting. Untried at present.

e. *Breech Hoods with Barbette Guns.*—No present example. Hoods are now being manufactured at Elswick for naval purposes.

*Advantages.*

*See* Barbettes. Good front protection against

*Disadvantages.*

*See* Barbettes. Applicable only to B.L. guns.

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*Shortly to be tried at Newhaven.

machine gun fire and shrapnel to loading numbers and breech action. Possibly additional protection against a hit by a heavy projectile at a small angle.

Possibly somewhat cramped for working. Lateral protection nil, unless angle of training is comparatively small. Target slightly increased. Shell, otherwise harmless, may be burst by the hood.

f. *Barbettes with turntable and horizontal splinter proof shield. Loading performed at elevation.*—No present example in the case of shore guns. Designed for H.M. Ship "Collingwood," &c.

*Advantages.*

Excellent protection to loading numbers. Gun offers a small mark during loading. Can be rendered fairly invisible. Protection equal to that of a turret, obtained at much less cost. Comparatively small weight to be moved for traversing.

*Disadvantages.*

Requires power to raise breech into firing position. Muzzle and chase of gun always exposed. Untried at present.

Group 3.

a. *Counterweight Carriages.*—Flatholme, Lavernock, Popton, Hubberstone.

*Advantages.*

Excellent protection to gun and detachment except to former at moment of firing. Laying performed under cover. Can be rendered absolutely invisible except for the short time the gun is up. Porbably highly economical when range of fire and degree of protection are considered.

*Disadvantages.*

Unsuitable to new long guns. Carriage necessarily somewhat complicated. Weight increases rapidly with that of gun. Possibly inapplicable to larger guns than 10-inch M.L. of 18 tons. Has at present been applied to no gun heavier than 9-inch of 12 tons.

b. *Hydro-pneumatic Carriage.*—Soon to be tried at Elswick with new 8-inch B. L. gun for Victoria.

*Advantages.*

*See* counterweight carriage. Addition of a turtle-back shield confers great overhead protection, except against high angle fire of heavy shells.

*Disadvantages.*

Probably requires much keeping in order. Difficult to repair. At present untried in this country for heavy guns.

c. *Counterbalanced Disappearing Platforms.*—Fort Constantine, at Kronstadt.

*Advantages.*

*See* a and b above. Gun can be sunk as low as desired below crest of parapet.

*Disadvantages.*

Both gun and platform have to be raised and lowered. Steam essential for rapid firing. Probably costly and somewhat complicated. At present apparently applied to 11-inch B.L. long guns. Not much known about success of working.

Other methods of protection might have been instanced, but the above may perhaps be accepted as a complete category of types under which all mountings adopted, or likely to come into use, may be classed. It is to be observed that, with one exception, none of the methods of iron protection above enumerated have been subjected to the actual test of war. The shielded casemates, cleverly extemporized during the American war, cannot be taken as fair specimens of their class, nor can the experience gained with the American monitors be considered of value as illustrating the effective protection conferred by a modern turret or cupola. The 5½-inch armour of the "Huascar's" turret was, however, hit three times by 9-inch Palliser shell in her action with the "Blanco Encalada" and "Almirante Cochrane." This turret was twice penetrated, and a shell burst on the deck below without preventing it from revolving. Further, there have been few experiments made under even approximately service conditions, with the exception of those carried out against two shielded casemates at Shoeburyness in 1865,* the three shots fired at the turret of the "Royal Sovereign" in 1867, and the two shots fired at the "Glatton's" turret from the "Hotspur" in 1872. The guns employed against the casemates were 10-inch, 9-inch, 8-inch, and 7-inch: against the "Royal Sovereign" 9-inch; and against the "Glatton" 12-inch, of 25 tons; so that, as indications of what might be effected by the far more powerful guns now afloat, the results of these experiments need qualification. The maximum effect of a projectile of given weight, material, and velocity, against a wrought-iron plate, can be predicted with some accuracy. The effect on compound plates is at present less certainly known. Of all methods of protection the continuous iron front perhaps lends itself best to the test of piecemeal experiment. Whether the armour can keep out a given projectile can be ascertained by the experience gained with individual plates, and there remains only some uncertainty as to the effect of a heavy shell striking just at the edge of the port, while the result which could be obtained by a shell after penetration, is more or less a matter of conjecture. All the other cases —masonry and iron casemates, open shielded batteries, turrets, cupolas—present certain doubtful features. Any one might chance to receive a hit, the effect of which cannot possibly be predicted.

On the other hand, earth batteries have been tried over and over again in the past, were hammered with heavy smooth-bores and rifled guns in the American war, and have recently been severely tested at Alexandria under conditions, on the whole, extremely favourable to the attack. With respect to earth batteries, therefore, we occupy a somewhat different position, and possess fairly satisfactory data from which to form conclusions.

As to other methods of protection we are still more or less in the dark, and reasoning cannot well be divorced from mere speculation. In some respects it would be extremely useful to make a few practical experiments, and a partial battering of Stack Rock by the "Dreadnought" would be sufficiently instructive to justify the expense. But the great difficulty of keeping the results of such experiments secret in England is unquestionably a strong argument against them.

Passing over the period when the early guns were mounted in castles, such as St. Mawes, and active defence had not begun to assert itself, the earliest form of coast battery was probably a low *barbette*, the guns simply firing over a wall or bank. Examples of such batteries are still scattered round our coasts, and are occasionally used for saluting purposes. The invention and development of shell fire soon tended to produce a higher front protection, and the earth and masonry embrasure arose the latter usually involving a stone or brick fort. The fort trying to compete with the ship in volume of fire would sometimes have two, three, or four tiers. The Spithead forts were originally designed for four tiers, as

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* *See* a paper by Colonel Inglis, R. E., Professional Papers, Second Series, Vol. XVIII.

well as guns on the top, while there is an existing three-tier stone work at Kronstadt. Great crowding of guns thus arose. The development of penetrative power which the rifled gun attained, led naturally to the adoption of iron shields, and works of the Bovisand, Hubberstone, Hoo, and Darnet type were constructed, the double tier being still retained in some cases, as at Picklecombe and Garrison Point. The desire to imitate the ship further, gaining still greater protection and this of a more uniform nature, produced the continuous fronts at Spithead, Plymouth, and Portland. Finally, still following the ship, a cramped advanced site, exceptionally heavy guns, and the desire to realize the most complete protection possible combined with an all-round fire, necessitated the Dover Turret. Meanwhile, however, the expense and other disadvantages of the stone and iron method naturally directed attention to other modes of protection, and about 1871 Colonel Moncrieff first reduced the disappearing principle to a practical shape, and succeeded in 1874 in overcoming great difficulties with rare energy and mechanical genius. In spite of the highly favourable report on the counterweight carriage for the 9-inch gun of 12 tons, this mounting can hardly be said to have been introduced into the service—there are only two existing examples—and practically the principal is restricted to guns not heavier than the 7-inch of 7 tons. The best example of the application of this principle is at Flatholme, where the emplacements are fairly dispersed, and well concealed. These emplacements are, as far as protection is concerned, quite as satisfactory as when they were first built. The worst instances are at Popton and Hubberstone, where the pits are built up in a row on the top of stone and iron casemates. The rapidly-increasing cost of the mounting in the case of larger guns led Colonel Moncrieff to the design of hydro-pneumatic carriages, which were never adopted in England for those guns, but are represented in principle and design by the hydro-pneumatic siege-carriage of to-day, and the new disappearing carriages for 8-inch long B.L. gun, under construction at Elswick.

Up to a certain point, therefore, the maximum possible of material protection was the object aimed at in gun-mounting. At the same time the great cost of invulnerability rendered other modes of protection necessary under some circumstances, and *barbettes* have not only never altogether disappeared, but have been largely constructed of late years. For fairly elevated sites, the *barbette* mounting, on account of relative cheapness, wide angle of fire, and unlimited facilities for elevation, has always found more or less favour, and the application of this principle in the French ships "Admiral Duperré," "Duguesclin," "Triomphante," "Victorieuse," "La Galissonnière," now in process of imitation in the "Impérieuse," and "Warspite," certainly points to this principle as little likely to be abandoned in the future. In the "Téméraire," England took the lead in applying the disappearing principle to a ship of war. Meanwhile, however, the great development of shrapnel and machine gun fire has tended to increase the minimum of height above the sea level, prescribed by theory for *barbettes*, to add to the height of front parapet, and to bring methods of under-cover loading into prominence. The heaviest English guns at present mounted —the 100-ton Armstrongs at Gibraltar and Malta—are in *barbettes*, fire over a high parapet, and have a complete system of under-cover loading, so that practically the gun alone is exposed to direct fire.

The general adoption of the breech-loading system is now inevitable for heavy guns. It is a necessity brought about by the demand for great length of bore, and is practically one of the direct results of the great advance in the manufacture of gun-powder. Breech-loading, originally condemned on the grounds of complication, is now virtually the simpler system in the case of the larger guns, since the difficulty of providing an altogether satisfactory under-cover loading arrangement for long muzzle-loaders will hardly be overcome. It is doubtful whether any better system can be devised than the so-called "protected *barbette*" proposed by Sir W. Armstrong & Co., and recently tried with a 10.4-inch M.L. long gun at Shoeburyness, but the inherent objections to this system are sufficiently apparent. Although few more heavy M.L. guns will now be built, the great number in the service cannot be expended, and the time at which all these guns will have been eliminated does not fall within the range of necessary prevision. It may even be contended that under certain circumstances the muzzle-loader is the most suitable weapon, and although it is difficult to admit that the handling of the breech-loader is beyond the power of local or coloured troops, it may nevertheless prove, that in distant tropical stations the new B.L. guns require an amount of care and attention to ensure efficiency, which they cannot with certainty receive. While, therefore, such considerations may conduce to the permanent retention in the service of the M.L. guns, it is safe to assume that all new guns of the heaviest class will be breech-loading.

Looking to the future, it seems clear that the number of possible methods of mounting may be somewhat reduced. After the results of recent experiments, it is highly doubtful whether stone and iron casemates will again be built. Open shielded batteries are also probably obsolete, while the counterweight principle does not seem to lend itself to long breech-loaders. The protection of new heavy guns in coast defences tends, apparently, to reduce itself to the continuous wrought-iron or compound front, Gruson batteries, turrets, cupolas, barbettes of some form, or open batteries with earth embrasures. Under exceptional circumstances, such as the very high sites available at Gibraltar, it is possible that heavy guns may be mounted in the open. . The above being premised, it becomes exceedingly important to consider which of these systems will be best under given conditions. The general problem is somewhat complex, and may be stated as follows:—The maximum present power, offensive and defensive, of the attack may be assumed as known. This power, in the immediate future, may be dimly foreseen. Considerations, more or less speculative, indicate the minimum number and powers the shore guns should possess. Economical considerations more or less inexorable tend to reduce that minimum. A study of the chart shows the water over which the fire must be distributed. How are the shore guns to be sited and how protected so as to give the maximum offensive power combined with the minimum of vulnerability? There are here a sufficient number of unknown factors. Relative vulnerability is excessively difficult to determine, and is, to some extent, a matter of pure conjecture. Moreover, vulnerability, in itself dubious, has to be balanced against offensive power, also in some aspects a matter of debate. The possibilities of the future must not be left out of account, nor can local considerations be altogether neglected. At a station far beyond the reach of telegraph, for example, where the advent of a roving squadron might be the first announcement of the outbreak of hostilities, it will evidently be desirable so to mount guns that they are sure to be available at the shortest notice, and a steam-driven turret would, therefore, be unsuitable. The complication of the problem is, however, not fully stated yet. Sub-marine mines have grown up as an adjunct—almost an excrescence—of harbour and river defence. Their proper relative position in a scheme of defence has never been assigned, perhaps cannot be assigned. Opinion has differed considerably as to their value. It might now, however, be argued with much force that, granting time for laying them out, mines alone would in some cases permit a great reduction of heavy gun power, while in others they would safely allow its modification. But in addition to fixed mines, fast torpedo boats constitute a factor of which the attack must certainly take account, while locomotive torpedoes are perhaps still in their infancy. With what relative importance shall we credit mine and torpedo defence?

The systems of mounting, above enumerated as likely to survive may be divided into two classes:—

1st. Those in which it is attempted to keep out absolutely the heaviest projectiles by material means—the continuous iron front, turret, cupola.

2nd. Those in which it is sought to provide only comparative protection to gun or detachment, or both, and at the same time to render it as difficult as possible for the enemy to make good shooting—the barbette and open battery.

The disappearing principle to a great extent combines the advantages of both these two classes. By this principle very great material protection is provided, except at the moment of firing, while at the same time perfect invisibility is ensured.

Were expense a matter of indifference, a continuous compound front, or a Gruson battery, for guns needing only a small angle of training, and a turret or cupola for all-round fire might seem to leave nothing to be desired. In the first place, however, it is not certain how much protection of this class we shall have to provide. The next ten years will, doubtless, see guns weighing nearly 200 tons afloat, and future improvements in powder and projectiles may give these guns much greater penetrative and destructive power than could now be obtained with the same weight. It is in the direction of greater penetrative power (*i. e.*, of offensive power against protection of this class), that gun progress is obviously moving. To oppose to the ship shore defences as closely as possible resembling herself, is in one sense to favour the attack, since the same guns and projectiles which the ship *must* carry, in view of a naval action, will be precisely the kind best suited for dealing with such shore defences. It is clear that we cannot build such batteries every ten years on our more important first line sites, and it would probably be difficult to strengthen a Gruson battery subsequently and not very easy to strengthen a turret or cupola. What measure of strength shall we decide upon? Moreover, to limit the range of our guns in future by the size of a port is not to be thought of; small ports and muzzle pivoting become inevitable, nearly the whole weight of the gun must be lifted or lowered in laying, and steam or hydraulic power soon becomes necessary. With a turret or cupola, the necessity for driving power is still sooner reached. It is doubtful if even a 38-ton gun could be worked by hand power in a cupola. There is, perhaps, no real objection to following the example set in the modern ship of war. But to do so clearly introduces a new set of risks, inevitable for the ship, but which should be avoided in the shore battery as long as possible. As long as a gun can possibly be worked by hand, there is evidently an argument against further complications of any kind. Turret and cupola alike must be full of machinery, which a single man who chanced, temporarily, to lose his head might damage beyond the possibility of immediate repair. Moreover, there must be a risk of jamming either turret or cupola by a lucky shot, for although the "Hotspur" failed against the "Glatton's" turret in the round fired with this object, the vagaries of a fired projectile, with the high velocities now attainable, defy calculation, and it would be unwise to assume complete immunity from this risk of the grounds of a single experiment *. It would hardly have been expected that a 10-inch Palliser shell striking the unarmoured portion of the "Inflexible," at Alexandria, would turn straight up and pass out through the deck. Further, there would, especially at distant foreign stations, be a certain amount of danger of these elaborate fighting machines being found wanting at the critical moment from carelessness, ignorance, or neglect.* A turret must, practically be always in commission, and cannot come

*On this question Colonel Inglis remarks, referring to one round fired at a turret target at Shoeburyness—"The projectile, which struck close to the bottom of the target, turned in the direction in which it felt least resistance, and passed vertically down into the earth. It is probable that a similar result, which would threaten fatal injury to a turret, was just avoided in this trial (that of the "Glatton") by the graze on the glacis giving the shot such direction as disinclined it to turn downwards on entering the armour." . . . . . . "To have made the experiment at all complete, the turret ought to have received a shot directed at a point on its side some few feet away from the centre as viewed from the gun." Until this and other points "have been more thoroughly tried, it cannot be said that our information on the subject of either land or ship's turrets is as complete as it ought to be." (R. E. Corps Papers, Vol. XXI., 1873). It is to be feared that our knowledge on these points is still imperfect, but much will, doubtless, be learned from the forthcoming experiments with a cupola at Eastbourne.

home periodically for repairs and inspection like an "Inflexible." Again, if defences of this class are to be adopted on a large scale, an entirely new force, corresponding to the Naval Engineer Department must be added to the Army.

Practically, however, expense is anything but a matter of indifference, and although Italy has decided on an immediate provision of 18 Gruson turrets for coast defence, it will probably be some time before we adopt similar measures. Nor does it appear to be certain that they are necessary, or even altogether desirable. The whole question of the choice of modes of protection will be found, on consideration, to be closely bound up with the views which may be taken as to—

1. The probable accuracy of the fire of ships.
2. The probable effect of shrapnel and common shell.
3. The probable effect of the fire of machine and quick-firing guns.

In adopting the *barbette*, open battery with embrasures, or the disappearing principle, certain risks are obviously accepted. Is it worth while for the sake of some great advantages to accept these risks? To this very important question different answers will doubtless be forthcoming, since few will agree on the measure of the risk, and the three points above-mentioned, admit—even court—much speculation. For the data are neither complete nor altogether satisfactory, and different conclusions may possibly be drawn from them. If a ship can hit a *barbette* gun, or plant a shell fairly in the neck of an embrasure once in two shots at moderate ranges; if every heavy shell which strikes near the exterior crest of a parapet will plough its way through, and burst in the battery, *barbettes* and embrasures would stand condemned. If the ship can at frequent intervals drop the bullets of heavy shrapnel at a considerable angle of descent over the crest of a battery, overhead cover is indispensable. If she can, with reasonable certainty, throw common shell which, striking a little short of the crest at a descending angle, blow in the retaining wall on the gun and detachment, iron protection in some form would seem to be inevitable. Finally, if the ship cannot do these things now, is there any reasonable probability that she will shortly be able to do so? Here is evidently a wide field for speculation. The record of ship's practice cannot be kept like a rifle-shooting register. Experimental firing against targets representing shore batteries is excessively rare, if not unknown. We have practically only the experience of Alexandria on which to build, and the very complete victory obtained by the ships, makes it all the less likely that the lessons of the action will ever receive serious attention.

There are some essential differences between a naval attack on shore defences now and at the time of Algiers. Then the vessel enormously outmatched the shore batteries. A first rate ship, with 66 guns to her broadside, was superior to almost any single battery. A fleet was immensely superior to a fortress. Where the shore works were open, the ships could pour in an almost continuous hail of shot and shell. There was room for plenty of bad shooting, and yet there would be plenty of hitting, while the continuity of firing was demoralizing in the extreme. Even in much later days the United States Fleet poured 45,000 shot and shell into Fort Fisher in two successive bombardments, the rate of fire on the first occasion being given as 115 projectiles per minute. It is not surprising that the return fire was very ineffective, and soon practically ceased. In the days of wooden ships the ranges were comparative short.* This was an advantage, inasmuch as the details of the work attacked could be well made out, the damage being inflicted was better seen, and the fire could be better directed. Moreover, mines and fast torpedo boats were non-existent and, if a ship could be laid alongside a shore battery—a course our naval com-

* At Copenhagen it was a matter of complaint that the pilots would not accept the responsibility of taking the ships nearer than 400 yards.

manders always strove to adopt—she could crush the latter by sheer superiority of metal and rapidity of fire.

Conditions are now completely changed. The single ship will rarely outmatch the modern first line battery. The fortress will far more nearly approach the fleet in weight of metal. Thus, the "Dupérré" carries only 4—46-ton guns in her barbettes, and 14 broadside 5½-inch guns. The "Inflexible" has but 4—80-ton guns and 8—20-prs. It is doubtful if these two ships together would be a match for the six turrets of Fort Milutine at Kronstadt. The whole fleet engaged at Alexandria opposed 80 heavy guns to 36 on shore; but, on the one hand, the shore guns could not all be simultaneously employed, while, on the other hand, the actual gun power of the broadside ironclads must be halved. Compare the broadsides of the "Inflexible" and an old three decker. With 4—80-ton guns and 4—20-prs. the former ship can deliver 6,880 lb. of iron at a single discharge. With 48—32-prs., 17—8-inch guns, and 1—68-pr., the latter delivered 2,556 lb. The 80-ton guns take five minutes to load, and the 20-prs. perhaps half a minute, the broadside of smooth-bores about one minute. Thus in five minutes the "Inflexible" fires 7,600 lb. of iron, the wooden ship 12,780. The total *number* of projectiles in this time is for the "Inflexible," 44, and for the wooden ship 330. Dealt with in this way figures are not, perhaps, particularly valuable, and the above estimate is highly favorable to the "Inflexible," since the 20-pr. of to-day possesses much less relative value than the old 32-pr., and would not have a chance of even disabling a properly mounted heavy gun, while the "Inflexible's" 20-prs. could not be served in face of moderately accurate shrapnel or machine gun fire from the shore. Omitting them, the proportionate rate of fire between the two ships is 1 : 82.5.* In any case, the importance of individual shots is now enormously increased; but it may fairly be doubted whether the possible destructive effect of a single projectile on well designed works has been materially augmented. It is conceivable that a single lucky 8-inch spherical shell might have dismounted a single shore gun and killed or wounded all its detachment. A 16-inch rifle shell can do no more in a properly traversed battery, may even effect less, since a modern gun and its carriage is a very substantial traverse against splinters, while it is open to a question whether a line of battle ship, engaged at 500 or 600 yards, had not actually a better chance of obtaining such a hit than an "Inflexible" at 2,000 yards. Comparing gun with gun, the accuracy of fire has immensely increased. Comparing ship with ship the chances of hitting have probably diminished, notwithstanding that naval gunnery has greatly improved in the last 30 years. The ranges at Alexandria were somewhat long—less than half those adopted by the French at Sfax however—but it is not certain that ships will gain a balance of advantage in future by closing with good shore batteries properly manned. They will, it is true, be able to bring their machine guns into action; but the effect of the latter will be neutralized in the case of B.L. guns, by the protection which can be provided, and by better-protected machine and quick-firing guns on shore. If the shore batteries consist of well designed and dispersed barbettes, with good cover for the detachments, the effect of the fire of the ship will in some respects actually diminish as she reduces her range. Shrapnel will become useless. The disadvantage of the ship will be the more pronounced as the elevation of site of the battery increases. Her one considerable advantage is that being nearer, she has a better chance of picking out and inflicting a direct hit on the shore guns themselves. But a shore gun offers a very small front target, and if the guns support one another well, the ship will not always be able to get a broadside shot at one barbette gun without laying herself open to the close unreturned fire of another. The comparative target of the single ship and single gun is enormously against the former,

* Captain Fisher, R. N., basing his calculations on tonnage, and omitting the 20-prs., arrives at the conclusion that it is now necessary to be 620 times as good a shot with the "Inflexible's" guns as with those of a line of battle ship; or, in other words, that a miss is enhanced by this number as a multiplier.

and if there is sufficient dispersion, it is clear that it is this comparison which must be instituted and not that of the ship and battery. Practically, however, the ship will in many cases have little option in the matter of range, on account of submarine mines and the action of fast torpedo boats; while, in most cases, it is possible for the designer of the shore battery to fix the minimum range at which a vessel of given type can engage it. If the tactics adopted by the French at Sfax—boats at "a few hundred yards," gun-vessels at about 2,300 yards, ironclads at 7,000 to 4,300 yards—were tried against well-armed and well-fought shore batteries, the policy of the latter would be evident. First dispose of the boats with machine gun fire and case, then sink the gun vessels with common shell, treating them simultaneously with shrapnel, finally commence deliberate fire with Palliser projectiles on the ironclads. The three operations can be successively carried on with considerable security. It will need a great deal of shooting from the gun vessels before a shore gun is grazed, and the ironclads will do no harm at all to the defences. At Sfax, after a remarkably deliberate fire of 2,002 projectiles delivered under peace practice conditions, the "defensive power" of the place is reported to have been "practically uninjured."

Some facts drawn from the Alexandria action throw a strong light on the question of the accuracy of fire to be expected from ships. Meks Fort, a prehistoric work, armed with five heavy R.M.L. guns, nine S.B. guns, and five mortars, was engaged by the "Monarch," "Penelope," "Invincible," and "Téméraire" for about three and a-half hours. During one hour, the "Inflexible" contributed a portion of her fire. The ranges of the three first-named ships varied from about 1,200 to 1,000 yards, that of the "Téméraire" was 3,500, and of the "Inflexible," 3,800 yards. The "Invincible" and "Téméraire" were anchored throughout the affair. The guns of Fort Meks were practically all *en barbette*, the three heaviest of them firing over a 4-feet 8-inch parapet, the interior wall of which projected 1 foot 10 inches above it, with a thickness of 2 feet 6 inches. During the action not a single gun was dismounted or disabled, and two only were touched by heavy projectiles, which just grazed them, having indents 1¼ inch deep. One gun was knocked over by an 8-inch Palliser shell from the "Penelope," fired at short range after the work was silenced, and when, therefore, there was no return fire, and no smoke enveloping the battery. The two grazes may of course have been similarly obtained. Altogether about 580 heavy and 340 light projectiles were fired at Fort Meks. Again, the "Inflexible," at about 3,500 yards, partly at anchor and partly under weigh, engaged two "most troublesome" 8-inch guns in Oom-Kabebé for about four and a-half hours. She was simultaneously engaged with Fort Ras-el-Tin. The two Egyptian guns fired over 4-feet 3-inch sills in a 5-feet 6-inch straight parapet, and were less than 36-feet apart without any intervening traverse. The whole sea-front parapet of the work was hit nine times, the top of the counterscarp or glacis three times. The extreme hits were 120 yards apart. The face containing the two 8-inch guns was hit four times, three hits occurring on the superior slope, and one on the cordon of the scarp. The three hits on the superior slope made large craters, the shells bursting well. One of them blew in the revetment wall between the guns for a length of 12 feet and a height of 3 feet. Neither gun was touched except by masonry splinters. If these guns had been 10-inch, manned by English gunners, and the "Inflexible" an unarmoured cruiser, the latter would doubtless have been sunk or disabled. The cost of mounting these guns, including the thickening of the old parapet, may have reached 100*l.*! In the whole action, in spite of the many advantages on the side of the ships, the total number of hits on the parapets of all the works—*i. e.*, on the superior and exterior slopes—was about 1 in 19 shots; excluding shrapnel and segment. Considering that a large proportion of these hits were on the exterior slope, and were practically thrown away, while the average was certainly improved by some short range practice after the works were silenced, the risk of a direct hit incurred by a barbette gun does not appear to be excessive at moderately long ranges. In many respects the action at Alexandria supplies a wholesome corrective to views based mainly on too wide a generalization from unsuitable data. Thus there can be little doubt that far too much accuracy has been expected from the fire of modern ships of war, and that the expectation has been derived from practice at Shoeburyness, and from the results obtained in experiments with siege guns. It would not have been impossible to carry out a series of experiments in which ships should fire at extemporized shore batteries under conditions as far as possible assimilated to those of service, the results being carefully noted; but such experiments were wanting, and exaggerated expectations were natural and even inevitable. Another generally accepted deduction from the Alexandria affair, and one extremely important to the defence, is that it is useless for ships to engage earth batteries by circling in front of them. It is necessary either to anchor to or steam up to a buoy to fire, and the elliptic courses which theory has prescribed must be utterly given up where coast defences cease to proffer a target.

Turning to the question of the employment of common shell and shrapnel against earthworks, Alexandria also affords subject for reflection. Problably the most destructive result which can be obtained by a common shell is a hit delivered with a descending angle a little short of the crest of a battery, blowing it in on the gun and detachment, thus practically adding a shrapnel effect to that of common shell. At Alexandria altogether 11 such hits were obtained, but many of these did not occur in front, or nearly in front, of guns, and in a well traversed battery would have been quite ineffective. With proper dispersion of guns—even without dispersion, if the batteries are well traversed—the chances of such a hit are very small. Moreover, where the retaining wall is a thick mass of hard concrete, but little of it would probably be brought down, while the employment of iron glacis plates in front of barbette guns would give complete protection. Very effective results against men are obtained by a shell which, with a descending angle (the larger the better), just skims the crest and bursts on it, or a few yards in rear. Are the risks of such a hit excessive? If a time fuze is used, the accuracy required is measured in hundredths of a second. If a percussion fuze is used, it must be delicate and instantaneous, with a view of bursting on the crest, in which case it will be perfectly useless for purposes of weakening a parapet. If it does not graze the crest, it will, with all ordinary angles of descent, burst on the ground beyond too far away to produce any serious loss. This, of course, presupposes that the emplacement is open to the rear, as it should be wherever possible. A common shell just clearing the crest of a circular pit would catch the wall beyond and burst, probably killing every man of the gun detachment, and unquestionably so blocking the pit that it might take hours to clear the gun platform.

Again, to burst a common shell in the air in front of an earth battery with embrasures, or a barbette with a high parapet, is practically useless. This was fully recognized in Admiral Porter's orders before the attack on Fort Fisher:—"All firing against earthworks when the shell bursts in the air is thrown away." . . . . "A shell now and then exploding over a gun *en barbette*, may have a good effect, but there is nothing like lodging a shell before it explodes." It is doubtless an excellent thing to burst a shell directly over a gun, but it would be interesting to know how many a ship would have to fire before obtaining such a burst. Some idea of the difficulty of obtaining much searching effect with common shell from ships' guns is conveyed by the fact that at 2,400 yards the 8-inch howitzer, our best high angle weapon, under perfectly favorable conditions, gave two effective hits in 20 rounds.

The question of shrapnel is, perhaps, even more important, since shrapnel is to some minds a species of bugbear. The real effect of the 417 shrapnel and segment fired at Alexandria is somewhat difficult to estimate. Only information from the Egyptian side could clear up the point. One gun and carriage received 49 shrapnel bullet hits, all apparently inflicted by an 11-inch shell from the "Téméraire," the head and base of which were picked up in front. This gun fired through an embrasure the neck of which had been previously ruined by the fire of the "Inflexible." Moreover, it is probable that the hit was delivered the day after the action. The remaining shrapnel hits on guns and carriages might be counted on the fingers, but it is of course possible that very oblique grazes might not have left a distinguishable mark. Some of the naval officers engaged at Alexandria were impressed by the good results of their shrapnel fire, but these results would be considerably enhanced by the defects of the Egyptian works. In estimating the Alexandria results, it is particularly necessary to separate those which the nature of the works rendered inevitable. The fact that a ship could silence the fire of the saluting battery on the line wall at Gibraltar with shrapnel would not be a convincing argument of the efficiency of the latter against coast defences generally. At Meks—a work almost *à fleur d'eau*—there was hardly a place where the head of an ordinarily tall man would be covered if he stood close to the parapet. The spread of the shrapnel fire of heavy guns has not been experimentally ascertained.* For present purposes, therefore, it is assumed to follow the same law as in the case of field guns, as enunciated by Lieut.-Colonel Nicholson, R. A.† Taking the lateral velocity as constant and equal to 90 f. s.,‡ the semi-angle of spread calculated as $\tan^{-1}\frac{90}{v}$, where $v$ is the velocity of the shell at the moment of burst, agrees in the case of the 64-pr. exactly with the result actually obtained at Dungeness. In the case of the 10-inch M. L., the spread similarly calculated varies from $3\frac{3}{4}°$ at the muzzle to $5\frac{1}{4}°$ at 4,000 yards. With this gun, therefore, in estimating the searching effect of shrapnel it will probably be sufficiently accurate to add 5 degrees to the angle of descent unless the shell is burst so far short of the object, that the increased curvature of the trajectories of the bullets becomes of practical importance. The possible effect will of course vary much with the height of the shore gun. Thus with the service 10-inch M. L. using a battering charge, a ship must be at 1,750 yards distance to obtain a horizontal trajectory at the crest of a battery 300 feet high, while to obtain an angle of descent of 6 degrees she must move to 3,350 yards.§ If the crest of the battery is 100 feet high, the corresponding ranges are 1,050 and 2,950 yards. Thus, supposing a shell to be burst in the most favourable position possible, the bullets in the case of a crest 100 feet above the ship's guns will at 1,000 yards have a drop of less than 11 degrees, and at 16 feet from an 8-feet parapet would be still 5 feet above the ground level. A just appreciation of the above facts will render apparent the difficulties under which the ship labors in delivering a searching shrapnel fire, and perhaps serves to explain why the French ships do not carry shrapnel for heavy guns. These difficulties will be materially increased by the introduction of guns giving higher velocities. The difficulty of killing men behind a high parapet by shrapnel fire from high velocity guns has, perhaps, been insufficiently appreciated, but the proposal to supplement the new field guns by low velocity guns or howitzers, is very significant. Practically, however, it will be impossible for ships to use howitzers with effect, and the excellent results obtained at Dungeness point no moral in relation to the protection conferred by shore batteries. As

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* Experiments are now being carried out to clear up this important point.

† "Shrapnel Fire," Lieut.-Colonel Nicholson, R. A.

‡ Calculated by Captain T. S. Jackson, R. N.

§ Taken from a diagram worked out by Captain T. S. Jackson, R. N.

regards searching effect, ships are now in a worse position than they were 50 years ago, and when re-armed with new guns their power will in this respect be still further diminished.

Some stress has been laid on the results which a modern ironclad might obtain from her auxiliary armament. Thus the "Duperré" carries 14—5½-inch guns of new type and 12 Hotchkiss machine guns, in addition to her heavy armament. This auxiliary armament adds considerably to her total rate of fire, which, however, will still be far inferior to that of a small frigate of old type. To use these guns, however, the "Duperré" must fight broadside on, and as they have no armour protection, they would be in the same position, as far as protection is concerned, as the guns of a wooden frigate opposed to modern heavy shell fire. If the shore guns were even moderately well handled, and especially if they were supplemented by a proportion of quick-firing guns, it might be expected that this auxiliary armament would be very soon put out of action with a heavy loss in men, and it might be by far the best policy for the ship to fight end on, using only her barbettes, and—except in the case of a battery on a high site—minimizing her target.

As regards the possibility of injuring the carriages of guns in shore batteries, the experiences of Alexandria were probably unexpected. Out of 35 guns under fire, there were, in addition to the dismounted guns, only two cases of injury of a damaging nature to carriages—a compressor arc broken and a front truck cut away by shell splinters. The case of a small unfinished two-gun battery in Ras-el-Tin Lines, heavily shelled by the "Inflexible" and "Téméraire," is somewhat remarkable. The embrasures in front were almost destroyed and the guns bared, yet both carriages were perfectly serviceable and were subsequently mounted at Ramleh. It is worthy of note that two 9-inch Palliser shell, which actually burst in the turret of the "Huascar," did not suffice to render either of the two carriages unserviceable.

As to the probable effect of machine gun fire, the present data are not altogether complete, yet here, again, Alexandria affords some teaching. Machine guns may be divided into two classes—1st, a continuously-fed gun, such as the multiple barrel Gatling, Hotchkiss, Nordenfelt, and Gardner; 2nd, a hand-loaded "quick firing" gun. The former class is capable of delivering a very rapid fire of bullets or small shells; the latter fires shells up to about 6 lb. weight, at the maximum rate of 10 or 12 per minute. At Alexandria, the fleet carried about 70—1-inch 4-barrel Nordenfelts, and expended more than 16,000 bullets. The expenditure of Gatling ammunition was only 7,000 rounds, and of Martini bullets 10,000. As to the results obtained, opinions have differed. It is submitted, however, that the number of hits on the guns and carriages of the defence may fairly be taken to afford some indication of those results. The hit of a Nordenfelt bullet on iron is generally unmistakable, but it is evidently possible that grazes at a very acute angle might have escaped observation. The total number of hits on guns and carriages was seven, and even this moderate number requires qualification. One hit was on the liberal target offered by the bracket of the Moncrieff carriage. This carriage stood upon the shore, the formality of building up protection round it having been omitted. The gun was not in action, and the natural fondness of the bluejacket for a good target can alone account for its being fired at.* It is stated that at the Ingogo affair where the artillery suffered severely from rifle fire, the guns were actually whitened by bullet splashes. The high scarps at Ras-el-Tin Fort, Adda, and Pharos, distinctly showed every Nordenfelt hit, but the total number of such hits was quite insignificant. It seems a fair inference that the vast majority of the 16,000 bullets fell short; or, as was actually the case at Meks, flew well over the battery. Captain Fisher, R. N.,

*At least four heavy projectiles were also fired broadside on at this carriage, which received one splinter hit only.

states—"Most of our ships used their Nordenfelt machine guns, but nothing is known as to the effect produced." "The bullets were found far and near, so it is to be feared the fire was not very accurate." "It is difficult, indeed almost impossible, to see where the comparatively small Nordenfelt bullet hits." The conditions at Alexandria were favourable to machine guns. The ranges of the inshore squadron were not excessive, and the tops of the ships were above the level of the shore guns. Captain Lewis, R. E., in his lectures on Permanent Fortifications,* remarks—"It might be quite possible for a boat armed with a machine gun to keep a heavy gun silent, that is, if the boat could manage to begin." It is not easy, however, to see why a boat firing at the water level should succeed, while the machine guns in the tops of the "Penelope" and "Invincible" failed for three and a half hours. In the case of an open battery at a moderate level above the sea, a machine gun on board a ship could effect nothing at short range. Mounted in a boat it would be still worse off. The explanation of the apparent failure at Alexandria is, doubtless, that the ranges were, on the whole, too great, and that even where the latter were more suitable for machine gun fire, the distance, the smoke of the shore guns and of the ships' guns, the sand thrown up and smoke caused by the bursting shells, utterly obscured the effect of the Nordenfelts, and the men who served them had no idea where their bullets were going. Whether matters would be otherwise in the case of the pigmy shells of the 1½-inch Hotchkiss must at present remain a matter of conjecture, but the prospect is not altogether hopeful for them.† As to the possible effect of the larger quick-firing guns also, nothing is at present known. These guns may succeed in making up the deficiency in rate of fire from which a modern ironclad suffers. They are capable of making good peace practice at 2,000 yards, and they are very handy. But, on the other hand, the angle of descent at 1,000 to 1,500 yards is not great, and they will have little searching effect. If it should prove possible to hit the chase or breech of a barbette gun at frequent intervals, the moral effect of the splinters will be considerable. Hits on the parapet in front will have little or no value. Shells successively delivered into the port of a turret or casemate would unquestionably be dangerous. It remains to be seen whether a ship can do these things, and good experiments would do much to clear up the point. In any case, the quick-firing gun will probably not be carried behind armour, and the unarmoured portions of a ship may be expected to suffer very severely in the first action in which modern coast guns are properly handled.

The introduction of heavy breech-loaders will affect the question of protection in the following ways. The great length and comparative weakness of the chase are somewhat unfavourable. Even with the otherwise complete protection promised by a cupola turret, the great protrusion of the gun will render it liable to a side hit which might easily disable it. Von Scheliha, in his treatise on coast defence, says, "guns mounted *en barbette* may always be disabled by an ironclad." The remark might have been made more general. All guns, however mounted, *may* be disabled by an ironclad, and, as far as safety is concerned, the disappearing principle probably affords by far the greatest protection. It might be fairly argued that the danger of being dismounted or disabled incurred by a barbette gun is little greater than that of a gun in a turret or cupola, provided always that the former has a limited angle of fire, and receives flank protection from bonnettes. A breech-loader, however long, can be loaded *en barbette* while offering a minimum target to front fire of all kinds, and the actual loading numbers are admirably protected by the breech of the gun itself, particularly if the operation is performed at elevation. Unless, therefore, the

* R. E. Occasional Papers, Vol. VII., 1882.

† Some light will doubtless be thrown on this question by the experiments about to be carried out at Inchkeith, but the absence of the smoke caused by a return fire will to a considerable extent vitiate the results obtained.

fire of more than one ship can be concentrated upon individual guns, which with dispersion, careful siting, and a moderate angle of training, will not be easy to effect, the gun detachments of new breech-loaders mounted *en barbette*, will be better protected than at present in spite of their greater distance from the parapet; while the great disadvantage attached to side loading of M.L. guns—the presentation during considerable periods of a broadside target—will be obviated. On the other hand, the breech mechanism brings a new source of danger. A mere burring up of the breech screw, by a machine gun bullet, or the cutting away of the locking lever by a shell splinter, might suffice to silence the gun for a long time. These dangers can, however, be met by a large steel hood enveloping the breech, or by special steel protection to individual weak points.

The general conclusions at which it has been sought to arrive may be stated as follows:—

1. The excellent all-round protection conferred by the turret will be sure to recommend it, but expense, combined with other considerations, will limit its adoption to low, cramped, advanced, or island sites. The great range of modern guns will somewhat check the tendency to push forward the shore gun to the water's edge, where a high site suitable for a barbette is available within a few hundred yards to the rear. Limitations of range due to considerations of the size of the port of the turret will not be tolerated. The heaviest guns will therefore be port-pivoting, and will be worked by hydraulic power, proved to be perfectly successful on board ship. At distant foreign stations, where there are no facilities for repairs, the turret can, under no circumstances, be adopted. In very hot climates, it may prove inadmissible. Where there are moderately high sites of sufficient area, it is unnecessary. The relative inaccuracy of the fire of the ships renders it probable that a turret would not be frequently hit in action, and the fact that, as recently proved at Buchau, a single segment of a Gruson turret broke up under four closely adjacent hits from a 12-inch gun, need not be held to condemn chilled iron armour. Such a favourable result would rarely be attained by ships in action. The question between compound steel and cast-iron armour is, therefore, mainly one of economy, and the latter will doubtless receive the attention it evidently merits. The fact that more than 90 Gruson shields and turrets are already mounted on the Continent, Germany leading, would alone suffice to secure that attention. A thick earth parapet up to the level of the glacis plate will be provided, where practicable, as at Kronstadt. In other cases, a gentle slope of hard concrete will be substituted.

2. The cupola, understanding by the term a conical turret containing a single gun worked by hand, is subject to some of the above limitations. Experiments about to be carried out will go far to show what measure of protection can be given without passing the limits beyond which power must be employed. Where exposed to the fire of the heaviest guns the cupola may prove inapplicable, since, if penetrable or capable of being easily disabled by a projectile, it is actually less favourable to protection against front fire than a barbette mounting, since it affords a considerably increased target. Where unexposed to very heavy fire, it is in most cases unnecessary. Since a cupola, if jammed, is for all immediate purposes as useless as if its guns were dismounted, it may be necessary to protect the crest of the pit with iron glacis plates like those of a turret. Directly the limit of easy and rapid hand-working is reached the two-gun turret becomes the more economical protection. Special and unexpected inconveniences may show themselves in the course of experiment.

3. The continuous iron front or the Gruson battery may still be employed under certain circumstances, for example—on a cramped low site where great volume of fire is required over a limited arc, or

where an all-round fire is needed of limited intensity on a given arc, but such that the flank and rear guns shall be available after those in front have been silenced. Armour may conceivably be desirable to protect machine or quick-firing guns in connection with turrets. This form of protection will usually labour under the disadvantage of offering a large target, while it will sometimes entail crowding of guns where dispersion is possible. As in the case of the turret, range cannot be sacrificed to size of port, and port-pivoting, probably entailing hydraulic power for the larger natures of guns, must be adopted.* A thickness of metal in a compound armour front should be well able to withstand the heaviest projectiles that the attack is likely to bring to bear upon it, and the possibility of subsequent strengthening should not be lost sight of. Since cast-iron armour cannot well be added to, a Gruson battery should possess a strength decidedly greater than that which present needs demand.

4. The disappearing principle will undoubtedly remain in some form, since it must always be an exceedingly effective mode of protection on account of extreme invisibility. A disappearing gun in a well placed pit provided with a turtle back splinter-proof shield is probably far better protected than in a turret. Moreover, a gun so mounted possesses the great advantage that future advances in the offensive power of ironclads are little likely to diminish the value of its protection. For the new breech-loaders the counterweight carriage is unsuitable, and hydro-pneumatic mountings have not yet by any means reached their full development. It will shortly be known whether these mountings can be satisfactorily applied to the 8-inch B.L. If this is the case, it may be expected that larger guns, up to the 10-inch B.L., will be tried with every prospect of success. Were several adjacent guns to be thus mounted, it will probably be desirable to provide a small steam engine able by pumping to ensure the maintenance of the pressure necessary to raise the guns. The engine would be merely a reserve of power, and would not be needed as long as the carriages were in perfect working order. For the old muzzle-loaders, there is no reason that the counterweight system should not be employed, as originally contemplated by Colonel Moncrieff, for guns up to the 9-inch M.L. The system would be applied only in cases where low sites, with deep water within short range, are unavoidable. The mounting is necessarily costly, but the gun may, probably, be considered to be as well protected as if mounted in a casemate with a heavily armoured front, while in the opinion of the Special Committee appointed to consider the question of counterweight carriages, one disappearing gun may be estimated as equal to two in casemates.

5. The principle of the "Collingwood" mounting appears to be eminently applicable to coast defence guns of the heaviest class. The measure of protection provided is at least equal to that of a turret or cupola. It is true that this protection is unquestionably inferior to that conferred by the disappearing principle, but the practical difficulties are certainly less. The target offered to the ship is so small that the comparatively slight risk of a direct hit—almost the sole danger to which a gun thus mounted is liable—may probably be accepted without hesitation. With the heavier guns hydraulic power must undoubtedly be employed, and there appears to be no better application. Whether the hydro-pneumatic principle can be applied to this mounting, so as to obtain a saving of power, and enable several guns to be worked by a small engine, remains to be seen. The addition of an armoured glacis will be necessary, and it is possible that chilled iron may be suitable for the purpose.

6. The barbette, with a central pivot, is likely to be the most general form of mounting. The heaviest

* Port pivoting has already been partially attained by the "small-port" carriages adopted for 10-inch and 12.5-inch M.L. guns, but entails the great disadvantage that the field of view is extremely limited. Guns thus mounted would, therefore, be best laid by the aid of a depression position-finder.

of the new guns at present tried with this mounting is a 43-ton gun, firing a charge of 400 lbs. Whether heavier guns, up to the limit of hand working, can be thus treated remains to be seen. With the larger natures a front pivot may possibly be necessary, and hydraulic power must be employed. The main danger of the barbette mounting is on the flanks, and protection should rarely be sacrificed to a wide angle of fire, where it is possible for a ship to take up a flank position. An angle not exceeding 120 degrees, with bonnettes, will be the most generally suitable, and can be obtained even with a front pivot. Circular pits are objectionable, but less disadvantageous on high sites. The emplacement should have the minimum possible of exposed masonry above the line of descent of heavy projectiles fired at a range of 3,000 yards. It may prove desirable to protect with iron the crest over which the gun fires, especially where considerable depression is required. In any case, good concrete and not stone should be employed for the front retaining wall, while an inner skin of thin iron plate would probably be advantageous in holding the concrete together after some disintegration has been caused by the blow of a projectile, thus preventing fragments from being driven into the emplacement. The range must not be diminished by limiting the possible elevation. Since the carriage designed at Elswick for the 43-ton gun admits of 20°, this limitation would not appear to be necessary. The protection of exposed gear on the side of the carriage, and of the breech screw (when withdrawn) from the chance hit of a shell splinter, as well as the whole question of steel hoods to cover the loading numbers, merit careful attention. Under some circumstances, the front pivot and embrasure will be advantageous. It is now certain that the results of experiments with siege guns need not be held to condemn the embrasure for coast batteries. Should the difficulty of under-cover loading for the existing M.L. guns prove incapable of satisfactory solution, it may be worth while to accept the limited angle of training and adopt the embrasure for these guns, mounting a larger number of guns to cover the same field of fire, in order to gain the considerable protection against shrapnel and machine guns which the embrasure affords to the loading numbers. The chain rammer experiments shortly to be carried out at Newhaven will serve to throw light upon this point.

7. In siting guns, dispersion will be aimed at as much as possible, and the placing of the most powerful guns of a battery in closely adjacent emplacements will always be avoided. High sites will be preferred for open batteries. Against the more powerful modern ironclads, the attack on the deck may possibly prove by far the most effective course. Barbette ships seem specially ill-qualified to resist such an attack. The very accurate fire of the new guns will be favourable to it. It is true that the flatter trajectories will produce a relatively greater tendency to rebound from the deck plating; but on the other hand there are plenty of objects on the deck of a ship capable of turning down a projectile, and once turned down it would be rash to attempt to predict its further course.

8. Invisibility will be striven for by all possible means. It is the cheapest form of protection. Clean cut lines, and even slopes, will altogether disappear, while vegetation will be judiciously encouraged. At Alexandria, the great difficulty of our ships was to find a definite object to aim at. In a well-designed earth battery there should rarely be anything clearly defined.

9. Parapets from 35 to 40 feet thick will be ample for all purposes of protection, and are likely to be equally serviceable ten years hence. Sand will be employed in front of gun emplacements where possible. A mere layer 4 or 5 feet thick on the top of an earth parapet will be advantageous.

10. Since it is now tolerably certain that ships will have to anchor, or come back to a given point to fire, when seriously engaging earth batteries, the employment of curved fire against them will sooner or

later find favor. The fact that with an 11-inch howitzer at 7,300 yards five shots out of ten were placed on a target representing the deck of the "Inflexible,"* is sufficiently significant. The heaviest ironclads are exposed to this attack on the deck by means of curved fire, and the moral effect of this fire, delivered from small groups of heavy howitzers, will probably suffice to prevent them from anchoring or even manœuvring at slow speed within range.

11. Shore batteries will employ machine and quick-firing guns; the latter should prove very effective at moderate ranges against the unarmoured portions of ships.

12. The advantages of range-finding which the shore battery possesses over the ship deserve to be utilized to the utmost possible extent.

In the preceding pages only a limited portion of a great subject has been dealt with. Large fields have been left untravelled or merely skirted. Some of the conclusions arrived at, as well as the reasoning on which it has been attempted to base them, are evidently open to criticism. The data are confessedly incomplete, and the personal equation will always affect conjecture. At the present moment a series of experiments in naval gunnery, carefully carried out under well considered conditions, is greatly needed. There is no sufficient reason against such experiments, and their expense would be fully justified. It is possible that the results would lead to a great saving in future coast defences.

LONDON, *March* 1884.

Since the above paper was written, important experiments have been carried out at Inchkeith to ascertain the effect of machine and quick-firing guns and shrapnel against an M.L. gun *en barbette*. Practically, however, these experiments little affect the views previously advanced. They show that an M.L. gun *en barbette* could not be continuously served in face of the machine gun fire of a ship if this fire were as accurate as the exceptional conditions at Inchkeith permitted. They attest the value of a shell-firing machine gun. They clearly demonstrate the disadvantage of circular pit emplacements unless employed in connection with horizontal or turtle-back shields. They indicate that machine and quick-firing guns are now a necessary part of the armament of coast defences. Finally, they appear to favor the disappearing principle for new B.L. guns on low sites, while indicating that on moderately high sites these guns can be served with small risk if furnished with well-designed steel breech-hoods, and provided that the arc on which a ship can directly engage them does not exceed about 120°.

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* *Journal R. U. S. Institution*, 27th January, 1882.

LONDON,
*September* 1884.

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