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### A New System of the Application of Adjourned Discussion

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# Evening Meeting.

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March 2nd, 1863.

Captain W. H. TYLER, R.E., in the Chair.

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NAMES of MEMBERS who joined the Institution from 16th February  
to 2nd March.

## LIFE.

Somerset, L. E. H., Captain R.N.

## ANNUAL.

Osborne, J. J., Ensign 15th Regt.

Parkinson, J., Lieut. 57th Regt. 1l.

Rouse, R., Capt. 3rd Suffolk Rifle Vols.

1l.

McCrea, J. D., Captain R.N. 1l.

Price, T. E., Lieut. R.A. 1l.

Woodall, J. W., Capt. East and North

York. Art. Mil. 1l.

Bravo, A., Captain 1st West India Regt.

1l.

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## A NEW SYSTEM OF THE APPLICATION OF IRON TO FORTS AND SHIPS.

By G. B. V. ARBUCKLE, Esq., late 57th Regiment.

Gentlemen—

I wish to preface the address I am about to make this evening with an account of the various experiments that have been made at different times with iron in plates and bars, to resist the penetration of shot and shell, as it is evident that, at this period, the science of attack and defence is undergoing a great change. Our war-ships are already cased in armour, and it is said that before many years our fortifications will be also.

This is a subject that has engaged the attention of many other nations, and, indeed, only a short period since, when the "Gloire" attracted so much notice, was the subject taken seriously in hand by our Government. Long previous to this (in 1854) specially constructed ships had been plated with  $4\frac{1}{2}$  inches of iron, but after the Crimean

war the subject was allowed to rest, until the French Emperor commenced the construction of an iron fleet, supposed to be invincible.

The first experiment of which we have any record, was made at Woolwich, thirty-three years ago, when bars of iron in two rows, one horizontal and one vertical, the former  $1\frac{1}{4}$  inches square, the latter  $1\frac{1}{2}$  inch were fastened into a mass of granite, 5 feet high, and 7 feet thick. This compound mass was fired at by 24-pounders at 600 yards, and destroyed completely.

The next experiment with bars of iron took place in 1859, when the bars of iron were 10 feet long,  $4\frac{1}{2}$  inches wide, and 14 inches deep. The difference in the amount of resistance thought to be requisite in the two cases is very remarkable: in the first  $2\frac{3}{4}$  inches, in the second 14 inches. The iron was furnished by Messrs. Thorneycroft and Co., of Wolverhampton, who have favoured me with the following account of the experiment:—

The target was 10 feet long,  $4\frac{1}{2}$  feet high, and 14 inches thick. Seven 68-pounders at 400 yards made slight indentations only. Wrought-iron shot clipped it slightly, they failed to break through, and the gun behind was protected.

This target stood no doubt remarkably well, and although the system was tried subsequently, it did not appear to answer so well; but the circumstances were very unfavourable. The bars were smaller, being 10 and 8 inches in thickness in place of 14, so that at the time guns were increasing in power, the targets were less strong—less able to resist. These are the only experiments that have as yet been made against bars, although we see every day accounts of plates from every manufacturer almost in the kingdom, and the result always the same—penetrated, broken, destroyed; while bars of iron, of great thickness, if well backed, “not unless,” are positively impregnable.

One of the great objects of Government is this—to obtain a protection for guns that shall resist the destructive effects of shot; and to effect this two methods have been advocated—bars, as before-mentioned, and plates. Plating consists of two kinds: one where a total thickness is made up of many thin plates, the other where a mass of iron is rolled or hammered into one large plate, as those at present supplied to the Royal Navy.

Plating has been experimented on from  $\frac{1}{4}$  of an inch in thickness up to 8 inches. In 1850, a target was made, composed of  $\frac{5}{8}$ -inch plates, representing a part of the “Simoom,” an iron-built ship. It offered very slight resistance, and clearly showed its inutility as a war-ship: the shot and shell broke up, scattering fragments everywhere. Although  $\frac{5}{8}$ -inches broke up shot and shell, it was found that a less thickness did not do so, shot and shell passed through plates  $\frac{1}{4}$  and  $\frac{3}{8}$  inches in thickness without breaking.

In 1854, some experiments were carried on by the Admiralty at Portsmouth.

A target, composed of  $4\frac{1}{2}$ -inch plates, backed with fir-planking, the whole bolted to a strong timber framework, well braced and strutted, was fired at by 32-pounders at 360 yards—plates indented and

cracked. At 1,200 yards, the 68-pounder, with a charge of 16lbs., cracked the plates, and at 400 yards, destroyed target and backing.

In 1856, plates 4 inches thick, backed by 2 feet of woodwork, were furnished by different makers for experiments at Woolwich.

Cast-iron shot, at 400 yards, indented and cracked the plates, drove in the bolts, and shattered the backing. Wrought-iron shot, at the same range, went through.

In 1857, experiments were carried on against steel-plates, which were found quite unserviceable from their brittle nature.

In 1858, experiments were made at Portsmouth with a gun proposed by Mr. Whitworth, but the gun having burst, the only record of the experiment is, that at 450 yards, a wrought-iron shot went completely through the 4-inch plating.

In 1858, the "Erebus" and "Meteor" were fired at, at Portsmouth. The "Erebus" had a  $\frac{3}{4}$  skin on iron ribs, 6 inches of oak planking, and 4-inch wrought-iron plates. The "Meteor" had an inner planking of oak from 4 to 9 inches, 10-inch oak timbers, 4 inches apart, 6 inches of outside oak planking, and 4-inch plates.

At 400 yards little damage was done to the latter, but the former was easily penetrated, showing, in the case of the "Meteor," the value of a good backing.

In this year also, a large wrought-iron plate, 6 feet by 6, and 8 inches thick, was fired at by 68-pounders at Woolwich, charge 16lbs., range 400 and 600 yards. Cast shot indented and cracked the plate, and wrought-iron shot broke it up. Previous to this, blocks of cast iron, 8 feet by 2, and  $2\frac{1}{2}$  feet thick, backed by granite, were fired at by 68-pounders at 400 yards with solid cast-iron shot.

Wrought-iron shot broke off large fragments from 10lbs. to 80lbs.

Cast-iron shot broke up.

Wrought-iron shot recoiled, much flattened.

I wish that point to be remarked, that, against a solid mass of cast iron, the solid wrought-iron shot "*recoiled*," making only an indentation.

In 1859, a special committee was appointed to consider the subject. Plates,  $1\frac{1}{2}$ , 2,  $2\frac{1}{2}$ , and 3 inches in thickness, were made and bolted on to a target representing the side of a 50-gun ship, in fact, an oak backing from 18 to 24 inches thick. Steel and cast-iron solid shot passed quite through the plates and backing, the steel entering the cast iron, breaking it into fragments. Of the shells, two passed through the plates but not through the wood, and all broke up.

In 1859, the woodwork of the "Trusty," one of the ships used during the Russian war, being found rotten in many places, it was determined to convert her into a target. She was originally built for a floating battery of 40 guns, being plated with iron  $4\frac{1}{2}$  inches thick, on 25-inch solid oak. At 400 yards the 80-pounder gun broke the plates but did not pierce. At 200 yards the cast-iron 100lb. shot did a great deal of injury, but did not penetrate. Homogeneous-iron shot punched a hole quite through the plate and 10 inches of timber remaining there: round shot, fired obliquely, did less damage than direct shot, and glanced off.

In 1860, the Jones's angulated target was tried. It consisted of an inner skin of iron, to which was fastened  $13\frac{1}{2}$  inches fir-planking; on this were fastened the armour-plates, placed at an angle of  $52^\circ$ . The armour was  $4\frac{1}{2}$  and  $3\frac{1}{2}$ -inch steel, and  $4\frac{1}{2}$ -inch wrought iron. Range, 200 yards. Result—the steel-plates were useless. Penetration declared to be less than half that on perpendicular plates. The effect on the *woodwork backing* very slight. I wish that to be *particularly remarked*, as it bears very much on the system which I wish to speak of.

In 1861, a Special Committee on Iron was appointed, their object being to consider the best manner of protecting our ships and fortifications, and the best form of applying the armour. Practical and scientific men were invited to attend, and the following plates were ordered from different factories:—

Homogeneous plates.

Hammered plates.

Rolled plates.

Steel plates.

Steel and iron combined.

As the plates were too thin, they yielded to the attack, and nothing satisfactory was elicited, except that it led to the trial of some other targets of greater strength by different inventors, Mr. Roberts, Mr. Fairbairn, Mr. Hawkshaw, an account of which trial may be interesting.

Mr. Roberts' target consisted of a mass of timber and T plates, protected by armour-plates 3 and 4 inches thick, rolled and hammered to present a series of angular projections (ridge and furrow), the apices of the angles pointed with steel.

*Result.*—Completely destroyed by 100-pounders and 68-pounders.

Mr. Fairbairn's target.—Plates 5 inches thick, attached by a number of screws to a  $\frac{3}{4}$ -inch skin supported by wrought-iron built-up ribs of  $\frac{1}{2}$ -inch plate, 12 inches deep, 18 inches apart. The screws were  $7\frac{1}{2}$  inches apart.

*Result.*—The plates themselves stood well, but the screws all broke, and the armour fell off.

Mr. Hawkshaw's target consisted of a resisting thickness of  $10\frac{1}{4}$  inches, being composed of one 2-inch plate, and 13 plates  $\frac{5}{8}$  inch each, held together by alternate screws and rivets.

*Result.*—Penetrated easily, and it was found that a number of plates, as compared with one solid plate, are comparatively weak, as the shot acts upon each plate in detail, the resistance being as the square of the thickness. Thus, if one plate is 4 inches thick, and another 3, then the resistance is as 16 to 9. A 6-inch plate, therefore, as compared with 4-inch, would be as 36 to 16, supposing the plates to be of equal qualities, and all the circumstances the same; but this is the great difficulty, both for plates and guns, a large mass of wrought iron made into one piece, at a high temperature, which it must be to manufacture, is in an *expanded state*, when it cools, it contracts, and the result is almost invariably, in large masses, a hollow in the centre. I will record one more experiment against inclined plates. They were

tried up to 3 inches in thickness at angles of 30°, 45°, and 60°, and no apparent difference found in the power of resistance. *But* the plates were simply held on to a *skeleton framework without backing*, and *this is the cause of the failure*. It was clearly shown in the case of the "Erebus" and "Terror" that a good backing is most invaluable.

I now come to the most important experiment that has been made at Shoeburyness, viz., the trial of Captain Coles' shield. It may be said, important, because successful. The first experiment consisted of 18 shots from a 40-pounder gun at 200 yards. The shield was slightly indented. From the 18th round to the 65th round, the cupola was fired at by a 100-pounder Armstrong gun at 200 yards also. The result at the 55th round, penetration, *but*, the plate was a very bad one, and, nevertheless, only yielded to eight or ten shots, which had struck it at the same place. This shield then, composed of iron 4½ inches in thickness, with a wooden backing at an angle of about 40°, stood 50 rounds from 40-pounder and 100-pounder guns. The advantage was all on the side of the defence, and the result clearly proved that iron at an angle, if well backed, can resist any assault, for it is manifest, however large your gun may be, the iron can be increased in thickness to any amount in wedge-shaped bars mutually supporting each other, but not in plates.

It has been represented by an eminent engineer, that, for a fort, the arch system of iron would not answer, *because*, the velocity of a shot is such that it overcomes everything that opposes it. The error of this argument is apparent, for if a shot is fired at a wall of iron sufficiently thick, we know perfectly well what must be the result; instead of the velocity overcoming the resistance, it is exactly the contrary, as was proved when wrought-iron shot were fired, in 1857, at a wall of cast iron 2½ feet thick, and were repelled. So, if the arch is sufficiently thick, it repels likewise.

The value of a curved and sloping surface has not been as yet sufficiently appreciated. With a perpendicular frontage (and with the experiments recorded in nearly all cases, the target has been at right angles to the trajectory) the whole force of a shot is expended *locally* on the part struck, whereas, with a curved surface, the force radiates in all directions, and is thereby much weakened.

To sum up the experiments then that have been made up to the present time—

1st. We have records of plates varying in thickness from 1 to 8 inches, and in one case, a wall of iron 2½ feet thick. The last case being the only one in which there was no penetration, as, of course, there could not be. In this case then the shot recoiled.

2nd. In the case of the "Trusty," shots glanced off.

3rd. In the case of the inclined target of Mr. Jones, round shot also glanced off, and the penetration was declared to be less than half that on perpendicular plates.

4th. Against the shield of Captain Coles the impression was almost nil, for, although the shield *was* penetrated, it was not till after 54 rounds had been fired at it; *that very number* proving its approximation to invulnerability under ordinary circumstances. It must not be

forgotten, too, that a little white spot was painted on a weak plate, and this could never happen in actual warfare; and that against the bars proposed by Messrs. Thorneycroft in the first experiment, the impression was slight; we may therefore conclude that a resisting mass may be obtained through which shot and shell shall fail to penetrate. It has been stated in the recorded experiments that plates at angles of 30°, 45° and 60° were penetrated, and it appeared there was no difference whether the plates were sloping or upright, *but*, it should be remarked, they were on a skeleton framework, and there was no backing. *In this* consists the whole theory of resistance, for, if it is desired to *break* a bar of iron, precisely the same course is taken, the ends are supported, leaving the middle *unsupported* to receive the full force of the blow; in the case of its being laid on a flat surface, such as an anvil, the force of the blow passes through the iron, and is, in reality, received by the anvil underneath. So, in the case of the "Erebus" and "Terror," both were covered with iron plates of "*equal thickness*," but, in one case there was a strong backing, in the other a slight one. The former stood well while the latter was knocked to pieces.

Of the "Trusty" experiment at Shoeburyness, it may be said,—1st. That no target ever stood such a hammering at all. 2nd. That any other target would have been broken to pieces. 3rd. That the extraordinary invulnerability of the target was owing to every blow being received on an arched and sloping surface, that arch diminishing the force of the blow.

You are aware that in the olden times, a simple wall surrounding a town was considered sufficient to protect the inhabitants from attack. The invention of gunpowder rendered these walls useless, and the various systems of Vauban, Dufoure and Cormontaigne were adopted. It is said that these will soon be as obsolete as the old walls which were once thought so good; that before modern artillery they will all succumb speedily, unless faced with iron, or some plan be devised by which a hostile force shall be held at bay.

The latest siege of a fortress favours this view, and that you may judge for yourselves the importance of the question, I will read the description of it from the despatch of the officer commanding the assault. It is of such late occurrence, having taken place only last year, that at this moment, when *really* nothing definite has been decided, it will forcibly establish one point, viz., the speedy reduction of any escarp of brickwork; and, unless the escarps are strengthened, they will all crumble to pieces before the combined attack of the present ordnance, unless outworks can be devised which shall prevent a besieger establishing his batteries, or they are otherwise rendered impervious to attack by being plated with iron.

*Account of the Siege of Fort Pulaski, in Georgia, during the months of February, March, and April, 1862.*

The fort is described thus:—"It is situated on Cockspur Island, casemated on all sides, walls 7½ feet thick, command 25 feet, mounting one tier of guns *en-barbette*, and one in casemates, surrounded by a wet



ditch. The fort mounted 42 guns." From the date of its fall, a new era in the matter of breaching fortresses may be reckoned. For, in the ordinary works on Fortification hitherto published, it has been stated that a wall may be breached with certainty from a distance of 500 to 700 yards, and, in cases of great necessity, at 1,000.

This fort was reduced at a *distance of 1,700 yards*.

From experiments lately carried on in this country, it was found to be impossible to reduce a Martello tower with smooth-bores at 1,000 yards. With rifled guns at the same distance a breach was made.

The report of the officer commanding before the fort of Pulaski, states that the breaching batteries were established at a distance of 1,700 yards from the escarp walls. The walls being oblique to the line of fire, and 7½ feet thick, backed by heavy casemate-piers and arches, a practicable breach was made in less than 48 hours, at an expenditure of 2,400lbs. of metal per lineal foot. The average expenditure in Spain was 2,500lbs. per lineal foot, and the breaching batteries were at a third of the distance.

The guns used were rifles and smooth-bores combined, of the former 58 per cent., the latter 42, these being 68 and 128-pounders. The rifle-shot were used to pierce and crack the walls, the heavy smooth-bored shot to bring down in lumps the masses thus loosened.

Heavy mortars and heavier guns were brought into position, and it was afterwards found their services could have been dispensed with. Had this been known, seven weeks of most harassing and tedious duties could have been avoided, as the batteries were established at the termination of a causeway which had to be constructed of planks, on soft ground, with swamps on either side. Bringing up the guns was a work of the greatest difficulty, each heavy piece requiring 250 men, and the greatest caution was necessary to prevent its being overturned, in which case it must have been almost irretrievably lost. The saving of labour (amounting to two months) which might have been made, is worthy of remark, also, when the guns once opened fire, the remarkably business-like way in which a breach was made; the rifled guns being used to pierce and loosen, and the heavy smooth-bores to bring down the masses thus separated.

It may be presumed, then, that forts such as exist already, are doomed speedily to succumb if invested, and the besiegers are able to carry on the customary operations of a siege. But what would happen if the ground encircling a fort were already occupied; and if that occupation were of such a nature that it must be reduced before breaching batteries can be established? It is only in this iron age that such a thing could be done. The method proposed is this—"The Vossoir System" either at right angles to the horizon, or sloping. Including the forts already built, such as Portsmouth and Plymouth in this country, Fort William and Fort St. George in the East Indies, and in all situations where the ground will admit of it, and the supply of water is unlimited, to place small iron forts or towers, either to take breaching batteries *in reverse* or *enfilade*. These, to be of any avail, must be "impregnable themselves," if they *can* be so constructed. Let us consider that point then.

The accompanying diagram shows the method of making an iron parapet to resist shot.

Bars of iron, 14 to 20 inches in thickness, or more, two sides curved and two diverging, *vide* plate v, fig. 1, inclined to the horizon at an angle of  $45^\circ$ , resting on buttresses at an angle of  $45^\circ$  also, fig 2; the bars wedge-shaped, and dove-tailed in the rear on another set of bars, so that the whole presents a series of arches at an angle of  $45^\circ$ , supported by suitable backing, and outside each segment if requisite a 2 or 3-inch sheeting of iron, the ends overlapping so as to be hid in the interior. This, unless shot away bit by bit, would be a network of great value. The whole presents a resisting mass without any bolt-hole in it, and once having a parapet impregnable, small fortresses of iron, with revolving turrets or cupolas, would present a formidable obstacle; bomb-proof barracks would be constructed within. This is the principle; the detail may vary.

One of the American vessels, when boarded, presented no place of *admittance whatever* to the assailants except the embrasure, which was seen slowly to revolve. It is needless to add the boarders were glad to retreat. Works of this kind, therefore, could not be taken by escalade; judging from the recorded experiments, it may fairly be inferred that forts may be made thus to resist anything, as there is a limit to the gun *but not* to the strength of the arch.

Allowing, for the sake of argument, that it requires a thickness of iron of 20 inches to keep out shot, this is the only method, at this time, by which that thickness can be given, except at an *enormous cost*; the iron wedge-shaped bars here spoken of are produced at 17*l.* to 18*l.* per ton, the present cost-price of iron plates, such as are supplied daily to the navy, is from 40*l.* to 47*l.* per ton, and the thickness  $4\frac{1}{2}$  inches *only*. Each segment, as before stated, rests on a suitable backing, as well as the buttresses, except that part immediately in rear of the embrasure. Here we must have given the thickness of iron that will repel shot at an angle of  $45^\circ$ .

In all calculations, something *must* be given on which to found a theory, otherwise the whole is hypothesis.

The engineer who carries his railway up a mountain-side, like those lately constructed in Spain, must have given the power of his engine, and the weight of the load to be borne before he can adjust his incline. The physician who cures our complaint must have given either the cause of our illness, or our symptoms, ere he can prescribe. So, to build a fort and make it invulnerable, you must have given the weight of the projectile, and the velocity with which it will be propelled to make the defence proportional.

The strength of the arch prevents its being broken in, and the outside plating, as well as the interior fastening, prevents the iron rebounding outward from the force of concussion. The elasticity of iron is slight, and the weight of each part tends to keep it in position when once in its place. Allowing that the outside plating would be much broken unless it was altogether displaced piecemeal, the parts left would form a valuable network to hold all together.

The embrasure is undoubtedly a most difficult and delicate point to

Isometrical Elevation of Iron Parapets  
*A.B.A.B.* are wedged shaped bars of iron at an angle of  $46^{\circ}$   
 supported by buttresses *C.D.* at the same angle.  
*e. e. e.* Tenons mortised into the bars *f. f.*  
 Principle not the detail shown.

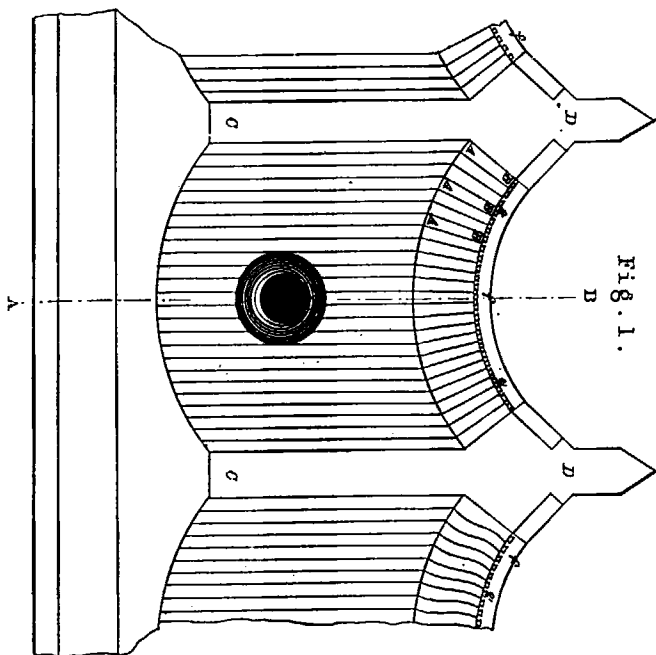
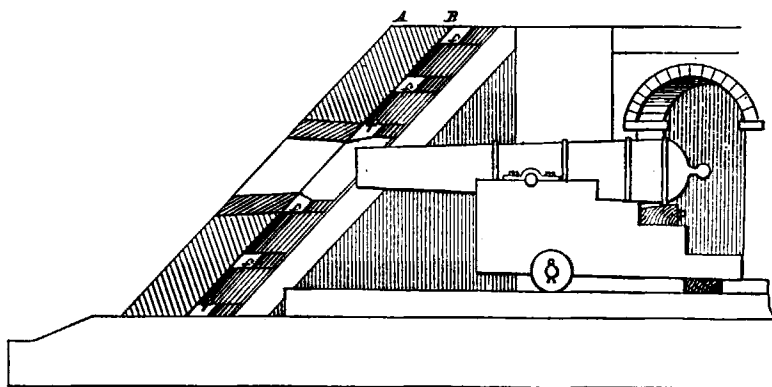
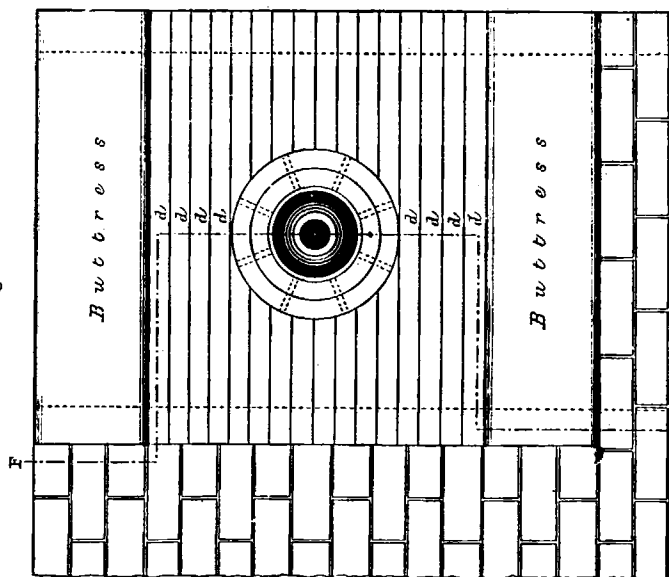


Fig. 2.  
 Taken on the Line A.B.



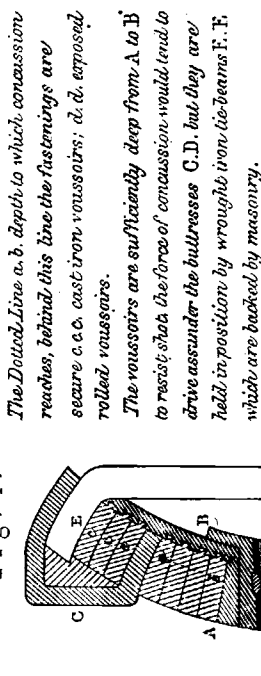
*For the defence of Harbours, Mouths of Rivers.*

Fig. 3.



Impregnable at an Angle of 45°

Fig. 4.



Note. The principle is only shown and there may be many varieties of construction  
Price of rolled voussoirs 281 per Ton  
Plates . . . 403.

# Explanation

The Dotted Line a. b. depth to which concussion reaches, behind this line the fastenings are secure a. c. cast iron voussoirs; d. d. exposed rolled voussoirs.  
The voussoirs are sufficiently deep from A to B to resist shot the force of concussion would tend to drive assunder the buttresses C, D, but they are held in position by wrought iron tie-beams F, F, which are backed by masonry.

Section on the Line E.F.

Impregnable at an Angle of 45°

settle, but if we have *given* the thickness of iron that will repel shot, probably the difficulty will be diminished. Until this is ascertained, it is impossible a satisfactory result can be arrived at.

Many experiments have been carried on at Shoeburyness, and the point is still undecided. The plan proposed may also be seen from the accompanying diagram, and the embrasure can be made of any resisting power.

The embrasure is made of concentric rings of iron, from 12 to 20 inches (or more) deep, each ring in itself is the hollow truncated segment of a cone, figs. 3, 4. The whole forms a massive, hollow segment of a cone; the depth of it must be sufficient to absorb a blow without dislocating the fastenings in the rear. By this method a solid resisting homogeneous mass of iron is presented. Bands of iron, also fastening in the rear, might be useful, as well as bolts let in, to prevent the rebound, and before one ring could be loosened, not one or two bands, but every band must be broken at the same distance from the centre to let it fly out: to protect these they are let in the rings so as to be flush with the surface. An embrasure of this description is said to be expensive. Doubtless it is so, but many expensive things are worth the amount demanded for them, and this probably is one, for the guns in a fortress must be defended at any price.

I will now proceed to make some remarks on artillery, and if I am in error, trust some gentleman will correct me, as this theatre is the only place I know of, where all branches of the service are invited to discuss professional matters, interesting to each member at home, and more so to those abroad who have not the opportunities we have either of witnessing the experiments or hearing the discussions. In a national point of view also they are important, as even now it is undecided whether the Spithead forts are to be built or not.

Let us consider then what is the immediate action of a shot impelled at high velocity? it either penetrates completely through the opposing substance, penetrates partly, or is repelled. If fired against a wall of iron of great thickness it is repelled, and the shot is much flattened; if fired against a thin wall of iron it penetrates completely. In one case pregnability, in the other impregnability. It follows then between the two there is a certain medium at which a shot would enter, and another where it would not enter. Let this be found, and by using a greater thickness you have comparative safety. And now with regard to ships. If it should be said that for ships so much weight could not be carried, then, *at all events*, let a ship be encircled at the water-line with such an impenetrable belt as would keep her afloat. Should plates not give it, one of Her Majesty's principal naval architects has informed us there would be no difficulty in applying the principle of the *voussoir* to ships, and from the actual results in the American war, we see clearly that a ship with one hole only at the water-line, sinks in fifteen minutes. *Vide* account of the action between the "Alabama" and the "Hatteras," when the large gun of the "Alabama" penetrated just below the water-line.

Between ships and forts I fear the former will have the worst of it

in any future naval engagement,\* for on the deep there is a limit to the weight of armour,—not so on land. To prevent the destruction of a wooden ship by liquid iron shells, a very thin plating of iron,  $\frac{1}{8}$ th of an inch in the interior, would render them fire-proof, and if guns can penetrate the thickest armour which a ship will bear on her sides, the armour must be increased, at *any sacrifice*, about the line of flotation.

Of the guns about to be tried at Shoeburyness. I will mention one gun, the weight of which is 17 tons, weight of shot 400lbs. Suppose this gun penetrates through a mass of wrought iron 12 inches in thickness, say 20, and that you require 24 inches to afford perfect resistance, the arch principle is the only one that admits such a resisting thickness. If it should be said, take plates such as are now being made, and set them up edgeways, *then* there is a defect, for they are all parallel to one another, and one pushed through, dislocates the whole. In the arch this is obviated, as any force acts laterally, while in the forer it acts locally.

It is in large works, more especially for the defence of your guns, that the principle is specially recommended, for this reason, you cannot get a homogeneous resisting front in any other way.

Having, then, an irresistible wall, which cannot be broken through, a bomb-proof barrack within renders the defenders perfectly safe. Any command desirable may be obtained by this method, and with revolving shields, which can be made impregnable on this system, the efforts of a besieger to establish himself would be a most hazardous undertaking, so much so, that he would probably decline the encounter.

The forts or towers should flank each other, with a glacis to render the foundations safe from attack, and a wet ditch as wide and deep as circumstances permit, fig. 5.

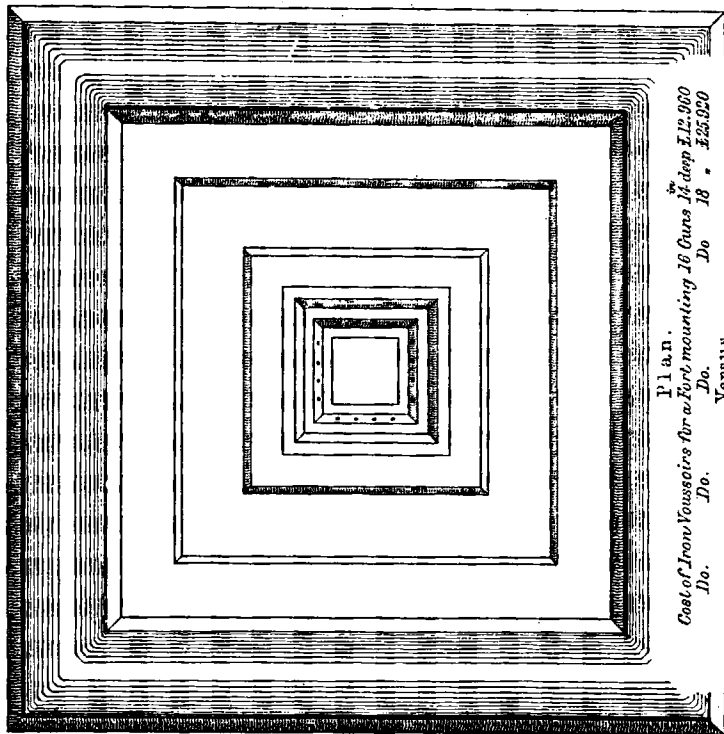
The expense of an iron fort for ten guns if compared with brickwork, will shew a very favourable comparison, *vide* fig. 5.

The southern coast of England is dotted in many places with Martello towers. These towers were each built for one gun on centre pivot traversing platform; the expense of one was 3,000*l.*, the expense of ten, therefore, would have been 30,000*l.* Now, the expense of an iron fort for ten guns, composed of iron 14 inches thick, would be very much less than the above, giving a lateral space of 17 feet to each gun.

The extraordinary use that one or two guns may be of, on certain occasions, cannot be better illustrated than by two cases reported in Sir John Jones's *Sieges*, vol. 2. In one case, Sir Sidney Smith, with the "Pompey," an 80-gun ship, the "Hydra," 38 guns, and another frigate, anchored about 800 yards from a battery of 2 guns, on the extremity of Cape Licosa and protected from assault by a tower in which were 25 French soldiers, commanded by a Lieutenant. The line-of-battle ship and the frigates fired successive broadsides, till their ammunition was nearly expended, the battery continually replying

Since this paper was read, March 2, 1863, accounts have reached this country of the attack on Charleston, and what was then stated has been actually verified.—G.B.V.A.

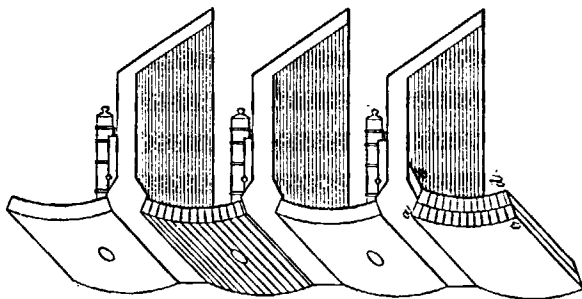
Section.



Plan.  
 Cost of Iron Youssins for a Turk mounting 16 Guns 44 deep £12 930  
 Do. Do 18 " £23 920  
 Versaus.  
 16 Martello Towers of Brick. £43,000.

### Isometrical Sketch.

a. b. c. d. represents a thickness of Par. pet. 28 in. obtained by one Arr. resting on another, a mode of construction not obtainable by Plates



Cost of Iron Parapet 12 ft by 12 ft & 14 deep	1.576.
	28
	£1090.

with a slow but destructive effect. The "Pompei," at which ship alone it directed its fire, had above 40 shot in her hull, a lieutenant, a midshipman, and 35 men killed and wounded. It afterwards appeared, that the carriage of one gun had failed on the second round, so that, in fact, the attack of an 80 gun ship and two frigates, had been resisted by a single gun. Another instance of one gun doing good service is related in the United Service Journal, No. 46. The small army that under Lord Lynedoch advanced towards Antwerp early in 1814, established a post on a head formed by the Polder Dyke, at some distance before Lille. The place is called Fort Frederick, though showing no appearance of fortification, beyond the barely visible site of two embrasures. From this post the French determined to dislodge them, and an 84-gun ship anchored at a distance of 600 yards for that purpose; the action lasted from 7 o'clock in the morning till 12 at noon, when the French ship hauled off, having lost 41 men killed and wounded.

Such, then, for defending our forts already built, is the plan proposed, viz., small impregnable outworks surrounded with water, wherever this can be obtained *ad libitum*. There is no reason to doubt the success of the defence. We have seen as in the case of Fort Pulaski only last year, that by the combined use of rifled and smooth-bore guns, an effective breach can be accomplished in less than 48 hours, in escarps of masonry, and this, too, at a distance hitherto thought impossible. Yet the longest range must be a known, a "*given*" distance, and by placing these little forts, as at Fort Lille, showing no appearance of fortification beyond the barely visible site of the towers or embrasures; by placing these forts, then, at a *greater than* breaching distance, they would render the investment of our fortresses, now existing, such a hazardous operation, that, until they were silenced, no investment could take place; the saving, too, would be enormous, as the escarp walls only of one fortress could not be iron-plated at a much less cost than a million. If not travelling beyond my *crepidam*, I should wish to say a few more words as to ships. The Premier, in a debate only last week, spoke of the necessity of having, as speedily as possible, an impregnable iron fleet. But haste may not be speed in this case, and it may be asked, are we not building fast without enquiring what the future effects of large ordnance are to be? Are we not building fast simply because the French Emperor set us the example some time ago?

Owing to the exertions of this excellent Institution, or rather to the officers who take great interest in it, is it not now tacitly admitted, that an expense of three or four millions has failed to produce a good naval gun, and that the rifled gun, as supplied to Her Majesty's ships, will not bear a large charge of powder, that, contrary to the opinions of naval officers generally, the value of smooth-bored guns with high velocity has been ignored, and the preference sought to be given (but repudiated by the navy) to long range.

It was stated also, lately, in the House of Commons, that ships must henceforward be strongly plated; that to send our sailors to sea in wooden ships would be little better than sending them to slaughter; but if the iron ships can be penetrated, and sunk with facility, in what



condition are they better than wooden ships only? indeed, if they can be penetrated at all at the water line, they are far worse, as the orifice made in a wooden ship *can* be plugged, in an iron ship it *cannot*.

It behoves us to proceed with the utmost caution. Our cousins across the water can take a much more dispassionate view of these matters than ourselves, and I will read an extract from the Report presented to President Lincoln, by the chief of the Ordnance Bureau in America.

*Report to the President of the American Republic by the Chief of the Ordnance Bureau—selected paragraphs.*

The constant and very natural solicitude manifested by the public in the changes which have been and continue to be made in the construction and armament of our ships of war, may warrant a more extended notice of technical details than might otherwise find a place in documents of this nature.

And yet, no definite conclusion has been arrived at in regard to either of these important problems.

Indeed, the most casual observer can hardly fail to perceive, that neither of them has advanced beyond the first proposition. And both are so unavoidably interwoven, that it is impossible to treat or consider either independently of the other, or to form any reliable opinion as to their future course or final shape. They represent, in fact, the competitive progress of attack and defence.

The Report then touches on the subject of their own guns, and alludes to the Russian war, the floating batteries at Kinburn, and states—

Peace was soon after declared between the belligerents, and very little attention seems to have been paid to iron-clad ships for two or three years, until the French produced the “*Gloire*,” one of great power, which was followed by a sensation and action in England, highly appreciative of the possible consequences of being too slow in acting on the hint. Of course, there were various opinions as to the capacity of this formidable craft.

The British Government very wisely, however, decided not to lose time in constructing similar vessels, and has since followed the decision with a remarkable celerity, quite regardless of expense.

On February 25, 1859, the First Lord of the Admiralty announced to Parliament the policy of the Government in this respect; and the construction was begun of an iron-clad frigate to surpass the “*Gloire*.” This ship has been completed, and is well known as the “*Warrior*,” others soon followed in France and England, and armoured ships are, it seems by common consent, to constitute the main force of all navies. Every variety of opinion is expressed as to the proper material and construction of such vessels; and the British Government, not feeling at liberty to wait until results have decided, are compelled to make use of whatever seems most plausible for the time; and thus we are astonished by the most gigantic and costly experiments the world ever saw.

Notwithstanding the earnest and long-continued course of investigation which has been carried on by the governments interested; so little is yet known of the effect of ordnance and the resistance of iron plates in different forms, that the ablest and most experienced cannot agree in the armour best calculated to resist, or the ordnance to be used in the attack.

The mode of armouring also demands attention, and no remedy has yet been found to prevent the fracture of bolts and nuts.

At Shoeburyness, experiments seemed to prove the invincibility of the “*Warrior*” target, and a series of experiments were made. At one time the defence seemed to have the advantage, at another the attack. Sir Wm. Armstrong’s 300-pounder gun promised great things, but burst at the fourth round; the rupture of this gun left

the way open to other competitors, and a long-neglected piece that had lain remote for years, was allowed an opportunity to try its powers. This was the Horsfall gun, its first blow was decisive. The plate 4½-inch was pierced and badly injured, and the gun quite unharmed. And to complete the entire failure of the defence, Mr. Whitworth drove a shell through the same target ("Warrior"). So that the system of armour that had been relied on, as affording perfect protection, proved vulnerable by shell as well as shot.

The ease and impunity with which one invulnerable ship can enter a port not specially prepared for such a visitor, and commit havoc at pleasure, suggest the policy of providing, by timely measures, against the possibility of damage to the immense resources thus exposed.

No method is suggested, but the report proceeds to state—

So far as opinion can be formed from experiments recorded, we are led to conclude, that those who, from their distinguished abilities and opportunities of investigation, should be the best able to form an opinion, have arrived at no final decision in regard to any of the essential points of the problem.

As the question now stands, the inference may be drawn; that forts may be impervious to attack, ships not so; in one case the weight of iron is of little moment, in the other of the utmost importance. The old proverb states, "A small leak will sink a great ship;" and as regards haste in building our "Warriors," &c., surely had the Committee which sat some time ago, and made its report May, 1862, been more numerous composed, and taken more voluminous evidence, their statements would not have been contradicted, as they have been, by an officer of artillery of known ability and science, nor would they have made hypothetical statements about the velocity of the 600-pr. and other guns, which guns, however, *are not yet made*.

Possibly, too, a gun that was *then* made, and the largest gun that has been proved in this country at this date might have been tried, and if so, it would *then* have been found true, as it has been since, that this gun would have penetrated the "Warrior," and all ships of her class, (and much stronger), with the greatest facility, and if it penetrated, under the water line, it would sink them to a certainty.\*

Guns of this description, if rifled on the plan strongly advocated by Captain Fishbourne and Captain Selwyn, would then combine the advantages of long range and precision, with those of high initial velocity and great smashing effect—so requisite in a naval gun, which, indeed, naval officers declare to be the first necessity. The accompanying formula shows the amount of water that flows through an orifice 13 inches in diameter, at one foot from the surface.

The velocity varies per second, as the square root of the depth of the orifice below the surface of the water.

If the depth below the surface is one foot,

$$\begin{aligned} v &= \sqrt{2gh} \\ &= \sqrt{2+32\cdot2+1} = 8 \text{ feet per second.} \end{aligned}$$

\* Having predicted with accuracy the fate of ships attacking forts, I may be excused giving an opinion on the present iron-clad men-of-war; viz., that they will be no match for an impregnable gun-boat of superior speed with one 300-pounder. The gun-boat would sink them all, in detail in a fair open fight with plenty of sea-room.—G.B.V.A.

The number of square inches in an orifice 13 inches in diameter is = 132.732.

Therefore in one second the cubic inches of water flowing through the side of a ship with one orifice will, if 13 inches in diameter, be  $132.732 \times (8 \times 12) = 12742$  cubic inches, and 277.274 cubic inches = one gallon.

Therefore, the number of gallons flowing in per second will be 46  
 = 2760 gallons per minute  
 = 27,600! in ten minutes.

But in consequence of the tearing effect of shot through a massive substance like iron, the wound is much larger than 13 inches in diameter, and, instead of 27,600 gallons of water pouring in, the amount would be in most cases more than double.

At two feet below the water line,

$$v = \sqrt{2 \times 32.2 \times 2} = \sqrt{128.8} = 11 \text{ feet per second nearly.}$$

This gives 37,800 gallons in ten minutes; but, as before stated, the amount is in reality much more. If double, it would be—

= 75,600 gallons, and two such  
 wounds = 151,200 gallons.

It may be judged from this how long a ship would float with only one such opening.\*

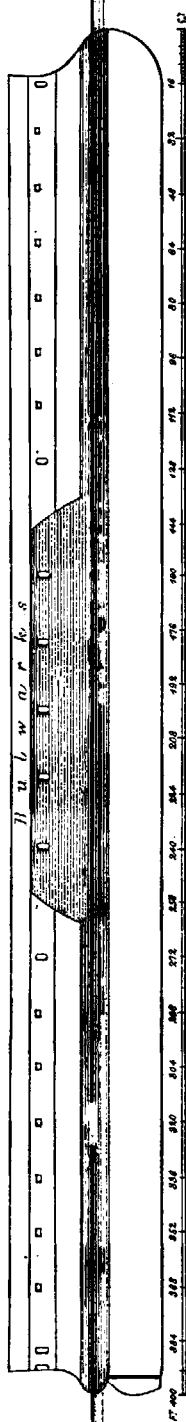
It may be said ships won't carry these guns. I have been in communication with one of Her Majesty's principal naval architects, who assures me, there would be no difficulty whatever in constructing a vessel to carry these guns, and with great speed. Would it not be advisable, then, to build vessels of this class of great speed and invulnerable, that is to say, rather than a large vessel with a number of guns, a small vessel with one gun. The large ship *cannot* carry armour (except on Mr. Scott Russell's plan, ships from 12,000 to 20,000 tons). The small ship with one gun (300-pounder) can do so. The ship's buoyancy, which is her life, *must* be the first care of the architect. If it is just to judge of the future by the history of the past, the days of the "Warrior" and ships of her class (although some are only now building) are already gone by.

Commander Scott, R.N., has designed a vessel of the above description, to carry six guns, now under consideration of the Admiralty (plate viii, fig. 2); it is said, too, the Emperor of the French taking advantage of the experience in the American waters, is diverting his attention rather to small vessels with few and heavy guns, than to large vessels with many and smaller guns, vessels of *great speed*, and carrying enormous ordnance.

The size of the gun is of vast importance, more than is generally

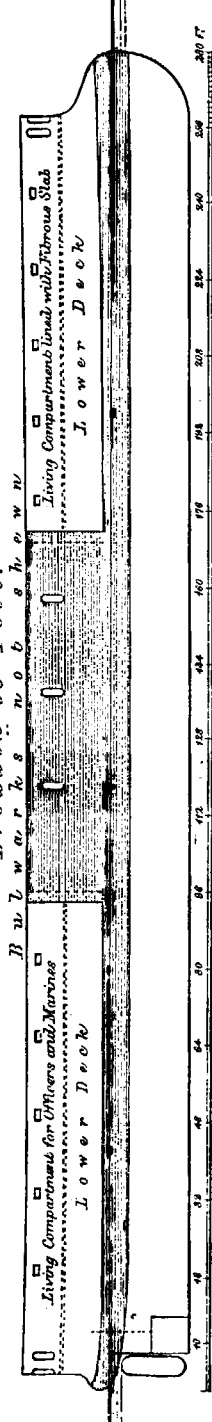
\* A ship not plated at all has this advantage, the holes are easily plugged up. Lately, firing at a target of wood with a very good rifle at 500 yards, I was surprised at hearing no sound, and concluded that every shot (20) had missed. On going up to the target no daylight could be seen through, which confirmed the original impression, but on going behind the target, which was on sloping ground, the earth was very much ploughed up, and, on a closer examination, I found that every shot had gone through the target (diameter of bullet .451), and the wood closed up again. The target was one and in some parts two inches in thickness.—G.B.V.A.

Fig. 1. Side Elevation of Frigate 6.600 Tons.  
Breadth 60 feet.



*This Vessel mounts 10 Horsfall Guns 300 lbs. 8 Light long rifled Guns, and 4 Light Howitzers in a fixed central Turret. — Mean Draught of Water 21 feet.*

Fig. 2. Side Elevation of Decked Corvette of 2.600 Tons.  
Breadth 58 Feet.



*This Vessel carries 6 Heavy rifled Guns firing smooth bore Ammunition, The Upper Iron Deck in the centre and the Lower Deck at the two extremities form a bomb proof protection against vertical fire. — Mean Draught of Water 17 feet.  
4 Light rifled Guns are carried as Bow and Stern Chasers.*

assigned to it, and for this reason,—twenty guns, each a 1-pounder, are fired at a target of iron  $1\frac{1}{2}$ -inch thick and produce no effect; one gun, a 20-pounder, is fired and smashes it, the velocity in both cases being equal—in both cases the same amount of metal is used, and on this principle an official record of experiments at Portsmouth states that one 68-pounder produced more destruction than 5 32-pounders. Arguing from this, it appears then 1 150-pounder is more effective than 10 68-pounders, 1 330-pounder is equal to 7 150-pounders, and a broadside of 3 330-pounder guns is more destructive than  $10\frac{1}{2}$  "Warriors." This result is very extraordinary and of the greatest consequence. The vessel proposed and approved of by many naval men, is of 4,600 tons, draught of water 21 feet, and carries 6 guns, each a 330-pounder.

A gun of this description has already been tried and found to answer, and for home defence it would be invaluable. When the gun was tried it was under the greatest disadvantages. The dispart was made of wood for the occasion, and a want of accuracy was assigned to it, but it is well known that up to 600 yards our smooth-bore guns are quite as accurate as they are desired to be by the Royal Navy. A ship then with very few guns, and fitted with Captain Symonds' twin screw-propellers, which enables a vessel to turn on her own axis instead of making the circle, would be a most formidable assailant. To show what a ship with one large gun can do, I will read an extract from the *New York Herald* of last year:—

*From "New York Herald."*

(Extract.)

The "Merrimac," fitted up by the rebels under many disadvantages, one day put out from Norfolk, ran by a fort of 20 guns, steering head on to the "Cumberland," 22 guns, crushing in her sides as if they were pasteboard, sending her to the bottom; in fifteen minutes fires into, captures, and burns the "Congress," 50 guns, riddles the "Minnesota," 40 guns; holds at bay the "St. Lawrence," 50 guns, and the "Roanoke," 40 guns; scares off a fleet of gun-boats, and, but for the "Monitor's" sudden appearance, the northern flag would have disappeared in those waters.

This, gentlemen, is the effect of one impregnable vessel carrying 2 guns, and can we doubt what would be the effect of one vessel, carrying 2 guns only of enormous power, among a fleet of "Warriors" and "Royal Oaks."

Experience has lately proved beyond a doubt that all the iron plates now in use by Her Majesty's navy can be pierced, and mathematical truth also clearly proves that with one hole of 13 inches diameter in a ship's side just under the line of flotation, water pours in at the rate of 17 tons a minute. The inference therefore may be drawn that vessels of the "Warrior" class (easily penetrable) are no match whatever for a gun-boat with one formidable gun, better protected and of greater speed.

On looking at the distant colonies of England, it appears that they vary in distance from 5,000 to 20,000 miles, and may be represented by voyages lasting from two or three weeks to two or three months. Of what use would our large expensive iron steam-ships be for their

protection, for as they can only carry coals for nine days, so they are only steamers for nine days, save when coals are to be obtained. Nelson chased the French fleet for 600 leagues 27 days, before he had the pleasure of seeing them at anchor. Is it not true that steamers would have shortened his voyage very little?

A leading article in the *Times* newspaper, when the accounts of the *Merrimac* reached this country, stated that after an expenditure to be reckoned by millions, England had only *one* ship. This is a most grave error, for beyond the channels our wooden walls are good still; but if it was not so and we should have opposed to us 100 ships of the "Gloire" class, they would be no match for vessels with fine lines, and few guns, smooth-bored and large.

Has it not been proved that shot and shell can penetrate the armour at present in use; if so, of what use is it?

We see the effects across the water; an iron vessel is penetrated, and sinks to a certainty. It may be a hazardous remark to make, but I believe a wooden ship (if lightly plated in the inside to prevent fire) is preferable to a ship with armour, if that armour is not shot and shell proof, for the holes in a wooden ship can be plugged up. The orifice made in wood is much less than the diameter of the ball which enters. In an iron ship the orifice is not only much greater, but tears and breaks the surrounding iron. It is to be feared the American view of the state of the case is the correct one—viz., "the British Government, not feeling at liberty to wait until results have decided are compelled to make use of whatever seems most plausible for the time;" and, "those who from their distinguished abilities and opportunities of investigation should be the best able to form an opinion, have arrived at no final decision in regard to any of the essential points of the problem."

Surely the nation would gain by the formation of a Parliamentary Council to investigate the state of the question as it now is, to examine and to act—as the Article of War has it—without partiality, favour, or affection, or, for the defence of the kingdom, to confide in the wisdom of the Royal Engineers, a distinguished corps that has never failed in any duty assigned to it. The voice of the nation is certainly not against a large outlay; the only conditions being that the money voted shall be judiciously spent, the attack and defence being as perfect as each can be. It is related by Louis Napoleon that the English lost the whole of Normandy in *one* year A.D. 1450 in consequence of their neglecting the improved methods of defence, which of course are equally available for the attack, and which the French used. I wish to remark particularly the word *improved*. From it we may gather that they had defences, and thought them good enough, until fatal y roused from their dream by defeat.

It is unbecoming in this great country, that an alarm, a panic *should* ever arise; besides being unbecoming, it is expensive, both to the nation and to individuals. The last panic called forth our noble National Guard. From its first enrolment in a few months, Her Majesty reviewed 20,000 men, suddenly made soldiers of the very first order, in Hyde Park. Peer and peasant alike came forward, and no

doubt it was a glorious sight, but the expenses attendant on the movement were not slight; the public and private expenditure being little less than two millions.

The time has gone by when any nation or combination of nations could conquer Great Britain, but the time has not gone by when the attempt might be made, and it is to guard against this that not I, who simply narrate facts, but the late illustrious Duke of Wellington, so often and so emphatically urged that England should ever be prepared to resist attack, and that the best method to ensure peace was always to be prepared for war.

The CHAIRMAN asked Captain Scott to explain various diagrams on the walls.

Commander SCOTT, R.N.: I wish to show by these tables which Captain Arbuckle has just referred to, not only the superior power gained by using very heavy shot, but also to prove that it is both very economical as to cost, and effects a very great saving in weight, and in the relative number of men required to work the guns. The table commences with the result of an experiment which took place at Portsmouth, when it was found that one 68-pounder fired against a 4½-inch plate produced a greater effect than five 32-pounders. And when it is remembered that the 68-pounder was fired with 16lb. of powder and one 68lb. shot, at a cost of only 17s., and was worked by seventeen men, and that it produced a greater effect than the five 32-pounders which discharged 50lb. of powder and 160lb. of shot, costing 2l. 1s., and worked by sixty-five men, there is evidently a very great advantage on the side of the large gun. But as we go on increasing the size of the gun, so we get a much more striking difference between the work done and expense incurred in using very large and comparatively small ordnance. For instance, ten 68-pounders are only equal to one 150-pounder, such a gun as that which was lately used at Shoeburyness, viz., the late Armstrong gun, called improperly a 300-pounder, though it fired only round balls, which were 150lb. when of cast iron, and 156lb. when of wrought iron; the wrought iron being the heavier metal. These ten 68-pounder discharges cost 7l., and required 170 men, while the 150-pounder, which costs only 1l. 13s. for the powder and shot, could be worked on board ship with sixteen men. I compiled this table with a great deal of care upon the data before-mentioned, and I have examined very carefully the effect produced upon targets by the Whitworth and other heavy shot, and I do think they very nearly correspond with this tabular statement. As respects the effect produced by shot, there seems to have been omitted in all calculations the local effect produced upon targets by the heavy shot, viz.: that the target itself is driven back, and the fastenings which support it destroyed. Now consider what would have been the case if the target fired at had been part of a ship. I believe that then the part hit would have been driven away from the bottom of the ship; for the shock from the blow is so great, that it would almost inevitably destroy the ship. Captain Arbuckle has, if he will allow me to say so, made a mistake as to the size of the hole made in a four-and-a-half-inch plate, and backing of the Warrior target by the 28lb. shot from the Horsfall gun. I have no doubt he has copied his diagram from a very beautiful photograph which I have seen, mistaking the dimensions; but the hole, instead of being 13½ inches as shown in his figure across, is in reality 23 inches, an aperture which was described by the Americans, "as a hole as big as the head of a barrel." If the shot which made this hole had not been of cast iron, and therefore been broken up by striking on the plate outside, it would probably have also gone through another target beyond, in which he pieces were found buried. I do not propose to work these heavy guns in the way in which we work our present broadside guns; nor do I intend to work them by hydraulic power, or by anything beyond such simple mechanical means as sailors are already accustomed to. The method I would propose is to have a block with a single whip upon the side of each gun, to be led through a block at the side, and over a winch, such as we constantly have to use on board a steamer, to run the gun out. In the same way I deal with the recoil which is very difficult indeed, to take up, in the usual plan of train-tackles with a ship

rolling; indeed, I cannot but express myself much surprised to see so little done towards winding up the *train-tackle quickly*, and working the guns easily, for at present there is a long train-tackle, and at the end of it a man or two, who cannot do the work fast enough. But supposing there was to be a single whip, and led through a block hooked on the rear of the gun-carriage, and then led over a large drum to take up as rapidly as possible on the gun's recoil, the slack of the train-tackle, then a great advantage would be gained. But I would not trust to the train-tackle alone with these heavy guns, it would not be sufficient. The great thing, however, which is required in ships to work these heavy guns, is space, and if properly handled, a big gun is as safe on a ship's deck as in any cupola; and has the advantage of more room. But there is more still wanted in working a very heavy gun; for it would not be safe to trust to the side-tackles any more than to a single train-tackle. It is intended that the gun should run on a slide, firmly held by pivots. On the slide there should be an arrangement to hold the gun, after recoil, but not to check it too suddenly; this could be effected by a kind of paul, on a plan which I hope to carry out some day. In case of anything going, or tackles being shot away, the gun would be stopped by the slide, which is sufficiently strong to hold the gun in any part of its passage out. Contrary to the usual way in which we work guns on board ship, I should place this long slide on rollers, which should both support and hold it firmly to the deck, and would use luff-tackles or the present gun-tackles for training, in the traverses proposed by me; that is, to put between every pair of guns a thin iron partition, so that on a shell coming into a port and bursting, its effects would be entirely local; for the traverses would prevent the pieces from spreading fore and aft through the ship, and hence the damage would be confined to the gun's crew. But these traverses are of further use: they bind the deck on which the gun rests to the upper deck. Nor is that their last use, as the tackles for training the guns are made fast to them, so that instead of being worked at the usual sharp angle, the gun would be very easily pointed by being pulled at right angles. Now I think I have sufficiently gone into the plan to show that large guns can be worked with few men, with two men at each side to man the winches, and two men to take up the recoil by means of the train-rope over a large drum, besides the first and second captain, loaders, and spongers. There are other arrangements, so that if anything be shot away, it can at once be replaced; but I need not go into these, for you will see that not more than sixteen men are required to work any of the heavy guns given in the table; that number is ample, as the training and also the loading is very easily done. But I will now turn to the manœuvring and say, that our present mode of turning ships by a single screw, will never answer for vessels in action, for it will not turn them fast enough. There is no doubt they could be butted by rams, and otherwise damaged by quickly turning vessels, and I therefore think we are very much indebted to Captain Symonds for bringing forward the twin screws, which afford the best way for turning our war vessels rapidly. It must not, however, be supposed from this observation, that our present ships with one screw cannot be arranged so as to be easily turned. What we want for this purpose is an auxiliary screw upon each quarter, and worked by a donkey engine, the screw giving a sort of pushing motion, and then feathering in to the side. Such a motion might be very easily given, and it would be sufficient to turn the vessel in action. I cannot say it is so good as the twin screws, because the motion of the twin screws must give greater stability to the ship. With one screw amidships, you could not keep a vessel nearly so steady as with one on each side; their motion tends to keep the vessel on a steady balance; for all of us who have been much on steamers know that directly the screw or paddle is stopped, the ship begins to roll tremendously.

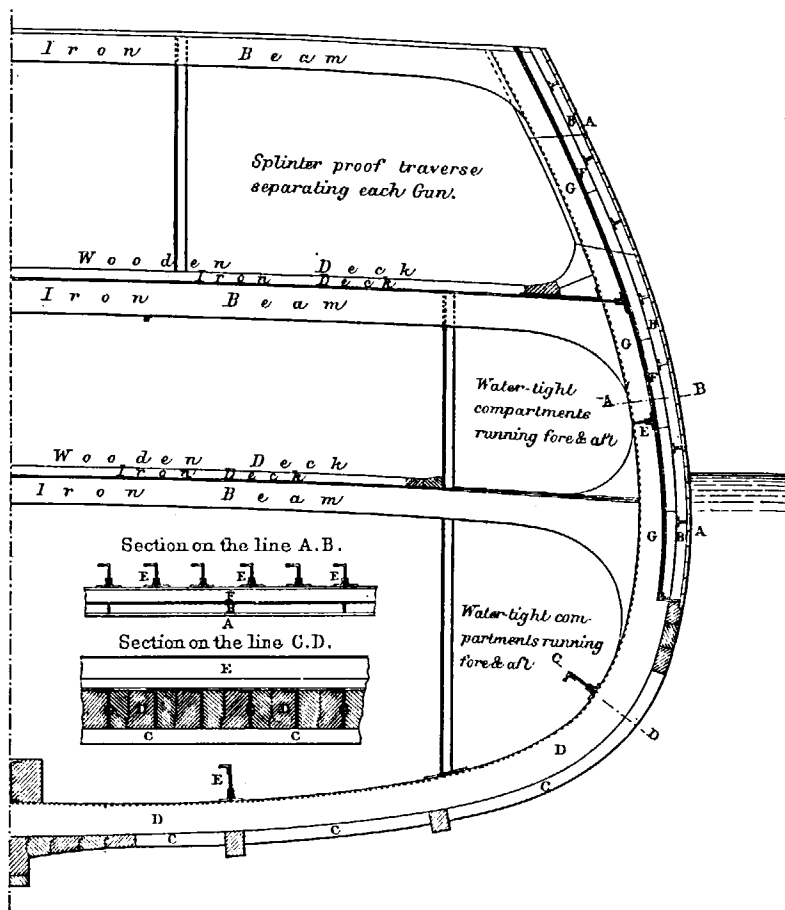
I will not go into the question of the comparative advantages of working very heavy guns in cupolas and on the broadside, for I intend to touch upon it when Captain Coles brings his cupolas forward, and then I purpose stating what others as well as myself deem to be objections to the cupola, and therefore I think ought to be fully and fairly stated; but if Captain Coles can make out a good case, then we must have cupolas.

I wish now to point out some advantages to be derived from the use of the thick iron wedge proposed to be used in lieu of the comparatively thin and broad plates.



## Mid-ship Section of Decked Corvette.

*Designed in the early part of 1862 by Commander Scott and laid before the Admiralty Dec. 1862.*

*Explanation of outside Construction*

- A.A.A. Wood/Planking outside of Fibrous Slab.
- B.B.B. Buffer of 6<sup>th</sup> Fibrous Slab breaking joint with the Armour Plates bolted through the corners.
- C.C.C. Wooden Planking copped outside.
- D.D.D. Wooden Timbers bolted through Wood & Iron.
- E.E.E. Strengthening Plates.
- F.F.F. Armour Plates.
- G.G.G. Iron Ribs.

Scale  $\frac{1}{3}$  of an Inch to a Foot.

*Frigate Designed in the early part of 1862.*

Captain Arbuckle, some time since, showed me his wedge principle as applied to forts. The pieces are of course narrower on the inside than on the outside, they are all wedge-shaped. I have observed, that all plates seem to deteriorate by concussion or vibration, and to deteriorate very rapidly when struck by heavy shot. For instance, if a plate be placed on the side of a vessel and fired at by a 68-pounder, at the first shot it may exhibit a remarkable amount of toughness; at the second shot it will show less toughness; at the third shot it will be brittle; and at the fourth or fifth break in pieces. This rapid change does not occur at Shoeburyness, because you have another condition, viz., the plates being put more closely against a firmer backing, and the firmer the backing the better is it able to conduct off the blow from the plate. But in the case of the target ship at Portsmouth, you have a comparatively weak wooden side, not nearly so rigid as the backing of a Shoeburyness target, hence the plate is destroyed much more rapidly. We learn two or three important things from this. In the first place, that wood alone is not sufficiently tough and rigid for a backing to the plates; and it is a fact, that wood is only valuable in so far as it is supported by the iron-skin, which is of course capable of supporting a very heavy strain. It is stretched out and fastened to the ribs so as to yield the greatest strength of which the wrought iron is capable. The strain brought upon it by the blow of the shot is "tensile," and the wood only performs the part of distributing the force of the blow over a larger portion of the inner skin, and does nothing else. But if instead of the 18 inches of teak, which keeps the plates so far off the side that they must soon work loose, about six inches of paste-board, mill-board, or some other tough material were used, no splitting would take place, and the blow of the shot would be more evenly impressed upon the skin, and hence there would be very much greater strength. If this be correct, the vessels that are now being built of wood alone, with iron outside, will be under a great disadvantage; for when the iron plate is broken up it will be readily driven through the wood, which will offer no resistance or comparatively none; for when the shot has barely got through the iron plate, it will have still sufficient velocity to go through the wood behind it.

Another and important use which the skin has is, when the wooden backing is split and knocked about, it keeps the vessel water-tight. Without this, a plated-ship cannot continue water-tight under the blows of heavy shot. My own particular plan is to put a cushion outside the iron plates (plate ix), for unless the blow be deadened by receiving the first shock of the shot upon a soft substance covering the armour, the plates are injured by the concussion and vibration set up; for supposing a plate to be stretched over wood, and held by bolts tightly against it, and a shot to strike it near one end, it would indent the part hit; the wood readily yielding, especially if there be no skin to support it; and then perhaps, the plate would break, not at the point struck, but on the opposite side. That has occurred repeatedly at Portsmouth. There is another point which I think was at first overlooked, but which is, I think, now clear to a great many besides myself. We have all heard what damage was being done to the plates by bending, whether they were bent hot or cold, and the deterioration effected by the blows of shot is analagous: supposing the plate to consist of a number of thin layers rolled together, directly the shot strikes in front, it draws the surface of the plate, and the whole of the particles towards the point of impact producing a similar effect upon the layers, to that which is produced by bending the plates, and equally straining them out of their normal condition, and as the shots continue to strike, more and more deterioration and disturbance of the layers takes place. It has been observed that the round ball damage plates very much more than the elongated shot, especially than those which are flat fronted, which cut their way through without, as it were, pulling asunder the layers of the plate; but with round shot as regularly as the plate is hit hard, it buckles inwards, and the whole front of the plate is drawn towards the centre by the force of the blow.

Having endeavoured to explain how the different layers of which the plates are composed, are disturbed, and sometimes pulled asunder, I may mention that, although the hammered plates bend well, it has lately been observed, that when either are bent, the hammered generally yield to the blows of shot more readily than the rolled ones. This seems to be the case at Portsmouth, but is not so discover-

able at Shoeburyness. At Portsmouth the plates are fastened to different parts of the vessel, and if perchance they happen to be spread along, just were the beams about on the ship's side, they are better supported than if placed in the space between the decks. In one case the backing is comparatively rigid, and in the other, the backing readily yields, whether more or less rigid. But as a rule the hammered plates deteriorate more rapidly than the rolled, when placed upon a wooden side or backing. Latterly the hammered plates have been annealed, and of course heated for the operation, but directly heat is applied, the particles of iron which, as you are aware are granular, are set in motion, and the more heat you apply, the greater will be their tendency to return to their original granular condition. The hammered plate when annealed, stands the first shot, and perhaps shows great toughness, but it very readily deteriorates under the blows of the shot, which the rolled plate does not usually do in so great a degree; but when the hammered plates have not been annealed, and have been really good; they have exhibited extraordinary signs of endurance under heavy pounding at short distances. I have pointed out that, with the usual wide plate, the concussion injures it across its width, and that when struck on one side it flies out on the other, the bolt being started, the plate itself perhaps broken. But in Captain Arbuckle's wedge bar we have a very different condition, there is a very small amount of outer surface to draw in together. The disturbance of particles would be nothing, and the vibration confined to a narrower surface when struck; for instead of great width for vibration, you have a large mass with great thickness. But supposing you do damage one of these wedge bars very much, you have only injured a comparatively small portion of the iron structure, and should the blow be on the ship's water-line, you would not damage or materially shake the whole surface along that water-line.

I will not go into the question whether they can be fastened to a ship, because that is a shipwright's question, but we are assured by Captain Arbuckle that they can be so fastened. It is a very great advantage to have the iron bars wedge-shaped, for when the shot strikes the wedge it yields a little, and if force is absorbed in giving motion, it cannot be also employed in destroying the plate. It would produce an effect somewhat similar to that which is produced upon shot moving at a high velocity, by putting a soft material in front, viz. it absorbs a great portion of the blow. Captain Arbuckle does this in a different way, and I must say, it seems to me to be the best plan that has yet been brought forward.

A MEMBER: Has that been tried against heavy shot?

Commander SCOTT: It has not been tried, but the resisting power of the bar, which Captain Arbuckle says is truly surprising, has been tried, and these bars stood, far more in proportion than the  $\frac{1}{2}$ -inch plates. I am speaking of the Thornycroft bars. When they bound them tightly together, they could not break them, but from not being wedge-shaped, on the fastenings giving way, they opened a little, and then got broken in detail. They were not as thick as the wedges proposed by Captain Arbuckle. The first bar-target was not broken at all on the the early trials, but afterwards a target was made, with much thinner bars, and more powerful guns having been made and mounted at Shoeburyness, the target, already too thin to withstand the former guns, was of course destroyed.

Admiral Sir GEORGE SANTONIS: A great deal has been said about the different kinds of plating, and the mode of fixing the plating. It appears to me that the great advantage claimed for armour-plating is to make a ship invulnerable; but if heavy artillery, that penetrates plating of any practicable thickness can be made use of at sea; then armour-plating becomes useless, and all the trouble we are now taking with respect to ascertaining the different qualities of plate, making the plate and fixing the plate, becomes unnecessary. We know that so long as an armour-plate made a ship invulnerable, it possessed great advantages which counterbalanced its disadvantages; but the moment it loses the quality of invulnerability, then it loses that advantage, and becomes useless. To make my argument more intelligible to landmen, I will take the case of a timber vessel that goes out to Canada to load with timber. She is then light, buoyant, a first-rate sea-vessel. She takes in a mass of timber, and then she becomes a heavy inert mass, the sea breaks over her, and in many cases the crew are obliged to quit her. In the same way, armour-plated vessels which under certain circumstances and in certain places would be of

great use, so long as the armour continued to be invulnerable, never could be made good sea-going vessels; they have not the qualities which make a useful man-of-war, having to cruise about in all parts of the world. Now artillery has been made which penetrates the armour-plate, and heavier artillery will still yet be made, and the enormous advantage of heavy artillery over artillery of less calibre, as Captain Scott has just pointed out, is another reason against the utility of armour-plating. If you can make spherical shot above three or four hundred pounds in weight, what plate will stand the blow? The result will be, that you must use the heaviest artillery that ships can be made to carry, and take your chance of being hit by the enemy. In my opinion, if you can make a vessel strong of wood alone, with three or four of these guns in the bow or in the stern, and having sufficient power to run a vessel down, she will be infinitely cheaper and far more powerful than any ship of the "Warrior" class. Have a "Merrimac," for instance, strong enough to carry three or four hundred pounders, made entirely of wood and strong enough to sink a vessel with a blow; such a ship would be able to carry a much larger quantity of coal, and be able to keep the sea, and should a fleet of hostile "Monitors" or "Warriors" be cruising about, this vessel having a superiority of speed would be able to choose her moment of attack, at night or in a gale of wind when her antagonists would be like half-tide rocks, not able to use their guns, and she could run in and sink them. The most important object now for us to pursue, is to continue our experiments with the guns, and ascertain what is the greatest calibre we can safely use, and then place them in ships. In the pamphlet I published a few months ago, I mentioned that I thought it possible that the heaviest guns that could be made use of on shore, could also be made use of at sea, by making the ships, the gun-carriages, and I think the plan of twin screws proposed by Captain Symonds will enable that to be done. The ship itself would form the gun-carriage, and by the aid of the two screws, guns could be pointed, the horizontal training given, and at the same time the vessel should be made available as a ram. The screws would be perfectly manageable, and the guns could be pointed with the greatest ease. Where the ram could not reach, the guns would reach. She would form about the most powerful description of vessel that could be made use of. She would be without iron-plating, because iron-plating, as I have said, is useless against guns carrying three or four hundred pound shot. All that would be required would be to apply some chemical means to render the vessel unflammable against molten iron, which would be the form of projectile that unprotected vessels would have to dread.

The discussion was adjourned to the following evening.

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