We beg to announce that American Subscriptions to ENGINEERING may now be addressed either direct to the Publisher, Mr. C. R. JOHNSON, at the offices of this Journal, Nos. 35 and 36, Bedford-street, Strand, London, W.C., or to our accredited Agents for the United States: Mr. W. H. WILEY, 43, East 19th-street, New York, and Mr. H. V. HOLMES, 1257-1258, Monadnock Block, Chicago. The prices of subscription (payable in advance) for one year are: For thin (foreign) paper edition, 1*l.* 16*s.* 0*d.*; for thick (ordinary) paper edition, 2*l.* 0*s.* 6*d.*; or, if remitted to Agents, 9 dollars for thin and 10 dollars for thick.

CONTENTS.

With a Two-Page Engraving of THE GERMAN NILES TOOL WORKS AT BERLIN.

NOTICES OF MEETINGS.

SOCIETY OF CHEMICAL INDUSTRY: LONDON SECTION.—Monday, June 2, at 8 p.m., at the Chemical Society's Rooms, Burlington House, Piccadilly. The following papers will be read and discussed: "A Contribution to the Chemistry of Whiskey," by Dr. Philip Schidrowitz, F.C.S.—(I.). "The Estimation of Perchlorate in Saltpetre, &c." by Dr. A. Dupré, M.A., F.R.S. "On the Will Test for Nitrocellulose," by Dr. Robert Robertson, M.A. "On the Effect of the Alcohol Duty on Chemical Industries," by Dr. O. Silberrad.

THE INSTITUTION OF JUNIOR ENGINEERS.—Monday, June 2, will visit the new signal cabin of the South-Eastern and Chatham Railway. Meet at Charing-cross Station, under the clock, at 7 p.m.

SOCIETY OF ENGINEERS.—Monday, June 2, at the Royal United Service Institution, Whitehall. A paper will be read, entitled "Notes on some Twentieth Century Locomotives," by Mr. Charles Rous-Marten. The Chair will be taken at 7.30 p.m. precisely.

RONTGEN SOCIETY.—Thursday, June 5, at 20, Hanover-square. The Chair will be taken at 8.30 p.m. The President will read a paper on "The Sources of Phosphorescence."

ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, June 6, at 9 o'clock. Sir Benjamin Baker, K.C.M.G., LL.D., D.Sc., F.R.S., M. Inst. C.E., M.R.I., on "The Nile Reservoir and Dams." Afternoon lectures next week, at 3 o'clock:—Tuesday, June 3, Professor Karl Pearson, M.A., F.R.S., Professor of Applied Mathematics, University College, on "The Laws of Heredity, with Special Reference to Man." (Lecture III.).—Thursday, June 5, Mr. M. H. Spielmann, on "Contemporary British Sculpture." (Lecture III.).—Saturday, June 7, Professor Brander Matthews, Litt. D., D.C.L., Professor of Dramatic Literature, Columbia University, New York, U.S.A., on "The Development of the English Drama."—III. "The Drama under Elizabeth."

GEOLOGISTS' ASSOCIATION, LONDON.—Friday, June 6, at 8 p.m., at University College, Gower-street, W.C., when the following papers will be read: "On a Peculiarity in the Course of Certain Streams in the London and Hampshire Basins," by Mr. H. J. Osborne White, F.G.S. "Note on the Occurrence of *Microtus intermedius* in the Pleistocene Deposits of the Thames Valley," by Mr. Martin A. C. Hinton and Mr. Gilbert White. After which the Rev. J. F. Blake will give a short account of the geological features to be observed during the excursion to Headington, Shotover, and Wheatley, on June 7.

ENGINEERING.

FRIDAY, MAY 30, 1902.

GUNS *VERSUS* ARMOUR-PLATES.

No more disquieting news from a naval point of view could be conceived than that which is recorded in the tabular report on page 724, accompanied by illustrations which we publish on pages 720 and 721 of this issue; for it establishes beyond any question the fact that armoured plate manufactured according to the latest process, including cementation and subsequent hardening by chilling the face, has been defeated by modern guns and projectiles. A 6-in. plate and one of 12 in. in thickness have been attacked by the Vickers 6-in. and 7.5-in. calibre guns, with Johnson capped shot and shell, and on each occasion when these projectiles were used the plate was completely perforated; and, apart altogether from the destructive power of the high explosives admitted in such shells into the interior of a ship through armour-plating, there is the equally disastrous effect of having the hitherto invulnerable water-line plating open to the sea. The ship's crew, the mechanism protected by armour, and the buoyancy of the vessel are consequently endangered, and that, too, by the attack of guns moderate in size and weight and in power, because it is obvious that weapons of higher calibre—9.2 in. and 12 in.—are proportionately more powerful. The importance of this triumph of the guns will be more fully appreciated when it is remembered that our modern battleships, already completed or in course of construction, are clad on the broadside with armour of corresponding resisting power to that defeated, but limited in the thickness to 9 in., 8 in., and 7 in.; Lord Goschen's "mighty" cruisers, now being delivered, and representing a cost of a million pounds each, have only 6-in. armour, while in course of construction we have sixteen armoured cruisers of the Kent and Devonshire classes, most of them with 4-in. armour, and the others with 6-in. broadside belts. The fact that foreign Powers—notably the United States, Russia, and Germany—have been striving, with the same energy as has been displayed by the Vickers Company, to develop a similar effect does not in any way lessen the anxiety with which these results will be received.

The Vickers Company have for several years been experimenting, with most satisfactory results, towards the increase of ballistics in guns, without which even the capped projectile could not avail; and with their 6-in. gun they have succeeded in developing a muzzle velocity of 3000 ft. per second, while for some reason which is not quite explicable our warships have been fitted with weapons in which the velocities have been limited to from 2160 ft. to 2500 ft. per second. The difference is most marked, meaning, as it does, a striking energy at 2500 yards range of 2922 foot-tons as compared with from 1515 to 2023 foot-tons for the Service weapons. Corresponding superiority might easily be recorded in connection with guns of higher calibre, but this one instance will here suffice. Moreover, the Admiralty are open to criticism in not realising the immense potentialities of a gun of greater calibre, notably that of 7.5 in., where a striking energy at 2500 yards range of 6627 foot-tons can easily be realised without any inconvenient increase in weight, since the United States Government, as well as some of the European Powers, have adopted, for the secondary armament in warships, guns more powerful than the largely utilised 6-in. piece in British ships.

But an important contribution to the defeat of modern hardened armour is the fitting of the shot or shell with a forged steel cap, which experience has proved protects and supports the point of impact upon a hardened plate, and enables the projectile point proper to find its way into the armour. Ten years ago Russia entered upon experiments with a so-called magnetic shot, in which the cap was secured to the projectile by magnetic attraction; but the Johnson cap has proved itself much more satisfactory, and the plates which have been perforated with this projectile, fired from a Vickers gun, establishes the success; an essential feature, of course, is the high-striking energy. The Johnson cap is of forged steel, cylindrical in form, with its bottom cored out to fit over the nose of the projectile itself. In the front of our engraving of the gun (see page 720) there will be seen two shells with this cap in position, while on the same platform ordinary projectiles are being placed ready for use by a gunner. For securing the cap there is cut round the projectile a small groove, having at one point of the circumference a slight nick, so that when the cap, by hydraulic pressure, is forced to grip into the groove, the nick prevents any tendency to rotation, which would be prejudicial to the effective absorption of the force of impact by the cap. The reproduction of the photograph of a 6-in. shot which has passed through a 6-in. Krupp cemented plate, given on page 721, illustrates the efficiency of the capped projectile itself, and shows this circular groove by which the cap is attached to the shell.

Turning now to the trials which have established the triumph of the Vickers gun and capped projectiles over the modern armour-plate, it may be noted first, as regards the latter, that it was manufactured at Messrs. Vickers' works, where completely new plant has been recently laid down for the hardening of armour-plate according to the latest process, and both the 6-in. and the 12-in. plates tried and perforated were manufactured according to British Admiralty specification. Moreover, the first shots fired at these plates were arranged to exactly correspond with the Admiralty tests prescribed for the acceptance or rejection of such plates. Thus the attack was by a 6-in. gun,

firing armour-piercing shot of 100 lb. weight, without a cap, and having a striking velocity of 1960 ft. per second, with a corresponding energy of 2664 foot-tons. As is shown on the engravings, the shots with this energy, and without the caps, made practically no impression upon the plate, excepting the usual surface abrasion, while at the same time the projectiles were broken into many pieces. The first shot fired against the 6-in. plate was broken up, the point only remaining fused in the plate; but there were no cracks, and no sign of bulge at the back. Against the 12-in. plate the 6-in. shot in the fifth round developed the high velocity of 2827 ft. per second, with a corresponding energy of 5542 foot-tons; but having no cap, the shot was completely broken up, although the point, which penetrated 3 in., remained fused in the plate, and a large piece of the projectile rebounded to the extent of 20 ft. from the front of the plate. These results prove that the plate was equal to the ordinary Admiralty requirements.

As to the effect of the new shot fitted with the Johnson cap, the engravings of the plates carry convincing proof, and clearly establish the triumph of the gun, with its new projectile, over the latest plates, and that, too, when developing relatively low velocities. Taking first the 6-in. plate, the third round was fired from a 6-in. gun with a Vickers shot fitted with the Johnson cap, the total weight being 105 lb. The initial velocity was 2007 ft. per second, and the striking velocity 1971 ft. per second, corresponding to a striking energy of 2829 foot-tons, with the result that the plate was completely perforated. This in itself is an important result, but more remarkable is the effect obtained from the 7.5-in. gun, which fired the second projectile at this plate. The striking energy here was 6795 foot-tons, and the result established the immense superiority of this gun for cruisers as well as for the secondary armament of battleships—a point we have already referred to; because, not only did the shell perforate the 6-in. plate completely, but the point of it, weighing 92 lb., was subsequently picked up in a sand heap at the rear of the target, having, after going through the plate, ploughed its way for 20 ft. into this sand. One can quite easily picture the effect of such a shell, with its bursting charge of 6 lb. of explosives, finding its way through the 6-in. belt of one of our many modern cruisers, and exploding its lyddite charge in the interior of the ship.

Referring now to the 12-in. plate, three rounds were fired on May 9, also in presence of high Admiralty officials, with results corresponding to those attained with the 6-in. plate, and recorded in our Table on page 724; but it will suffice here to "point the moral" of the attack by the 6-in. gun on Friday last, when, as mentioned in the detailed results on page 724, several members of the Board of Admiralty were present at the trials. The fourth and fifth rounds against this 12-in. plate not only establish the high velocity of the Vickers weapon of this calibre, but also the efficacy of the Johnson cap, and incidentally proved the advantages of nitro-cellulose powder as compared with cordite. Burning more slowly, it exerts a longer and therefore a more powerful propelling effect upon the shot, and at the same time does not erode the gun as in the case of other compounds containing nitro-glycerine, whereby the ballistics are greatly reduced, as has been proved during the Transvaal War. Rounds 4 and 5 were fired from the same gun, the only difference being that in the one case (Round 4) the Johnson cap was used. With the cap the shot passed completely through the plate, but was held up by the wood backing behind, and, as shown in the engraving, the rear end of the shell was about 9 in. from the surface. All the evidences point to the fact that water would be admitted in such case, as the wood backing and the steel plate, corresponding to the skin of the ship, badly bulged. But, as will be seen in the engraving, a 7.5-in. shell with a cap—the third round—defeated even this 12-in. plate.

Without entering further into the details embodied in the official tabulated report, it may be deduced that a capped 6-in. projectile will completely perforate a 12-in. plate if such a velocity as 2800 ft. per second is developed, and this the Vickers gun can easily attain; whereas with an uncapped shot, even at this high velocity, the plate undoubtedly triumphs, the extent of penetration being only 3 in. As for the 6-in. plate, which is much more extensively adopted in our armoured cruisers, it has been fully demonstrated that a 6-in. shot, when capped, will effect complete penetration, even with a striking velocity of about 1971 ft. per second; and in the series of experiments carried out by the Vickers' Company there are several examples of such plates being perforated and the shot remaining intact. Even at the risk of repetition, it is proper to point out that the 6-in. projectiles we have been referring to are not shell, but with the 7.5-in. gun on these trials shells were used containing the equivalent of a 6-lb. bursting charge, and these completely perforated the 6-in. modern cemented plate with a velocity corresponding to a range of 2500 yards. It may be thus taken that such a gun using lyddite shell with a Johnson cap could perforate the water-line armour of all the battleships of the Canopus and Duncan classes, as well as all the armoured cruisers we are now building, making a very considerable hole and causing much internal destruction; while the 6-in. gun at a range of 2000 yards could similarly defeat the 4-in. armour of the Kent class.

There can be no question about the earnestness of the present Board of Admiralty and of their strong desire to bring the Navy into the first rank of efficiency, and we can only hope that the serious significance of the results attained will enable them to carry their desire more fully into practice. The nation itself will gladly "foot the bill," and no difficulty should be experienced in securing the financial aid necessary. Lord Selborne has embarked upon a commendable policy of re-arming some of our ships which otherwise are fairly efficient, and it is incumbent upon him to ensure that not only will all the vessels be supplied with capped shot and shell, but that the guns will be fitted in such a way as to attain the high velocities necessary to ensure the fullest penetrative power for such projectiles. The difficulties are unimportant, and no armour-piercing shot now in store need be discarded, because the Johnson cap can very easily be fitted to any projectile at little cost, and with the result of increasing their efficiency by 30 per cent. even at moderate velocities. Since the French, Russian, German, and United States navies have adopted such caps, there is the greater need why our naval weapons should be thus brought into line, and for ensuring that the new guns to be fitted to our battleships and cruisers should be improved in their ballistics, while at the same time the 7.5-in. instead of the 6-in. gun should be adopted as the secondary armament of our battleships. This is the more important as these guns are not only of very great power, but attain a high rapidity of fire. At the trials to which we have been referring, a test was made to ascertain their quick-firing qualities, and it was found that, firing at a target 1000 yards away, five aimed rounds were discharged within 31 seconds, representing a rate of fire of nine aimed rounds per minute. No more opportune time could be chosen for a spirited naval policy; the country, still smarting under the sense of impotence displayed in connection with the Transvaal campaign, will welcome any well-defined and liberally-prosecuted policy by Lord Selborne and his Board, while our great ordnance-manufacturing firms are in an admirable position for carrying out extensive gun-construction work, as they are not, and have not been for some time, fully engaged upon such work.

NAVAL ENGINEERS.

THE letter addressed to us by "Expert" last week (see page 677 *ante*) puts forward very clearly the reasons why the Admiralty experience so much difficulty at the present day in getting suitable candidates as naval engineers, and the shifts that the Board have been put to in order to fill up vacancies. Why a young man, or the parents of a young man, should elect that he should enter the Navy as an engineer, to receive at the age of twenty-four 7s. 6d. per day, when by entering him as a doctor he could get 14s. a day, it is difficult to imagine. Even paymasters of the Navy, who certainly do not need so exhaustive an education as engineers, soon overtop the latter in regard to the remuneration they receive for their services. The Table which our correspondent gives is extremely instructive, and is a good explanation of the fact that, according to Mr. Arnold-Forster's own admission, 85 vacancies remained to be filled in the entry of engineer officers through Keyham. It is also a commentary on the fact that no candidates were forthcoming for assistant engineers for temporary service in January, whilst only two presented themselves in March, of whom one was successful. The appointment of temporary engineers from outside is, of course, one of the shifts to which the Board of Admiralty have been put by the failure of sufficient number of engineer officers through the orthodox course at Keyham. At best it is a poor shift, but even at that it has failed.

The time has arrived when the Admiralty must face the problem of engineer officers seriously, unless we are to abandon our sea supremacy, if it is ever challenged. This is an absolute fact, respecting which those best acquainted with marine engineering have come to a conclusion; and it is, we believe, recognised by a large number of young officers, as well as by some of the older ones, of the executive branch. The course of events has thrust this conviction upon naval officers chiefly through the torpedo flotilla, where the executive officers are brought more in contact with the engine-room than in larger vessels, especially in cases where they have no one in the engineering branch of higher education and authority to depend upon. It now seems possible that we shall have a somewhat extensive flotilla of submarine boats, and in the management of these high engineering ability will again be specially needed. Every effort has been made in the past, and is still being made, to avoid this issue. It is repugnant to the sentiment of some elderly naval officers either that engineers should exercise authority, or that executive officers should undergo efficient training as engineers. The introduction of steam into the Navy was opposed fifty years ago. It is a sentiment that will have to be subdued if, as we have already stated, the British Navy is to remain supreme, no matter how many ships may be built, or what other steps may be taken.

A way in which it has been endeavoured to avoid this paramount issue in naval administration has been by attempting to give naval officers of the executive branch a smattering of engineering education, with a view of rendering them capable of undertaking a certain amount of direction, whilst the actual work was to be done by an inferior grade. We have made reference to this endeavour of the Board of Admiralty on past occasions when proposals of the kind have been tentatively put forward; but within the last few weeks an effort, of a determined nature, in this direction has been made. It has been stated that orders had been issued by the Admiralty that the care and maintenance of gun-mountings and torpedo appliances on board His Majesty's ships should be handed over to lieutenants. A committee, consisting of the Captains of H.M.S. Excellent and Vernon, respectively the gunnery and torpedo-training schools, together with the Chief Inspector of Machinery at Portsmouth, was instructed to report on the best way in which the proposed order could be carried out, it being understood that it was the wish of the Board of Admiralty that the changes should take place as quickly as possible. The meeting of the three officials was delayed by the illness of the engineer member; but his absence does not appear to have been considered a very serious matter, as the two captains drew up a report, to which was attached an appendix describing proposed qualifying course. The course of engineering for qualifying gunnery and torpedo lieutenants or engineers was one whole month (!) and we cannot help saying that the recommendations contained in this valuable document were framed in a manner which displayed an ignorance of engineering subjects which we should have thought no one connected with the Royal Navy could have possibly displayed.

We are loth to the use of strong language, but our duty calls on us in this matter to use plain speech. The captains' report was, no doubt, forwarded to the Admiral Commanding at Portsmouth in the ordinary course, together, presumably, with a separate report from the Chief Inspector of Machinery. The Commander-in-Chief sent them to the Admiral Superintendent of the Dockyard for his views. At any rate, the reports were sent on to the Admiralty. Exactly what reception they received at Whitehall is not known. One would suppose that the Chief Inspector of Machinery was communicated with, and, if so, it is to be presumed that he would disagree entirely with the reasons of the Captains of the Excellent and the Vernon. At any rate, a statement appeared in the *Times* of April 19 last to the following effect: "The recently issued instructions with regard to the care and maintenance of gun-mountings and torpedo appliances on board His Majesty's ships were yesterday withdrawn, and for the present the engineer officers

GUNS *VERSUS* ARMOUR-PLATES.

(*For Description, see Pages* 717 *and* 724.)

7.5-IN. VICKERS QUICK-FIRING GUN AT ESKMEALS.

not have thought that any excessive amount was spent on the rolling stock.

Next Professor Carus-Wilson takes the receipts and expenses per mile of line, and embodies them in Table II. given on the previous page.

A note to this Table says "Per mile" means mile of line regardless of the number of parallel tracks, and this, unfortunately, goes far to destroy the value of the Table for purposes of comparison. We have not the information at hand to show what proportion of the Italian lines are double, but probably it is not more than 10 per cent., if so much. The Great Northern Railway, in December, 1900, was 825 miles in length, of which 176 miles were single, and 649 miles "double or more." As there are four roads on much of the distance from London northwards, we shall not be very far wrong in taking all the 825 miles as double, and all the Italian lines as single. We then get the Great Northern expenses per mile as 1211*l.* against 421*l.* in Italy, and the receipts as 3230*l.* against 1605*l.* However, this point is not of much importance, as the remaining calculations are based on train-miles. On the Lecco-Colico line the passenger receipts are only 380*l.* a mile; on the Sondrio-Chiavenna, 220*l.*; and on the Milan-Varese-Arona-Laveno lines, 600*l.*

There has been a very large increase in the train service on the electrified lines. The old trains hauled by steam locomotives have been replaced by trains half their weight, and capable of carrying about half as many passengers — that is, 165. From Milan to Gallarate the schedule speed has been nearly doubled, and the frequency increased 3.5 fold. From Gallarate to Varese the speed has been increased 75 per cent., and the frequency about fourfold. The carrying capacity of the line, in passenger miles, has thus been increased about 75 per cent. On the branch line to Arona and Porto Ceresio the speed has not been much increased, on account of the gradients. Professor Carus-Wilson estimates the cost per train-mile for the new service at 12.7d. per mile against 20.7d. for the steam trains (see Table I.). Coal is reduced from 5.3d. to 3.4d., the stoker is saved and a cheaper man taken as driver; the wages of the conductor work out to less per mile on account of the increased speed, and repairs are halved because the trains are reduced in that proportion. On the other hand, there are wages at the generating and converting stations to be allowed for, the net result being a saving of about 8d. per train mile. But the train mileage has been increased in the proportion of 8 to 28, and thus the cost per mile of line has risen from 510*l.* to 1110*l.* In addition, 5000*l.* per mile have been spent on the electric equipment, which at the very inadequate interest of 3½ per cent. would add a charge of 175*l.* per mile, making the total increase 775*l.* per mile. The present passenger receipts are 600*l.* per mile, hence the passenger traffic must be increased 129 per cent. to pay the interest and increased cost of running, assuming that the old fares are maintained. When the hydraulic power plant is complete and coal is no longer required, the cost per train-mile will be reduced to 9.3d., and the traffic will only need to be increased by 80 per cent. to pay expenses.

On the Lecco line the service of steam trains was about half as frequent as on the Varese line, and the proportional increase will be about the same. The increase of the cost of running, with transformer sub-stations, will be about 150*l.* per mile per annum with water power. The passenger receipts per mile per annum are, as stated, 380*l.* for the section Lecco-Colico, 220*l.* for Colico-Sondrio-Chiavenna, and 330*l.* for the whole line. Thus an increase of 325*l.* per mile per annum will require an increase in the passenger traffic receipts of 128 per cent. If the fares are reduced, as is contemplated, a further additional increase in passengers will be required. These figures appear to assume that the goods and miscellaneous traffic will be worked by electricity at the same rate as by steam, and that the locomotives will be practically scrapped. Probably such assumptions err on the side of safety. If all the capital cost of the electric installation is debited to the passenger traffic, there should certainly be a small saving on the goods traffic, for the repairs and renewals of electric locomotives cannot be as high as those of steam motors, the boiler being the chief cause of expense.

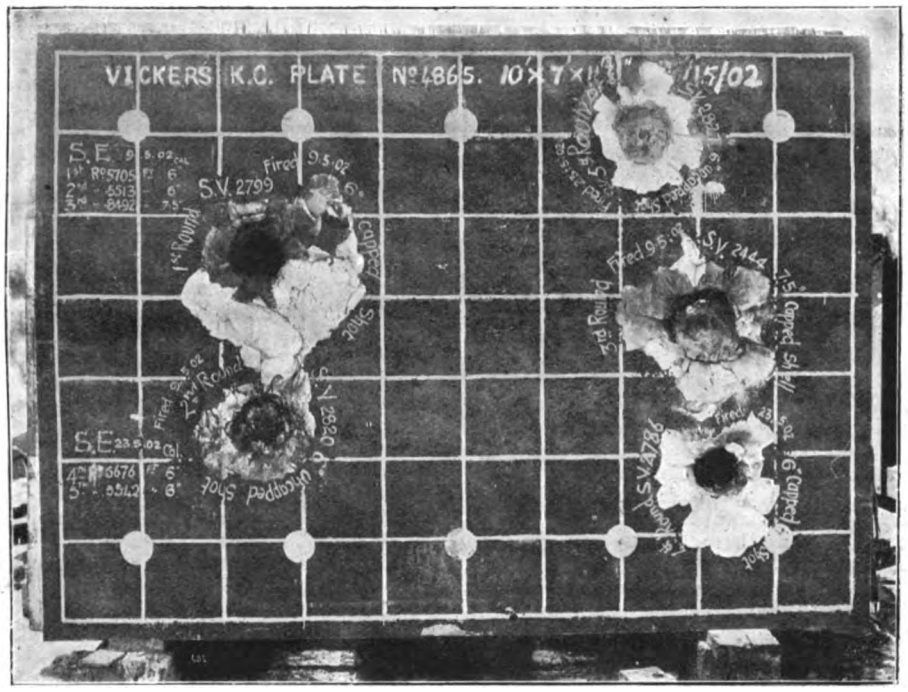
Professor Carus-Wilson then attempts to apply the same principles to an English railway—the Great Northern—and calculate what extra traffic will be needed on a branch having eight trains per day to pay for the cost and maintenance of electric working. He makes the cost per train-mile to be 8.16 pence against 13 pence for steam, the weight of the train being reduced to one-half and the speed about doubled. The saving is largely attained by halving the repairs and renewals; in addition the cost of driver and stoker is cut down from 3.8 pence to 1.5 pence, on the assumption that only one man will be required. It is, however, generally understood that the Board of Trade will not allow a train to be run by one man. One man is allowed on a tramcar, but that is at a speed not exceeding 12 miles an hour. On the other hand, on the Isle of Man electric tramway, which is practically a railway, only one driver is employed on a train, but possibly the Isle of Man lines are not under the control of the Board of Trade. The wages of the conductor are written down from 1.5d. to 1.2d. per mile on account of the increased speed, and, on the other hand, there is rather more than a penny a mile added for wages at the generating and converting stations.

From these assumptions Professor Carus-Wilson arrives at the conclusion that the running expenses of a line with eight trains per day each way are 320*l.* per mile, and that if the service is altered to 28 trains per day of about half the weight and double the speed, driven by electricity, the cost will be 960*l.* per mile, made up of 680*l.* running expenses and 280*l.* interest on plant. The net result is that the passenger traffic must be increased by 61 per cent. to cover the increased expenditure.

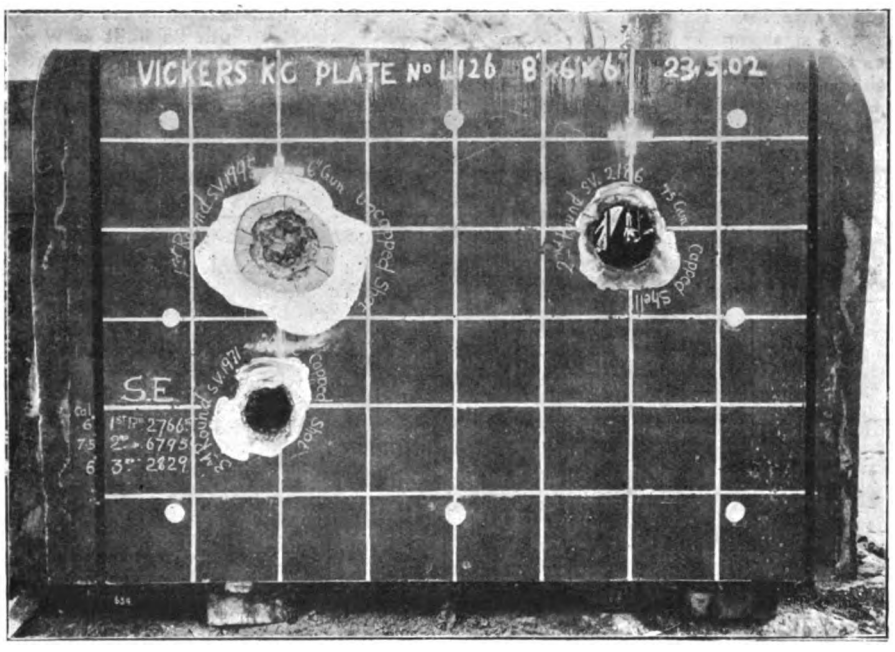
We perfectly agree with the professor's contention that electric working will not pay without increased traffic, and have already put that view forward several times in these columns. We, however, find a difficulty in accepting all his figures. The 3½ per cent. he allows on capital outlay is certainly too small, but it might pass if an adequate amount were added for depreciation and renewal. He allows 1.2d. per train-mile for repairs of motors and generating stations, and inferentially

GUNS *VERSUS* ARMOUR-PLATES.

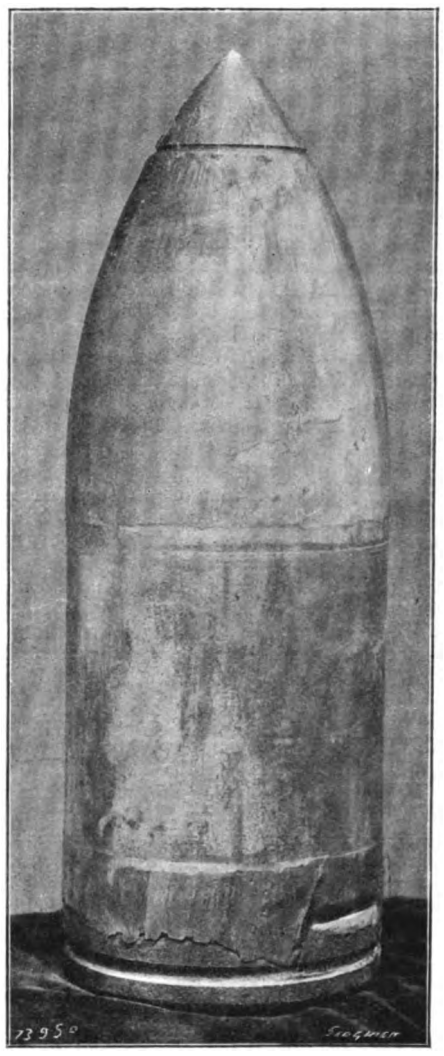
(For Description, see Pages 717 and 724)



RESULTS OF FIRING AT 11½-IN. CEMENTED ARMOUR PLATE (KRUPP PROCESS) BY VICKERS GUNS AT ESKMEALS.



RESULTS OF FIRING AT 6-IN. CEMENTED ARMOUR-PLATE (KRUPP PROCESS) BY VICKERS GUNS AT ESKMEALS.



6-IN. PROJECTILE AFTER PASSING THROUGH 6-IN. PLATE.

for sub-stations and line equipment, as these are not mentioned elsewhere. This sum, on the basis of his traffic, works out to 100*l.* per mile per annum, or 1.2 per cent. on a capital expenditure of 8000*l.*, making for interest, depreciation, and repairs, 4.7 per cent., or less than half what it should be. Locomotive power usually averages about 9½d. per train-mile on railways, or 800*l.* a year on a 20,000-mile running. Of this 3d. to 3½d. is for renewals and repairs, which, on a basis of 20,000 miles a year, amount to 250*l.* annually on a capital expenditure of 2500*l.*, or 10 per cent. annually. We need to add at least 400*l.* a year to Professor Carus-Wilson's figures, making them 1360*l.* a mile in place of 960*l.* Passenger receipts he takes at 43d. per train-mile; hence, according to his calculations, it would require an addition of 61 per cent. of passengers to pay the extra 640*l.* a mile required yearly; and, according to our calculations, an addition of 100 per cent. to pay 1040*l.* a mile.

Averages are, however, apt to be delusive, and it would be safer to take the case of a line which corresponds more nearly to the Italian Railways than does the Great Northern. We might select the Isle of Wight Central, which, as many people know, is not distinguished for speed or convenience. It comprises 41 miles of single road, and its total passenger receipts in 1900 were 26,162*l.*, or 638*l.* per mile. The total gross revenue is 44,055*l.*, the net revenue 14,152*l.*, and the return on the 585,734*l.* of paid-up capital about 2.4 per cent., of which the shareholders get nothing, the debenture interest swallowing the whole. To electrify the line at 5000*l.* a mile would cost 205,000*l.*, involving an annual charge of 20,000*l.* a year for interest, renewal, and repairs. Now, it is evident to the blindest that it is absolutely impossible to reduce the present gross expenditure of 29,903*l.* by the sum of 20,000*l.* by any system of working that can be devised, and consequently it is only by an increase of traffic—and that a large one—that electric traction can be made to pay. If the present eight or nine trains each way per day were maintained as at present, and no alteration made in frequency or speed, then the passengers would need to be increased nearly 80 per cent.; while if there were a substantial increase in train-mileage, the proportion of new passengers must be still greater.

All this sounds very discouraging, and seems to suggest that there never will be any electrification of our branch railways. But in spite of it the Italians are pressing forward with their work, and are doing so with the full assurance that it will pay. There is a great deal of travelling capacity in this country not yet provided for, especially away from main lines. The instant success of electric tramways and light railways shows this. If the Isle of Wight Central Railway were worked as a tramway, there is but little doubt it would be a success. Its present capital is only about 14,000*l.* a mile. If 5000*l.* were added to this for equipment, the total would still be below 20,000*l.* This is by no means an excessive capital for a tramway. For instance, the Potteries line, of 19 miles, has cost 558,000*l.*, and is paying well. The Blackpool, St. Anne's and Lytham tramroad, of 5½ miles, cost 129,000*l.*, and earns nearly 4000*l.* a year net profit. The Rossendale Valley Tramway, of 6⅓ miles, cost 67,676*l.*, and has 3000*l.* net receipts. Other more apposite instances might be found were it not that the latest figures available are nearly a year old, and it is only recently that electric tram-

NOTES FROM THE UNITED STATES.

PHILADELPHIA, May 20.

A VERY unexpected demand has been presented for steel rails, and for railway equipments and supplies for 1903. Inquiries are now arriving, and owing to the continued oversold condition of all mills, it is quite probable that within the next few weeks very large 1903 requirements will be covered. Inquiries have also been received for deliveries during the latter part of this year. One order has gone abroad for Pacific Coast delivery. It is understood from the very best authorities that the requirements for the coming year will be extraordinary. The demands will include shop and round house equipment. A great many heavy sections ranging from 70 lb. to 100 lb. rails will be presented. It is quite evident that the railway managers recognise the probability of a continuance of existing conditions, and in view of the fact that an immense amount of railroad building is projected, they are taking time by the forelock, as rail-makers are willing to take contracts at 28 dols., and may advance prices later. All statements, and, in fact, all intimations given, go to establish the probability that steel rail quotations will be kept where they are, but railway managers have taken alarm and desire to be secured. Steel billets are not to be had, and quite a number of inquiries have been rejected and orders turned down. Quotations are nominally 35 dols. German steel can be imported 30 dols. to 31 dols., but there is little to be placed upon prompt deliveries. The demand for structural material continues to crowd mills, and prices are nominally 2 dols. to 4 dols. per ton higher. Engineers, contractors, and others have turned to Europe, and are endeavouring to place large orders abroad—in several instances have succeeded in doing so. The present production of pig iron is 1,150,000 tons per month, or 18,000,000 tons per year. This capacity will be exceeded with the incoming of several furnaces now being hurried to completion. Bar mills throughout the country are oversold and overcrowded, and a large amount of business is in sight for summer placing. The plate-iron steel makers fail to meet or put up prices, but another meeting will be held on June 5 for that purpose. The demand for merchant steel and merchant pipe and boiler tubes, including skelp iron and steel, is extraordinary, and all mills are being strained to keep up with the urgent demands of buyers. It is probable that some very large contracts will soon be placed for crude steel for 1903 delivery. Everything is sold up for this year, and manufacturers appear to be willing to place orders for 1903 at current rates. There is danger of a further advance in Southern iron from 12 dols. for No. 2 foundry. An order has been placed abroad by Chicago parties for 20,000 tons of billets; 2000 tons of imported sheet bars were ordered from Pittsburgh a day or two ago.

ARTILLERY *VERSUS* ARMOUR.

WE reproduce on pages 720 and 721 photographs taken of cemented armour-plates (Krupp process) after being attacked by the Vickers 6-in. and 7.5-in. guns and various types of projectiles, also manufactured by Messrs. Vickers, Sons, and Maxim, Limited, while the accompanying Tables set out the official results in tabular form. The plates, as shown on the engravings, are 6 in. and 11$\frac{13}{16}$ in.—practically 12 in.—in thickness, and were manufactured to Admiralty specifications. The first of the trials took place on the 9th inst., when the Controller of the Navy—Admiral May—and other naval officials were present. The remainder of the shots were fired on the 23rd inst., when practically the whole Board of Admiralty was present, excepting the First Lord—Earl Selborne—who was prevented at the last moment from attending, owing to the suddenly-convened meeting of the Cabinet to consider peace proposals.

The attack on the 9th inst. was against the 12-in. plate, and the results are set out in Table I. The first round from the 6-in. gun, with a capped projectile at the high striking velocity of 2799 foot-seconds, completely perforated the plate, although the projectile was broken up. The second shot, without cap, penetrated 3$\frac{3}{4}$ in., and the third, an explosive shell from the 7.5-in. gun, was buried deep in the plate, as shown; a probe could be inserted round the edge to a depth of 7 in. On the 23rd inst. two further shots were fired at this plate, both from the 6-in. gun, as recorded in Table II., the one with a cap going through the plate, and remained in the backing; but the fifth shot, without a cap, was broken up, and measurement showed that it had only penetrated to a depth of 3 in.

The attack on the 6-in. plate on May 23 consisted of three rounds, the first and third from a 6-in. gun, and the second from the 7.5-in. weapon. Both guns using capped projectiles completely defeated the plate, the 7.5-in. explosive shell passing through it; the greater part (92 lb.) was discovered bedded in a sand heap beyond the target, but the 6-in. shot without a cap did not make any impression on the plate.

TESTS OF 6-IN. AND 7.5-IN. GUNS AGAINST 6-IN. AND 12-IN. CEMENTED (KRUPP) STEEL ARMOUR-PLATES.

TABLE I.—FIRST, SECOND, AND THIRD ROUNDS AGAINST 11$\frac{13}{16}$-IN. PLATE.

Date: May 9, 1902. Firing at Eskmeals range for trial of 7.5 in. and 6 in. Vickers armour-piercing projectiles fitted with Johnson cap against a 12-in. Vickers K.C. plate, No. 4865. Ordnance No.: 1037A, 6 in., B.L. Mark B.; and No 1017A, 7.5 in. B.L., 50 calibres. Mountings: Naval pedestal. Present: Admiral May, R.N.; Commander Hope, R.N.; Major Minchin, R.A.; Major Bittleston, R.A.; Mr. Albert Vickers; Lieutenant Dawson; Mr. Malcolm Hay; Mr. E. M. Johnson; and Major the Hon. A. Lambart.

Round.	Charge. Nature.	Charge. Weight.	Projectile and Fuze.	Velocity. Mean Muzzle.	Temperature of charge 80 deg. Fahr. Thermometer {Dry bulb 48 ,, Wet ,, 47 ,, Barometer .. .. .. 30.25 in. S.V.	S.E.	Ramming.
		lb.		ft.-sec.	ft.-sec.	ft.-tons	in.
1	R.R. 381, Nitro-cellulose	34	Vickers 6 in. A.P. shot, fitted with Johnson cap 105 lb.	2856	2799	5705	41.65
2	Ditto	34	Vickers 6 in. A.P. shot without cap 100 lb.	2880	2820	5513	41.55
3	Cordite $\frac{30}{30}$	43	Vickers 7.5 in. A.P. shell, fitted with Johnson cap, 205 lb.	2480	2444	8492	66.75

ROUND 1.—Completely perforated plate. Projectile was broken up. Penetration measured 18 in. to base of shot, after removing its fragments the penetration measured 23$\frac{1}{2}$ in. Extent of injury by scaling, 18.5 in. H. by 20.5 in. V. No cracks. Diameter of hole 6 in. This shot struck exactly in front of a horizontal H. girder, and bulged it back 1$\frac{7}{8}$ in., otherwise it would have gone completely through.

ROUND 2.—Projectile completely broken up. Penetration about 3$\frac{3}{4}$ in., but point of shot remained fused in plate. Extent of injury by scaling, 18$\frac{1}{2}$ in. H. by 19 in. V. No cracks. Diameter of portion of shot in hole = 8 in. There was no trace of bulge at back, or any displacement of backing.

ROUND 3.—Projectile broken up, but all the point portion, including 2 in. of core, remained in plate; it was not, however, fused in as in Round 2, for a feeler could be inserted in many places round the periphery up to 7 in. from face of plate. Penetration to front end of core was 5 in.; if, therefore, the point preserved its profile, the total penetration would be 9$\frac{1}{2}$ in. Base portion set up and part flowed in molten state into the front of core, moulding itself to its contour. Extent of injury, 23.5 in. H. by 21.5 in. V.

TABLE II.—FOURTH AND FIFTH ROUNDS AGAINST 11$\frac{13}{16}$-IN. PLATE.

Date; May 23, 1902. Firing at Eskmeals range for trial of Vickers 6-in. armour-piercing shot fitted with Johnson cap, against a Vickers 12 in. K. C. plate, No. 4865. Ordnance No.: 1037A, 6-in., Mark B. Mounting: Naval pedestal. Present: Lord Walter Kerr, Admiral May, Admiral Fawkes, Captain Foote, R.N., Colonel T. E. Vickers, Mr. Albert Vickers, Mr. Douglas Vickers, Lieutenant Dawson, Mr. Malcolm Hay, the Hon. S. P. Bouverie, and Major the Hon. A. Lambart.

Round.	Charge. Nature.	Charge. Weight.	Projectile and Fuze.	Velocity. Mean Muzzle.	Temperature of charge .. 80 deg. Fahr. Thermometer {Dry bulb .. 55 ,, Wet ,, .. 54 ,, Barometer .. .. .. 30.3 in. S.V.	S.E.	Ramming
		lb.		ft.-sec.	ft.-sec.	ft.-tons	in.
4	R.R. 381. Nitro-cellulose	34	6-in. Vickers A.P. shot fitted with Johnson cap. Weight, 105.5 lb.	2841	2786	5676	41.75
5	Ditto	34	6-in. standard A.P. shot without cap. Weight, 100 lb.	2887	2827	5542	41.7

Three rounds had previously been fired at this plate on May 9, 1902.

ROUND 4.—Shot completely perforated plate, but did not get through the wood backing or skin-plate. The shot remained in backing, the rear of base being 9 in. from surface of plate; a feeler could be inserted along the outside of shot to a distance of 16 in. from surface of plate. The extent of injury by scaling was 20 in. H. by 22$\frac{1}{2}$ in. V.

ROUND 5.—Shot completely broken up. Penetration 3 in. Point of shot remained fused in plate. A large piece of shot rebounded and was found 20 ft. in front of plate.

TABLE III.—TRIALS AGAINST THE 6-IN. PLATE.

Date: May 23, 1902. Firing at Eskmeals range for trial of Vickers 6-in. armour-piercing shot and 7.5-in. armour-piercing shell, both fitted with Johnson caps, against a Vickers K.C. plate, No. 4126, 8 ft. by 6 ft. by 6 in. Ordnance: No. 1037A, 6-in., Mark B, and No. 1017A, 7.5-in., 50 calibres. Mounting: Naval pedestal. Present: Lord Walter Kerr, Admiral May, Admiral Fawkes, Captain Foote, R.N., Colonel T. E. Vickers, Mr. Albert Vickers, Mr. Douglas Vickers, Lieutenant Dawson, Mr. Malcolm Hay, the Hon. S. P. Bouverie, and Major the Hon. A. Lambart.

Round.	Charge. Nature.	Charge. Weight.	Projectile and Fuze.	Velocity. Mean Muzzle.	Temperature of charge .. 80 deg. Fahr. Thermometer {Dry bulb .. 55 ,, Wet ,, .. 54 ,, Barometer .. .. .. 30.3 in. S.V.	S.E.	Ramming
		lb.		ft.-sec.	ft.-sec.	ft.-sec.	in.
1	Cordite $\frac{20}{17}$, Lot 119	12.5	6 in. A.P. shot (Vickers), without cap. Weight, 100 lb.	2034	1995	2766	41.25
2	Cordite $\frac{30}{30}$, Lot 117	35.3125	7.5-in. A.P. shell, fitted with Johnson cap. Weight, 205 lb.	2221	2186	6795	66.75
	Cordite $\frac{20}{17}$, Lot 119	12.24	6-in. A.P. shot (Vickers), fitted with Johnson cap. Weight, 105 lb.	2007	1971	2829	41.31

ROUND 1.—Projectile broke up, point remaining fuzed in plate. Extent of injury by scaling, 24 in. H. by 22 in. V. There were no cracks. There were signs of a bulge at the back.

ROUND 2.—Complete perforation took place; no pieces of shell, except the base-plug, were found. The size of hole was 8.75 in. by 8.5 in. Extent of scaling, 14.5 in. H. by 14.5 in. V. The point of shell of this round, weighing 92 lb., was subsequently recovered, having penetrated 20 ft. into sand at rear of target.

ROUND 3.—Complete perforation took place. Projectile broke up, pieces being found in rear. Size of hole, about 6$\frac{1}{2}$ in. Extent of injury by scaling was 13 in. H. by 14 in. V.

A series of five rounds was then fired from the 7.5-in. gun at a target 1000 yards off. Starting with the gun loaded, the time to pressing trigger for fifth round was 31 seconds. All the rounds hit within a space about 6 ft. H. by 5 ft. V.

THE NORTHERN COALFIELD.—A report of Mr. J. M. Hedley, His Majesty's inspector of mines for the Newcastle district, for 1901, has been issued as a Blue Book. Although the returns show that 3452 more persons were employed, the output of coal—viz., 24,416,572 tons—fell below that of the previous year by 75,745 tons. Cumberland and Durham showed an increased output of 86,887 tons and 59,687 tons respectively, but there was a falling off in Northumberland of 222,319 tons. The falling off in the output was not altogether unexpected, although it is somewhat anomalous to find it coupled with an increase in the number of persons employed. The inspector explains the decline by pointing out that during the early part of the year trade was brisk, and consequently a considerable number of additional persons were engaged. The demand afterwards fell off; but instead of any hands being discharged, all the men's names were kept on the books and the pits worked short time. The quantity of mineral raised per person employed was: In Cumberland, 323 statute tons per employé below ground, and 243 above ground; in Durham (North), 380 tons below ground and 302 tons above ground; in Northumberland, 345 tons below and 279 tons above ground; making an average for the district of 357 tons below and 285 tons above ground, as compared with 375 and 297 tons respectively in 1900.