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Evening Meeting.

Monday, February 15th, 1869.

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ON DEFLECTING-ARMOUR-PLATED SHIPS FOR COAST] DEFENCE.

By Mr. J. M. HYDE.

THERE is no subject of so much importance, and so necessary to the existence of England as a first-class nation, as that of its Navy. The insular position of England gives her a security that can only be assailed by a naval force, and hence the importance of her possessing an efficient and well-appointed Navy.

"Naval affairs" often form a subject of discussion. Indeed all parties admit that England should be in possession of the best and most powerful fleets; her marine, her wealth, her intelligence, and the position she has held, demands it, and however much it might be the fashion for some to underrate this necessity, sad indeed would be the day when this particular arm of the United Service should be neglected.

In the early naval fights of England, sailing ships alone were used,

and to the skill and daring of our seamen are we indebted for those grand and glorious victories we are so proud to remember. The introduction of steam has, however, so changed the entire system of naval tactics, that in all future engagements, the engineering element must form a most prominent feature. Wooden ships and small guns have had their day, and in discarding them we must not forget the duties they have performed, but rather confess that our present knowledge has been accumulated from the experience they have given.

In passing from wooden ships to iron-clads, there is a step so profound, so immeasurably distant, that we can hardly imagine the change has been introduced in so short a time. The sailing of the Baltic fleet in the early stage of the late war, comprising such a host of grand and splendidly equipped ships of the old type, a fleet now only existing in history; and the sailing of an experimental squadron of iron-clads within the period of a few short years, not only exhibits the power of England to obtain, but also the possession of a great amount of skill and intelligence to design and produce a class of ships, so vastly different in form and in material, and yet so necessary for the altered circumstances of the day.

The general application of iron as the material for the construction of the hulls of all ships, whether for war or commercial purposes, has so many advantages, and is now so universally adopted, that nothing need be said on that point; but the production of ships with armour plates is of such recent date, and yet the necessity is so obvious, as to produce astonishment at its not having received earlier attention. The continual improvement in modern artillery and projectiles has certainly produced this necessity, for without some such protection it is obvious no ordinarily constructed ship could possibly swim after receiving the first concentrated broadside, and an engagement under such circumstances would be a momentary fight of extermination; armour-plates, therefore, became a necessity for defence.

The extraordinary manufacture of these plates ought not to escape our notice, and there is no English manufacture that so forcibly exhibits the skill and power of Englishmen, their machinery, and their perseverance. These plates are now produced certainly up to 15 inches thick, and this thickness can doubtless be exceeded, if desired. The object of deflecting-armoured ships, however, is to dispense with the necessity for using such heavy plates, as I hope to be able to explain to the satisfaction of the members of this Institution.

Modern gunnery has had a large amount of science and ingenuity given to it in the production of the various arms, both large and small, which we now possess. Science is as important, however, in defence as in assault. In olden times, individuals in self-defence covered themselves with coats of mail, upon which the blows or projectiles of an enemy were received; this armour doubtless deflected the thrust or cut of the sword, and gave the combatants opportunities for displaying that great skill in arms, of which history records so many brilliant examples.

We often read, too, in more modern times, of hair-breadth escapes caused by the deflection of a shot from the metallic accoutrements

of our soldiers; such cases are familiar to those who have knowledge of actual war. There is, perhaps, no modern case of such grave importance, and affording such singular proof of the advantage of deflection as the case of the recent attempt on the life of His Royal Highness the Prince Alfred; had not the ball of the assassin been most providentially fired obliquely, and hence deflected, the life of His Royal Highness must have been sacrificed. We must all, therefore, rejoice that by the deflection of the shot, we were certainly saved a great national calamity.

The armour-plates first applied to ships did not, I believe, exceed 3 or 4 inches in thickness; these have been gradually increased as the guns have improved. There is, however, no occasion to recapitulate the numerous experiments that have been made both in shields and guns up to the present time; those interested in the question must have read the results given from time to time in the public papers. Numberless have been these experiments, and the results of the contest between the guns and the armour show the deep importance of the question. Between the 4-inch armour of a few years since, and I may say the 14-inch armour of the present day, there is certainly a great stride. To arrive at this thickness, endless experiments have been carried on for many years past at a vast expenditure, and the grand result may be said to be centred in this one fact, that a chilled shell from a 600-pounder gun will penetrate a 10-inch plate and pass through it. This is certainly a fact beyond dispute, as is shown by the firing at Shoeburyness; and even a 15-inch plate has been broken up by such projectiles. Of the practicability of building ships to carry even thicker armour than of 15 inches, I am bound to admit, but as to their cost, stability, and seaworthiness, without investigation I dare offer no opinion. The gradual development of any system that presents a chance of success, if economical in construction, seems more desirable. With this object in view I have, since the year 1853, made numerous experiments and designs for armour-plated ships on the principle of *deflection*, feeling quite sure that any vertical structure that can be carried by a ship of reasonable tonnage will be penetrated by modern artillery; however ingenious that structure might be.

All the artillerists of the present day are agreed upon this point, and however unpalatable the truth, it cannot be disputed; those who saw the practice against the 15-inch plates recently at Shoeburyness, must have seen that vertical armour-plates, even of that thickness, would stand but small chance against the skill of the Woolwich gentlemen; the shot buried itself 11 inches in the material of the plate, and a shell so striking, exploded and blew off a large segment weighing some tons. There were two of these plates fired at, one of them hammered, the other rolled, and both produced with great care by the most celebrated makers of the day; yet both were destroyed, broken up into large fragments. Had these huge plates been hung on the sides of a ship and assailed by similar guns, the result would have been the same—certain and positive destruction to the ship receiving the last shot. If 15-inch armour can be so broken up, what then is the use of hanging 6- or 7-inch plates on a ship's side? The question is natural.

Fig. 1.

HYDE'S
Double deflecting Armour-Plated
shot-proof ship designed to have
easy draught of water and sturdy
Gun Platform.

Fig. 2

Longitudinal Section.

Fig. 3.

Midship Section.

We sometimes hear it said that all naval powers are alike in this respect, and this is offered as some consolation. In these modern days of keen competition, circumstances rapidly change; what is new to-day is old to-morrow, and the race must still go on until the time shall arrive when all men will be of one mind, and will not only agree to use no explosive bullets, but to use no bullets at all. Until that day does come, however, we must still be prepared and so prepared, as to be able to meet every possible contingency. What then can be devised to "keep out these direful shells?" Obviously, deflecting sides. Vertical structures must either be made so thick, and of such rigid material, as to stop by main force a projectile moving at the rate of 1,300 feet in one second of time, or they will be penetrable, and thus useless; whereas deflecting sides, if at an angle sufficiently acute, will cause a projectile to ricochet from its surface, and expend its force in the atmosphere, or in the sea, instead of in penetration. This fact is certainly well known, and has often been alluded to in the description of some modern ships. For instance, I have noticed that lighter armour-plates have been used in places where shot can only hit at an angle, as under the counter. Again, some ships are especially designed for *end-on* duty, that a small section only may be presented to the enemy, and this a curved or angular surface. Deflecting-sided-ships may be said to be *end-on all round*; and, in a general action, would offer no point for special attack, and therefore possess an immense advantage over the ordinary *end-on* ship, which is open to be penetrated at the stern and on the broadside in a general action.

I have heard some gentlemen argue the great importance of the ram as a means of offence, and doubtless a ship of 3,000 or 4,000 tons, steaming at the rate of 12 or 13 knots is capable of doing great damage in the event of a fair hit. My deflecting-sided-ship, I have no hesitation in saying, is proof against this very modern naval operation of ramming. The horizontal rib, extending all round the hull, quite prevents any injury from ramming. This projecting rib of solid metal 18" deep, is a safeguard no other ship possesses, an arrangement in the design of a deflecting-sided-ship of the greatest value. Armour-clads, ramming at each other, are not unlike animals butting at one another when engaged in deadly strife. This is certainly not a very dignified operation, the one being a fight of physical, the other of mechanical force, a mere pugilistic encounter, in which science forms a very secondary part; but so long as ships are made to ram, certainly others should be constructed to resist that operation.

Model No. 1, represents an armour-plated double-deflecting ship, designed for coast defence. The extreme length of this vessel is 255 feet, extreme breadth 60 feet, breadth at water-line 50 feet, depth of hold 13 feet, height between decks 7 feet 9 inches.

I need not say these particulars may be varied to suit circumstances, thus the beam and depth may be increased to admit of larger stowage of coals, and would be a simple matter of calculation.

The profile drawing (Plate vii., fig. 2), will show the internal ar-

rangements of such a ship, among which I particularly wish to notice the large deck accommodation for the crew, entirely above the water-line, so that there would be no occasion to pump in the vital air to the crew, as they do in coal mines.

The drawing fig. 3 is a midship section of this ship. One of the peculiarities of my system is the external application of timber to protect the armour. This I have found by experiment to be the true and proper place for a timber lining, and it forms an important feature in my plan. The external timber cushions a projectile, and in this case alters its line of flight before it reaches the metal plates. The shot in passing through this timber carries a portion of the compressed fibre of the wood before it, and thus distributes the force of the shot over a larger base than the apex of the projectile, upon which the whole force of the work to be done is concentrated. Although this is self-evident, yet mere assertion in this practical age can make but small progress unless supported by actual experiment. I have therefore made a series of experiments to illustrate the principle of *deflection*, the results of which are here, and, with your permission, I will hereafter explain them. Hitherto artillery and target experiments have been carried on at very great cost, in consequence of using the actual full-sized guns, targets, and ammunition. Now, as that would be entirely out of the question in the case of a private individual, and as the difficulty of using for experiments, material belonging to the State is equally out of the question, it occurred to me that a fair result might be obtained by reducing all the elements in an experiment to a scale. These so reduced, would then be within the power of any one. Instead, therefore, of firing at full-sized targets, with a full-sized gun, I reduced the entire system to a scale of 1 inch to the foot; and, although it may appear remarkable, I have obtained similar results to those arrived at with the large guns and targets, as I hope shortly to explain.

But to return to my ship. The midship section, fig. 3, shows the usual construction of war ships as regards the bottom; this is cellular, having an outer and inner skin, with various water-tight compartments, the sides however are sponsoned out as shown, to a point some 3 or 4 feet above the load line; from this point the top sides fall in-board, at an angle of about 20° , the two angles combined not exceeding 45° . The mode of securing the armour plates to the inner skin is by bolts in the usual way, but the armour plates are riveted together at the apex of the angle where they are flanged for that purpose; these flanges are 18 inches deep, and when thus fitted together, form a mass of metal, so arranged as to be not only difficult to hit, but when hit, the metal to be disturbed is so large in quantity as to be equal to withstand even a 600-pounder. Upon the outer surface of this armour, I place a timber facing, as is shown in the drawing; this timber, if 1 foot in thickness, will offer for penetration in the horizontal line a thickness of 30 inches, assuming the projectile would pursue a straight course. That, however, is really not so, as the timber when placed at the angle adopted, causes the shot to ricochet somewhat before it comes to the metal; it thus receives a

curved motion, and is therefore the easier deflected when contact is made with the metal.

These angles are continuous all round the ship, and if the beam and length were the same, such a craft would be of course circular—hardly a ship-shape form of construction—but equally shot proof, if made oval as in the shape suggested by this design, or circular, as suggested by Mr. Elder, in a paper recently read by him at this Institution.* As a practical proof of the advantage of an external facing, I selected two $\frac{3}{4}$ -plates, one a naked plate, and the other faced with 1-inch timber representing 12-inch in the full size. The naked plate was the first fired at, and the result, as you see, was perfect penetration. In this experiment the same shot, charge, and range, were used as in all other experiments. In the second experiment on the plate faced with 1-inch timber, with the same weight of shot, charge, and same range, the result was very different indeed; the timber of course was penetrated, but not the plate. Now this is easily accounted for with round-ended shot, the fibre of the timber is compressed under the blow, is in fact condensed, and must be almost of equal density with the metal itself, the powder force is therefore distributed over a base equal to the area of the shot, and hence the resistance of the plate so protected. With a pointed shot, however, the result is different, deeper injury, but not actual penetration. These experiments clearly show the importance of placing a timber facing on the *outside* of armour plates as well as on the *inside*.

The gun I used in these experiments represented a 600-pounder on a scale of 1 inch to the foot. The 600-pounder gun is known as a 12-inch gun weighing some 23 tons; the bore is 12 inches in diameter. Reducing this to a scale of 1 inch to the foot would make the bore exactly 1 inch in diameter. The shot of the full-size gun is 18 inches long, this reduced to 1-inch scale, would, of course, be $1\frac{1}{2}$ inches, and the full charge of powder represented by a cartridge of about the same length. Now the experiments at Shoeburyness have shown that a shot from the 600-pounder gun has penetrated a 10-inch plate. I have seen the holes in a 10-inch plate, and there is no doubt of it, and in making my experiments, I have taken the proportion of 1 inch to the foot all through. In my targets, a 6-inch target is represented by $\frac{1}{2}$ -inch plate; a 9-inch target by $\frac{3}{4}$ plate; a 12-inch by 1 inch; the range too reduced from 70 yards was some 17 feet—thus the gun, the shot, the powder, the target, and the range were all reduced to the same scale, and the result was the same, viz., that my target representing the 10-inch plate was penetrated as the 10-inch plate was with the big guns. The experiment is of equal value, but was of infinitely less cost, and I may be pardoned for holding the opinion, but I believe that very great and important results may be obtained by carefully making such experiments upon a reduced scale, and thus save a vast sum to the State. In the one case the result of penetrating a 10-inch plate was obtained by the expenditure of many thousands of pounds, in the other of a few shillings only.

* Vide Journal, vol. xii, page 529.—ED.

Having thus found that a 10-inch plate can be easily penetrated, we may fairly argue that even thicker plates would be in the same condition with bigger guns; indeed the gentlemen at the head of the Artillery Department, all say that they can penetrate any plate that can be produced. Where then is to be the limit, what the cost of ships equal to such elements? what the risk and cost of navigating them, if compelled by modern artillery to carry such armour? Is there no other system of construction? Yes, by deflecting the hostile shot, since it cannot be kept out. Let your ships be made in the form of these models, and the result will be invulnerability; ships shot-proof all round from stem to stern; no weak points at the ends, as well known to any possible enemy as to ourselves; ships proof against that very modern evolution of ramming; ships with an uninterrupted deck *above* the water line, thus rendering it unnecessary to support the crew with *air* by artificial blowing machines; ships easy in a sea-way from the buoyancy given them by the sponsoned sides. Now, in proof of the advantage of the deflecting-side, I have constructed a target to illustrate the effect on a ship. This target is made of homogeneous metal, tempered by a peculiar process, it is riveted together just as the sides of an actual ship would be, and has been faced on the outside with timber to act as a cushion to the shot before it reaches the armour plate.

This target, representing the side of a ship, has been fired at with the same shot and charge as were used in the other experiments, and fairly represents the effect of a 600-pounder on such a ship, and the result, as you see, is partial destruction of the timber, but no injury to the metal beneath. This experiment gives a result I am certainly justified in claiming for a similar experiment if made against the actual ship's side, and clearly proves the vast and immeasurable advantage of this system of construction over any other yet suggested.

It has been urged by some gentlemen who have seen these models, that deflecting-sided ships fitted with turrets, would be the most perfect and apparently the most efficient ships that could be produced. To make a model turret and fire at it with even a model gun would occupy considerable time and add much to the cost of my experiments; but it would most certainly be alike satisfactory to the advocates of the turret-system to have it tested by the largest of our guns, and also to the tax-paying public to be assured, that the sums to be expended in the construction of turret-ships would be so expended with some chance of success in actual war. Of the wisdom of leaving so grave a question in doubt, I offer no opinion; I may, however, express a hope that abler men will be led to urge its deep importance upon the attention of those who have the power to order a full and careful investigation into the entire system. I may add the singular fact that I have never yet been able to find a thoroughly practical mechanic, when called upon to give his real non-official opinion, that is, the true and candid expression of his judgment and experience, upon the turret and its machinery, but who has invariably expressed a *doubt* as to its capability of withstanding the rough usage of war when assailed by big guns. I pray that so direful a calamity may never happen to this

country as the failure of the system so generally adopted, when too late to alter it.

I have extracted from a work recently published by "Von Scheliha" on "Coast Defence," a list of the armour-plated turret-ships of the United States engaged in the attack upon Charleston in 1863, and the effect the Confederate guns had upon their turrets. From the official report it appears that there were 9 of these ships engaged in the action; of these, 1 was sunk, 3 withdrew out of action, and the remaining 5 had their turrets all injured and jammed.

United States Armour-plated Turret-ships engaged in the Attack on Charleston, 1863.

"Weeshawken," *turret injured*, went out of action.

"Passaic," *turret jammed*.

"Montauk," withdrew out of action.

"Patapsco," *turret jammed*.

"New Iron Sides," Admiral's ship.

"Catskill," withdrew out of action.

"Nantucket," *turret jammed*.

"Nahant," *turret jammed*.

"Keokuk," sunk.

These reports all appear under official authority, and are detailed reports of the individual Officer in command of each ship, and are embodied in the report of the Commander-in-Chief to the Secretary of State, and are most authentic records of a very important action, and certainly ought not to be lost sight of. If all future war-ships were only armed with 68-pounders there would perhaps be little difficulty with the turret system, but when 300, 600, and even 1,000-pounders will be the most probable guns of the future, then it would certainly be only fair to test a turret with a few 600-pounder shots before committing the Navy of England to such an untried system.

Ships of my construction would answer the purpose of forts moored in particular harbours, and at the same time would admit of their going to sea.

The application of Messrs. Dudgeon's system of twin screws with independent engines, which is now so universally copied by builders of war-ships, gives such craft an opportunity of manœuvring to the best advantage. It might be objected that so much armour, and such heavy guns at the ends of a ship, will be a disadvantage, if such craft had to fight at sea.

To obviate this the ends may be cut down, as in the model, No. 2, and the guns placed in a deflecting casemate amidships; in this instance the position of the guns will depend upon the size of the ship and their weight. Such a form seems very likely to represent the future line-of-battle ship: deflecting-casemate, and sloping-sides certainly offer the best chance of keeping out modern projectiles.

DEFLECTING ARMOUR-PLATED SHIP WITH CENTRAL CASEMATE.

(Scale $\frac{1}{4}$ of an inch to a foot.)

There is another point to which I wish to direct the attention of the members, and that is the oft-repeated idea of conversion. This has been the subject of much debate, and is certainly well worth attention, on the score of economy. There are many very splendid hulls yet remaining from the fleets of former days; the best of them may be made to do efficient duty as deflecting-sided ships.

I have shown a design for conversion in the drawing before you. This is the mid-ship section of a line-of-battle ship, and upon it I have placed a section of a deflecting-side. What I would propose, is to cut down all the upper decks and sides as low as the lower deck, and upon the remaining bottom, build an independent system of angular sides, so arranged and so fitted that when the bottom had become by age unfit to give safe support to the iron structure above, a new iron bottom of the usual form may be added. Thus you will utilize the present ships without destroying the added structure for reconversion again. This, I think, is a very simple and cheap conversion, and may certainly be tried at comparatively little cost. In submitting this idea for the conversion of some of the finest of our wooden ships, there are two important essentials; the first is the preservation of the present fixed machinery, which need not be moved out of the ship, and the second, that the added structure would be available for a new hull, when the timber had become too old to be longer trusted. The details of such a system of conversion are not shown in this drawing, details being a matter of professional arrangement. Such a system is, of course, like all other systems, open to criticism, and hence I have ventured to introduce it, that in the discussion, which usually follows a paper read at this Institution, some notice may possibly be taken of it.

To those who contemplate building armour-plated ships, it would appear desirable to consider the question, whether vertical sides, even when plated with the thickest armour, will keep out the most modern projectiles. The experiments at Shoeburyness answer that question indisputably. Will naval powers, on the other hand, agree to use small guns? this would be a desirable arrangement, but we must consider it impracticable.

I may then, as an advocate of the deflecting-sided system, most earnestly urge, even on the score of humanity, that it should be tested in an efficient manner. It can hardly be expected that an ordinary individual should, at his own cost, enter upon the construction of a full-size target. It must be acknowledged that in the production of such models and experiments as are here shown, a considerable sum

has been already expended; and although they show what the result would be in the actual ship, yet a target made on the principle of this model of a deflecting-sided ship, would at once demonstrate its advantages. There is certainly no naval power in the same financial position as England. To such, a shot-proof ship of moderate cost would be an essential of the greatest moment; and to such I would say before expending large sums in ships of doubtful vulnerability, consider fairly whether double deflection is not the true form of construction for economy, seaworthiness, invulnerability, difficulty of capture by boarding, and last, though not least, comfort for the crew.

It is very well known that naval powers generally are not only seeking every kind of information upon the subject of ships and guns, but are actually preparing themselves with both as rapidly as circumstances will admit. Take, for instance, the fact of the Americans possessing a host of 15- and 20-inch smooth-bores. The fact also of the Prussians being engaged in the manufacture of the largest guns our Shoeburyness experiments have taught them the necessity of. These and similar circumstances show how important it is that any possible contrivance, having a chance of success, should be investigated, that England may not be compelled to concentrate her energy at an enormous sacrifice when a naval panic places her at a disadvantage. The public, if we may judge from the interest taken in this question by the paper, quite understand its importance.

I remember to have read in the *Times* of December 8, 1866, the following remark:—"We learn from experiments now reported, that a large percentage of shots would be rendered practically harmless by such an inclination of a ship's side towards the muzzle of a hostile gun." Now this is what I have endeavoured to urge for the past 16 years, and I hope, in the course of a few more, to see such a system adopted. Every day's experience confirms its importance, and those who are conversant with these subjects, cannot fail to acknowledge its practicability and usefulness, for, however much we may rely on the pluck and daring of the British Officer—qualities we know they possess in the highest possible degree—there is another element we must not forget, that of the British seaman, once a numerous race, that seem, from some unexplained cause, to be passing away, and hence the necessity of giving those we have, a fair chance when called upon to fight the enemy. This too, is an argument in favour of a ship that can successfully keep out the hostile shot. Skilled seamen and gunners take some years to produce, and when educated for such duties at great cost and care, are certainly more likely to be of service to the State in a shot-proof ship than in a ship vulnerable at all points.

The great and rapid changes which have taken place, and which will, doubtless, continue to take place in the design and construction of ships suitable for the purposes of war, offer to a wise statesman a subject of deep investigation. Naval tactics, like military evolutions, when skilfully performed, are said to give important advantages; but these can hardly be accomplished without such material in the shape of ships and guns as shall ensure success. England has the means to obtain, and the desire to possess—her statesmen all acknowledge

that no circumstances should prevent the possession of—the most powerful fleets. Her people have at all times been most ready to bear any cost for such efficiency, and although the ships now built are grand and magnificent structures, reflecting the highest possible credit upon those gentlemen under whose care and judgment they have been designed, and whose experience had given such great perfection, yet their vertical sides have an acknowledged vulnerability. Let us hope then that some plan will be suggested to keep out those fearful shells, and, in the absence of any better, I have been permitted by the Council of this most useful and valuable Institution to introduce to your notice these models and drawings. They explain a system I have worked at for the past 16 years; and I claim to add that the result of experiment in every variety of form, shows that a glacis all round a ship externally covered with timber, will cause projectiles to ricochet, and that such is the system that offers the best chance of success against the guns of the present day.

Description of Targets.

Targets 1 and 2 are representatives of 6-inch targets; that is, they are plates $\frac{1}{2}$ inch in thickness, No. 1 being of iron and No. 2 of homogeneous metal tempered. They were fired at with the same shot and charge, No. 1 being penetrated and No. 2 only bulged, thus proving the great advantage of homogeneous metal.

Targets No. 3 and 4 are representatives of 10-inch targets. No. 3 being a naked plate and No. 4 protected with timber equalling 12 inches. The first shot at No. 3 was of cast-iron, similar to that marked 1 on the board, and the remains of the shot fired are placed with it. No. 2 shot of this series was of wrought-iron, the shot fired is also placed on the board; the impression on the target with both the cast- and wrought-iron shot is small. No. 3 shot was of tempered steel, this penetrated the target; the shot is also on the board. No. 4 and 5 were fired at an angle of 10° and did not penetrate. No. 4 target, lined with wood, was not penetrated, and the shot is still in the metal, thus proving that the wood is an advantage even in a vertical position.

No. 6 target represents the angular sides of a ship; one side of this target is faced with wood, the other is naked. Upon examination, it will be seen that the wood has entirely prevented the shot from even touching the metal. The naked half of this section was also fired at, and the result was a small indentation only; there can be no doubt, therefore, that a similar result would be found in firing at an actual ship with a full-size gun.

No. 5 target is a representative 12-inch target. The first shot only got half way through, but, with an extra half charge of powder, the second shot, as you see, very nearly penetrated. Both these shots were uninjured.

Mr. HYDE: If you will permit me I will now further explain this target (No. 6) representing the side of my ship, as the experiment was a most remarkable one. In firing at this target, the wood actually made the shot ricochet. This is the

piece of wood placed upon the target in an early experiment. If you examine it, you will find that the shot has simply grooved out the wood, and the fibre is torn up, but it failed to penetrate the wood, it did not touch the iron. That result was so astounding and marvellous, as showing that mere vulgar wood would keep a shot out of a ship, that I repeated the experiment on two or three occasions, and found the same results. You will notice that there were two shots fired here, and they failed, both of them, to penetrate the wood,—they ricocheted from the surface and passed away.

It might be asked: what would be the effect of a plunging shot? This (pointing to a target) is the effect of a plunging shot. A shot was fired so as to show the effect, but it failed to get through the iron. It went through the wood, but not through the iron.

This diagram shows the thickness of the wood, a foot in thickness, as would be used in my construction. A shot penetrating, assuming it went in a straight line, would have to go through 2 feet 6½ inches. Probably it would ricochet, as in this case, pass off and go away without reaching the plate at all. This diagram represents the full-sized plate of 3 inches. The midship section shows more clearly how the armour-plates would be secured, and the wooden facing on the outside.

The CHAIRMAN: If any gentlemen would like to make any remarks or ask any questions, Mr. Hyde will no doubt answer them satisfactorily.

The points on which I should like to be enlightened are, firstly, what power of training right and left will there be in this gun with that surface to point through? I do not quite see that there is the same power of training right and left here as you would have in a vertical side.

Again it seems to me that such a ship as the one represented would be more suited for coast defence, than for sea-going purposes, inasmuch, as I think in the first place she would roll more, and her upper deck would probably be swept continually. These are two of the points I should like to hear more about. Do I understand also that no shot ever penetrated the iron through the wood? As for instance there: (pointing) what became of those shot? Did they lodge in the wood, or go on away, or did they remain? I see one has remained.

Mr. HYDE: This shot must have fallen out; it could not be found.

The CHAIRMAN: I conceive that the ricochet of the shot would be very mainly determined in this case by the fibre of the wood being in that particular line, but supposing the fibre to be the other way, I do not suppose there would be any necessity for placing the wooden *facing* with the fibre that way; but supposing it were, I presume the shot would have a better chance of penetration than it would with the fibre placed in the way in which we see it.

Captain BEAMISH, R.N.: Mr. Hyde has pointed out a piece of wood through which a shot did not go, was that shot fired vertically at that piece of wood, and had it armour plating behind?

Mr. HYDE: The piece of wood was placed in the position you see it on the model.

Captain BEAMISH: May I ask what is its thickness in proportion to the iron?

Mr. HYDE: Three inches of iron and twelve inches of wood.

Captain BEAMISH: Another thing that struck me about the construction of vessels on the principle before us is this, that at sea they would be very likely to be severely struck in the rise and fall of heavy seas, in consequence of the shape of the vessel being so very much over-hanging. As far as my experience goes, vessels with large spousons offer very great resistance to the sea, and it appears to me that this vessel, though it certainly would offer immense advantages in the way of deflecting shot, offers the disadvantages all round that a vessel with an over-hanging stern offers only at the stern, or which one with an over-hanging bow offers only at the bow. I do not know whether Mr. Hyde has had any opportunities of testing it, he cannot have done it with mere models, but it strikes me that with that construction there would be a very great strain upon the vessel from over-hanging weights, such a strain as comes to a vessel which has an over-hanging stern or bow, more particularly when the guns are run out.

The CHAIRMAN: I was going to mention that at sea, be the ship what she may, with the wind on one side, she would always heel over a great deal, to say nothing

of the rolling, and in that case I presume she would suffer much more from the enemy's artillery, because the shot would be very liable to go below that deflecting surface, and the deflecting surface under those circumstances would not be at the same invulnerable angle that it is when she is on an even keel. That is supposing she was a sea-going ship; for coast defence it would not be so.

Mr. J. B. WILSON: I would ask whether exactly the similar results would be attained with full-sized artillery and full-sized targets as were obtained with the model, or whether it is not a matter of calculation and also of experiment, whether full-sized guns would not prove more destructive to full-sized targets than was found in the case of the model targets.

Mr. SAMUEL J. MACKIE, Associate I. C. E.: With reference to what the last speaker said with regard to the full-sized targets, having had great experience in these things at Shoeburyness, I must confess my very great surprise at finding that these targets, particularly No. 3, as any one may see, so accurately show in miniature the various forms of perforation made upon the plates of larger size. If any one will look at the back of that plate they will see the same four rays breaking out, and similar bulgings at the back; they will see a large circular disc broken away, and on examining the front of the plate, will perceive the same ripple mark round the hole in a manner marvellously like those which are witnessed in the experiments at Shoeburyness.

With regard to that plate, and the wood that is put in front of it, it has caused me some astonishment. If I understand it rightly, it represents a 3-inch or 4-inch plate covered with 12 inches of timber. We know perfectly well if a plate of 3 or 4 inches thickness, backed with 12 inches of timber, is hit direct from a 600-pounder, the shot will pass through it as through pasteboard. If you get such results in practise from a 600-pounder it will show that the deflection of the plate has an exceedingly high defensive value. Of course, when allusion is made to experiments on a small scale, I cannot for one moment admit that it would prove any economy to the nation to try experiments on a small scale. Experiments on a small scale are suitable for inventors, and have been carried out by many of them, as by Major Palliser and others, before their inventions were brought forward to the public or to the Government, but experiments on a large scale must be necessary before practical works could be engaged upon. No acceptance of any principle could ever be made upon a small model, it must and ought properly to be tried on a large scale. With regard to the over-hanging shape of the stern of the vessel, and of the sides and bow, it is a point upon which I think it would be well to have some further consideration than the mere over-hanging of the sponsons of a vessel would give us. There seems to me to be in the over-hanging of a vessel of this kind an enormous dead weight, which is very different to the over-hanging sponson of an ordinary ship. This dead weight I apprehend is a certain amount of weight to be elevated against gravitation, and which action must to a certain degree absorb much of the momentum of the striking object, or wave. I think that is a point worthy of investigation with regard to a structure of this kind. There evidently is a great deal of defensive resistance to be got by angulating the target, we have seen this at Shoeburyness in the 8-inch Warrior target, part of which is at an angle of $37\frac{1}{2}$ degrees, representing the bow of a ship, for in no case did the Palliser shot penetrate that. In fact, the ogival head of a Palliser shot especially, is pretty nearly certain to be deflected in consequence of the form of the head. This happens even from as yielding a surface as water. I had no idea of speaking this evening, but these are some of the points which appear to me to be worthy of consideration with respect to the plan submitted.

Mr. HYDE: Referring to an observation you, Mr. Chairman, were kind enough to make, with regard to the training of the gun, of course I need not tell you that to give a gun a large amount of training, you must have a very large port, or adopt the muzzle pivoting system: the large port is a point in the structure of ships that one generally tries to avoid. I might say the modern application of the double screw or the hydraulic system of steering almost prevent the necessity of giving a ship a very large port, for she can be twisted and turned with the double screw almost as readily as the turret itself. However, the trainage here would be, perhaps, a point, fore and aft, unless the port was made large.

As regards your remark about the fibre of the wood, in making such a structure, no one would, for a moment, place the timber what we call practically, fore and aft—it would all be vertical. If a shot struck the side of a ship, where the timber had been fixed fore and aft, it would possibly destroy a dozen planks, whereas, if the plank was placed vertically one only, or one and a half, or two might be destroyed. So that in all cases the fibre of the wood would be direct to the flight of the shot as it is placed on this particular surface.

As to the rolling of the ship at sea that is a question which it is almost impossible for anyone to answer satisfactorily. We can only say that merchant ships, having sponson sides, are known to be easy ships in a sea-way; and as an illustration of that, I would allude to a ship navigating our own River Thames. I think it is the "Lion." This is a ship with a sponson side. I have gone on board that ship, and asked the sailors how she behaved in a sea-way, and they all say the ship was the most buoyant craft that they ever sailed in. We do know, as a fact, that small boats, the sides of which are mainly sponsoned, so to speak (the greatest breadth of a small boat being just at the gunwale), we know that little boats live in a sea that a big ship would founder in. That is a well-known fact, so that as far as my judgment and my inquiry go, ships with sponson sides would be more buoyant and more seaworthy than those with vertical sides only. Of course, these vessels are supposed to present the smallest possible surface to the enemy, and hence would swim, perhaps, three or four feet out of water. The point is to keep a shot out of a ship. If you are obliged to put 14-inch armour or 12-inch armour upon a ship, she must be very large, the displacement must be very extensive, and even then we know that vertical structures are still vulnerable. Hence this is resorted to. I do not mean to say that there are not disadvantages. A heavy sea rolling over—that cannot possibly be avoided. You cannot have the old wooden structure and the armour-plated shot-proof ship too. If you want a ship made shot-proof, you must either give her a form of this kind, or else you must have her sides so thick that the structure must be monstrously big—some 8,000 or 10,000 tons—to carry it.

As regards the heeling of a ship of this description, and the exposing a weak point of her structure, all ships are the same. If you take a broadside ship of the present form, she is just the same; if she heels over, she exposes her weak points. If you give a ship of this class sufficient beam she would not expose her weak points so frequently as a vertical-sided ship, and these ships must have more beam to carry their weights, so that the weakness below the water is much less than it would be in an ordinary ship.

As regards getting the same result from the model that you would from a big gun—well, that is a question of deep research, which I confess I am not able to answer off-hand. All I can say is this, that with a gun an inch to the foot, and a target an inch to the foot, you get the same results they have got at Shoeburyness. If you reduce your 600-pounder to half the size, you get half the duty; if you reduce it to a quarter the size, you get a quarter the duty, and you may go on down to one-twelfth the size. I think the argument is a good one, and I think it is highly probable because the results are the same. If the results were not the same, then I might say the experiment was defective, but with a similar result as to the penetration of a plate equal to a 10-inch plate—the only plate they have fairly penetrated is a 10-inch plate—the 12-inch plate or the 15-inch plate they did not quite penetrate, it was broken up in fragments,—but the 10-inch plate they have penetrated: so we have here, the shot goes through it, and I have no doubt experiments, however numerous, made under similar circumstances, will yield the same results. I have brought the targets, I have brought the gun, I have brought the shot, and the result is here. Anybody may make the same experiment.

The only reason the overhanging form is given in this particular mode of construction is simply to get rid of the shot; we know we cannot get rid of it in any other way. However thick, or however big you may make your plates, gentlemen, at Woolwich, say "We will knock them all to pieces if we cannot get a shot through." Therefore, we must make something that will keep the shot out—of course, there might be something better,—but in the absence of any better, I present

you with this. If you have any better scheme for keeping shot out of a ship, then I make my bow : at present I say this is the best.

It has been noticed that the weight at the ends may be disagreeable. I am not prepared to say it would be disagreeable, especially for coast defence, because in a ship entirely devoted to harbour duty, or coast defence, there is no probability of her getting into Atlantic waves. But in the event of a ship going to sea in a gale of wind, take the ends off and we present you with a form of this description—we put a casemate in the middle with a glacis all round it. Remove the weight from the ends and keep it in the centre ; but I think both plans equally good, and I think would do equally good and efficient duty under any circumstances.

The CHAIRMAN: I think the meeting will join with me in giving their thanks to Mr. Hyde for his very able lecture upon this subject. It seems to me that he has gone as near as possible to the great object of keeping the shot out of the ship. With regard to the material, the only doubt that can be thrown upon this to my own mind, is that the material is stronger in proportion as it is smaller than it is on a great scale, but excepting that, it seems to me that these experiments are very conclusive. Certainly, they are very good as guides for larger experiments on a grand scale. I should think it would be very desirable to have experiments on the full-sized scale afterwards, before we could fully and entirely trust these means for ship-building. The only doubts I, as a sailor, have, are, that we have so many other problems to deal with when we go to sea, besides keeping the shot out of the ship, but as far as keeping the shot out of the ship goes, that, no doubt, can be tolerably accomplished with deflecting sides. You will I am sure, join with me in thanking Mr. Hyde.