TO CORRESPONDENTS.

**** *Covers for binding the volume can be had from the publisher, price 2s. 6d. each.*

**** *We must request those of our correspondents who desire to be referred to makers of machinery, apparatus, &c., to send their names and addresses, to which, after publishing their inquiries, we will forward any letters we may receive in answer. Such answers, published to catch the eye of an anonymous querist, are in most cases merely advertisements, which, we are sure our readers will agree with us, should be excluded as much as possible from this column.*

ERRATUM.—*In Mr. Williams' letter on Heat and Steam, in our last number, the last sentence of the fourth paragraph should appear, not as a quotation, but as Mr. Williams' own comment on the two sentences just preceding it, and which embraced the matter intended to be quoted.*

C. T.—*Nearly every boiler maker is a Cornish boiler maker, provided he is asked to make one.*

A. G. (Glasgow.)—*Mr. Thomas' address is Newgate-street, City, corner of St. Martin's-le-Grand.*

J. T.—*Steam may be instantly condensed at any pressure by admitting it into a condenser of sufficient size.*

J. H.—*Each turnpike trust has its own tolls. Mr. Garnett's bill, now before the House of Commons, aims to introduce an uniform and equitable toll for such vehicles.*

S. T. D.—*We believe the Society of Engineers is in what may be called a satisfactory condition, both pecuniarily and in respect of the influence which it commands.*

BODMER'S WASHING MACHINES.—*Mr. R. Bodmer requests us to state that the washing machinery illustrated in* THE ENGINEER *of February 8th is the invention of M. Charles Brown, of Winterthur, and M. F. Witz, of Frauenfeld, Switzerland.*

SARNIA.—*Tramways, so far as they attract vehicles from the macadamised covering of the road, will certainly reduce the wear of stone, and possibly affect the stone trade to some extent. The increase of highways, however, is likely to keep pace with that of tramways, and the latter may, indeed, stimulate the construction of the former.*

A. M.—*A calculation would give nearly 600 lb. as the bursting pressure of your egg-ended boiler, supposing it to be rivetted in the usual way. It ought to be safe at 100 lb., or even 125 lb. The other boiler is, certainly, badly proportioned, and, as small as it is, we would not care to work it above 50 lb. We mention these pressures on the presumption that the workmanship is of good quality.*

T. T. (Constantinople.)—*The only rule we know of whereby to "find the pitch" of a screw propeller is to divide the distance intended to be run in a minute by the number of revolutions, and then to increase the quotient by from 10 to 20 per cent. for slip. The "proper way to line out the bearings for the whole length of the screw shafting" is a question which we would like to submit to our practical readers, any of whom, by answering it, will oblige an engineer abroad.*

W. P.—*The strength of a cast-iron pipe to resist bursting depends upon the diameter and thickness of the pipe, and the quality of the iron. If the latter have a tensile strength of 8 tons (17,920 lb.) to the square inch, then multiply 17,920 by twice the thickness of the pipe, and divide the product by the diameter in inches. The quotient will equal the bursting pressure in lb. per square inch. This multiplied by 2·3 will express the head of water in feet at which the pipe will burst.*

CAST-IRON IN SEA WATER.

(To the Editor of The Engineer.)

SIR,—Can any of your readers mention any cases where cast-iron has withstood the action of sea water for a number of years, and, if so, what is the quality of the iron? PYM.

FORGING SCREWS.

(To the Editor of The Engineer.)

SIR,—Would you, or any of your readers, be kind enough to inform me whether there is any machinery for making the thread of screws in a red-hot state? T. D. L. H.

Anzin (France), February 19th, 1861.

HIDE ROPE.

(To the Editor of The Engineer.)

SIR,—Will you, or any of your numerous correspondents, be kind enough to inform us where "hide rope" is to be obtained? It is largely used on board of ship, but is now more extensively used for sack-tackle purposes, &c. Any early information will oblige.

Frome, February 17th, 1861. JOHN RODGERS AND SON.

THE BAND SAW.

(To the Editor of The Engineer.)

SIR,—Will you be so kind as to inform me, in your next number, who is the patentee of the band-sawing machine for wood cutting, and about the time it was patented? I know of several patentees for improvements, but cannot find out the patentee for the machine. J. N. P.

High-street, Colchester, February 15th, 1861.

HEATING FEED-WATER.

(To the Editor of The Engineer.)

SIR,—Can you kindly inform me, through the medium of your columns, whether there is a patent out for heating water after leaving the force-pump and before going into the boiler? if so, whose, and on what principle?

Sunderland, February 19th, 1861. AN OLD SUBSCRIBER.

[*We publish the above for the purpose of inviting some of our correspondents to answer the questions asked. Such heaters are in use, but we cannot say whether they have been patented.*]

THE SLOTTING DRILL.

(To the Editor of The Engineer.)

SIR,—Under the heading of "Notes and Memoranda," in THE ENGINEER of the 1st inst., the following paragraph occurs:—The "slotting or cotter drill was first employed, we believe, by the late Mr. Holtzappfel. It was subsequently improved by Mr. Nasmyth, the late Mr. Forsyth (of Messrs. Sharp, Stewart, and Co.), and others." I feel it due to myself, as well as to you, to state that I made my first "slotting machine" or machine specially adapted for cutting slots in the interior of wheels, &c., in the year 1824, previous to which time and subsequent to 1817 I had cut slots both internal and external, on the "planing machine," also invented by me. The slotting machine made by me in 1824 had its cutter in the form of a chisel. In the year 1834 I made a machine for cutting slots in which the cutter was a *drill*.

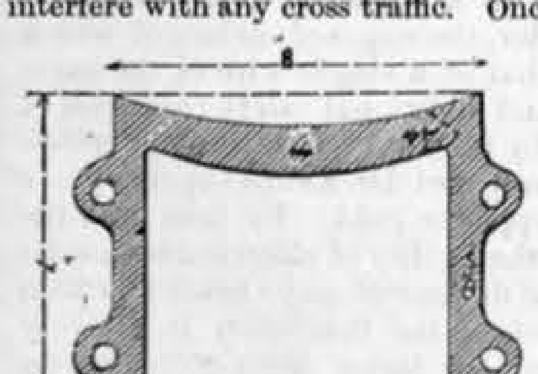
Hitherto I have believed myself to be the original inventor and manufacturer of both the "chisel" and "drill" slotting machines, and I am not aware that the former has been improved by anyone except myself, when I adapted it for *paring* and *shaping metal objects*. Should I be wrong in this conclusion, I have no doubt I shall be set right by some of your correspondents. RICHARD ROBERTS.

10, Adam-street, Adelphi, London, 20th February, 1861.

STREET TRAMWAYS.

(To the Editor of The Engineer.)

SIR,—As much is now being said about the street tramways I beg to submit the following plan as cheap and durable in practice:—It could be laid in any street; and, being set level with the pavement, would not interfere with any cross traffic. Once laid, it would be permanent until the tram was worn through, and need not then be removed if the upper or wearing surface was inserted in the base by a dovetail-joint, shown at the dotted lines. I submit the following would be one of the most, if not the most, economic plans that companies or corporate bodies (the latter being the likeliest parties for such undertakings, they being the local governments of the cities and towns to be benefitted by such institutions), could adopt, and could be cast in lengths most convenient for use, the same being made continuous by coupling bolts passing through lugs or flanches; or dovetail-joints might be used. This plan would be permanent for many years, admitting of crossings at right angles or any degree of curvature, and would be a safe receptacle for the electric wire, now so essential to the progress of business in our cities and towns.



Companies and corporations will do well to consider this plan, as the tram could be cast at a price equal to that of water or gas pipes, and the interest on that portion of the capital might be secured in part by the use of the same for the reception of electric wires. J. W.

Goathland, February 8th, 1861.

MEETINGS NEXT WEEK.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 26, at 8 p.m., continued discussion upon Mr. Fox's paper "On Iron Permanent Way," and, if time permits, "Description of a Pier erected at Southport Lancashire," by Henry Hooper, Assoc. Inst. C.E.

SOCIETY OF ARTS.—Wednesday, 8 p.m., "On the Alpaca, and its Introduction into Australia," by Mr. George Ledger.

INSTITUTION OF NAVAL ARCHITECTS.—The following is the programme of proceedings which the council of this institution have issued. The meetings, it will be observed, are to be held next week:—Thursday, February 28th. The Right Hon. Sir John Pakington, Bart., G.C.B., D.C.L., President of the Institution, in the chair. Morning meeting at 12 o'clock. Paper 1: "On the Construction of Iron Vessels of War, Iron-cased," by J. D'A. Samuda, Esq., Member of Council.—Paper 2: "On the Professional Problem presented to Naval Architects in the Construction of Iron-cased Vessels of War," by J. Scott Russell, Esq., F.R.S., Vice-President.—Paper 3: "On a New Mode of Constructing Shot-proof Vessels of War," by Charles Lungley, Esq.—[The remainder of this meeting, and an evening meeting also, will be occupied by a discussion on the above subjects, in which Capt. E. P. Halsted, R.N., Vice Admiral Sir G. R. Sartorius, Rear-Admiral T. Henderson, Capt. Sherard Osborn, R.N., Capt. Coles, R.N., J. Nasmyth, Esq., J. Anderson, Esq., Josiah Jones, Esq., and other gentlemen will take part.]—Evening meeting, at 7 o'clock. Discussion on Iron-cased Ships of War, as stated above.—Friday, March 1st. Morning meeting at 12 o'clock. Paper 1: "On the Rolling of Ships," by the Rev. J. Woolley, LL.D., Vice-President.—Paper 2: "On a Method of Calculating the Hydrostatic Stability of Ships," by S. Read, Esq., Member of Council.—Paper 3: "On a New Method of Calculating the Stability of Ships," by F. K. Barnes, Esq., M.I.N.A.—Paper 4: "Notice of the late Mr. John Wood, and Mr. Charles Wood, Naval Architects," by J. Scott Russell, Esq., F.R.S., Vice-President.—Evening meeting at 7 o'clock. The Right Hon. the Earl of Hardwicke, D.C.L., F.R.S., in the chair. Paper 1: "On the Deviation of the Compass in Iron and Other Vessels, considered Practically with reference to Material, Position, and Mode of Construction and Equipment," by F. J. O. Evans, Esq., R.N., Assoc. I.N.A., Superintendent of the Compass Department of the Admiralty.—Paper 2: "On American River Steamers," by Norman S. Russell, Esq., Assoc. I.N.A.—Saturday, March 2nd. Morning meeting at 12 o'clock. Paper 1: "On the Wave Line Principle of Ship-Construction." Part III. Conclusion, by J. Scott Russell, Esq., F.R.S., Vice-President.—Paper 2: "On the Classification of Iron Ships," by J. Grantham, Esq., Member of Council.—Paper 3: "On the Construction of Unsinkable Iron Ships," by Charles Lungley, Esq.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—Thursday, at half-past 7 p.m., "The Foundry," by Mr. A. F. Yarrow.

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THE ENGINEER.

FRIDAY, FEBRUARY 22, 1861.

THE GREAT EASTERN, AND IRON-CASED WAR-SHIPS.

GENERAL SIR HOWARD DOUGLAS has long been recognised as the principal literary champion of wooden ships of war. Whenever there has been a chance of introducing iron into their construction, he has uniformly exerted his influence, which is by no means inconsiderable, against the project. In his latest pamphlet on this subject he reminds us that he was long ago consulted by the late Sir Robert Peel as to the use and efficiency of iron frigates, and that he stated, in reply, "that vessels wholly constructed of iron were utterly unfit for all the purposes of war, whether armed, or as transports for the conveyance of troops." In the pamphlet just mentioned he has revived his former objections, and contended, as we saw some weeks ago, against the use even of the iron-plated ships of the present day.

Up to this time, Sir Howard has had the field almost exclusively to himself; but during the last few days Mr. Scott Russell has stepped forth in vindication of the use of iron, and has published a pamphlet* which will exert a serious counteraction to the influence of Sir Howard's writings. It is generally known, by this time, that the author of this pamphlet was consulted on the iron-cased ship question by the National Defence Commission, and that he prepared numerous designs for them; it is also known that he has had plans for iron-cased frigates before the Admiralty ever since 1854; for both these reasons he is entitled to speak with some confidence upon this question. On general grounds, also, it will be acknowledged that the defence of iron, as a material for ships, could scarcely have been undertaken by any person more likely to do it justice in a pamphlet intended for public perusal.

The passage in Sir Howard Douglas's remarks, which seems to have excited Mr. Scott Russell's open opposition, contains a depreciatory observation respecting the Great Eastern, and runs as follows:—

> The question which I proposed to examine was as follows:—Whether ships constructed wholly, or nearly so, of iron, are fit for any of the purposes and contingencies of war? I came to the following conclusion: first, that ships formed wholly, or nearly so, of iron, are utterly unfit for all the purposes and contingencies of war, whether as fighting ships or as transports for troops; 68-pounder solid shot would pass through the Great Eastern with tremendous effect, and the perforation in the outer shell could not be plugged up; she is an awful roller, and has never attained anything like calculated speed; second, that thin plates of iron, even ⅝ths of an inch thick, are proof against shells or hollow shot in an unbroken state, but that the fragments of the shot and shell pass through the plates and produce an effect perhaps more formidable than any shell; third, that being proof against shells will avail little unless the vessels are likewise proof against solid shot; fourth, that the thickness of plates required to resist shot, fired from the heaviest nature of gun, must not be less than 4½ in.

This, it will be admitted, reads much more like the language of a pamphleteer than of a philosopher. It is, however, in no way inferior to many other portions of Sir Howard's last production. The 4½ in. mentioned at the end of the above quotation must, he says, become 6 or 8 in. if the iron is to be used without a timber backing; and then he "constructs a dilemma," as Mr. Russell truly says, in the following fashion: 6 or 8 in. of thickness are essential to the perfect impregnability of iron. This weight of iron cannot be carried without destroying the sea-going qualities of a ship—therefore a vessel of war cannot be made at once impregnable and a good sea-boat. Now Mr. Russell denies that the true issue between the two materials, wood and iron, is here fairly stated. The real question, he says, is this: Is iron less liable to injury by the missiles of modern warfare than wood?—not, is it absolutely invulnerable? Will the balance of advantage be, on the whole, with the wood or with the iron? And he undertakes to show that an iron fleet, superior in every way to a wooden fleet, may be constructed. The iron ships shall be stronger, he says, than wooden ships of equal weight; they shall have less draught of water; shall carry heavier weights; shall be more durable; shall be safer against the sea, fire, explosive shells, red-hot shot, and molten metal; and shall be practically impregnable even against solid shot. Some of these advantages are, of course, well known to belong to iron vessels; and it seems to us somewhat pedantic on the part of Mr. Scott Russell to write each of them out at length, as he does, in a separate paragraph, and with a number of its own. We do not require him, or anyone else, to tell us impressively that iron will not take fire so speedily, or burn so well, as wood. Further, in the above enumeration of advantages, we get the same thing recurring in two or three places. For instance, if one ship be lighter than another, and therefore draw less water, our humblest reader will see, we trust, that she will carry greater weights than the other at an equal draught. It is quite true that the pamphlet is intended for general perusal; and it is equally true that there is an under-current of banter directed against Sir Howard Douglas, of course, in this and other parts of the production. Still, as the paper is intended to be read by men of science as well as men of no science, and as it contains other matter of a most weighty nature, we should have been glad to have seen small considerations, or well-understood facts stated less imposingly. We dwell for a moment on this point because that of which we complain recurs frequently in the course of the article, or manifesto, or whatever it may be more properly termed. On page 20, for a further example, Mr. Russell gives an *exposé* of certain prejudices which experience "has one by one painfully rooted out;" and the first prejudice which the author thinks it necessary to discourse upon is that "iron cannot swim." He occupies some twenty lines with an explanation of "how iron swims." Nothing, we cheerfully acknowledge, could be more lucid or effectual than the explanation which he gives; but was it necessary at this time of day? To suppose that it was given ostensibly for the especial and exclusive information of Sir Howard Douglas would be to suppose Mr. Scott Russell to be very cruel indeed in combat. Yet we are disposed to think this is the true cause of its appearance here; for, on a previous page, we find a foot-note written expressly for the purpose of informing Sir Howard that in iron shipbuilding it is not usual to bring the corners of four plates together!—a piece of information, which, we are sorry to say, Sir Howard seems to stand in need of. There is yet one other exception which we have to take to Mr. Scott Russell's essay. Near the end he tells us that, not many years ago, it was commonly found that the calculation of the displacement of a ship was an effort of skill which exceeded the powers of the Department of the Surveyor of the Navy. We think this must be—nay, we are confident it must be—an error. The department was, we admit, sadly unscientific before the present race of naval architects carried their skill and culture to it, but it was not so bad as all that!

Having pointed out what we consider the principal blemishes of the paper before us, we must now proceed to say that, notwithstanding these defects, it is a most important production. The reply to Sir Howard Douglas is, in the main, most masterly, and *must* exercise a great influence upon the public mind at this crisis of our naval history. Before noticing its main features, it is right also to say that the designer of the Great Eastern disposes most completely of Sir Howard's ill-advised remarks upon that noble vessel. He shows that when the motions of the great ship were tested experimentally, in the worst weather encountered on the outward voyage to New York—by Mr. Zerah Colburn, of that city, and by a fellow-engineer of his, Mr. Holley—the roll was never found to be greater than 8 deg. to windward and 13 deg. to leeward, giving a mean of 10½ deg. A table of observations, furnished by Mr. Russell's son, who performed the voyage in the ship, confirms the testimony of these gentlemen, and is, of course, confirmed by it. The author ingeniously adds to these facts and figures—by way of showing his readers what an "awful roller" is—an extract from Mr. Wood's brilliant narrative of the Prince of Wales' tour in Canada, in which he asserts that the Ariadne rolled from 24 deg. to 26 deg. to windward, and from 30 deg. to 36 deg., or even 38 deg. to leeward. As to the speed of the Great Eastern, Mr. Russell states (and appeals to the ship's log for confirmation) that she realised 13·9 nautical miles, or 16 statute miles an hour on the whole of her voyage from America, during a great part of which she was not in her best trim; while his own calculations never induced him to hold out an expectation of more than 14 knots when in her best trim. We can ourselves confirm the latter assertion by reference to a circumstance which we perfectly well remember. On the day when the members of the Houses of Parliament lunched on board the great ship in the Thames, some time before she left her moorings, we had an interview with Mr. Scott Russell on board, and requested him to tell us what speed he himself expected the ship to realise; and his answer was—"I expect 14 knots; we may get a little more, but we can't expect it. Remember she has but 1-horse power to nine or ten tons." What Mr. Russell now says in his pamphlet is exactly what he then said to us. He concludes his reply to Sir Howard, on this question of speed, by quoting a calculation made and published by Mr. Reed, by which the performance of the Great Eastern is shown to be very excellent.

We must refer our readers to the pamphlet itself for a full statement of the arguments by which the author rescues iron from the charges brought against it by Sir Howard; suffice it here to say that he denies in detail that 68-pounder shot would do the Great Eastern so much harm as they would do a timber-built ship, or that the perforation in the outer shell could not be plugged. He contends that the

* The Fleet of the Future: Iron or Wood? Containing a Reply to some Conclusions of General Sir Howard Douglas, Bart., G.C.B., F.R.S., &c., in favour of Wooden Walls. By J. Scott Russell, Esq., F.R.S., Mem. Council Inst., C.E., and Vice-president I.N.A. Longman, Green, Longman, and Roberts. 1861.

experiments hitherto made with iron plates, as targets, instead of being adverse to the merits of iron, have shown that thin plates, even five-eighths of an inch thick, are proof against shells, that plates 2 in. thick are impenetrable even to fragments of shells; that 4½ in. plates are nearly impenetrable to shot fired from the heaviest guns; and that 6 in. plates are practically impenetrable. He contends also that the experience of Captain Hall and Captain Charlewood, in ships of iron actually engaged in war, has shown the three following things:—First, that even where the thickness of the vessel's side is not more than half-an-inch thick, shots fired obliquely have glanced off, although they would have penetrated a weaker vessel; secondly, that shots fired directly have passed through both sides of the ship, doing less damage directly, and less damage by splinters, than would have happened in timber ships; and, thirdly, that the shot-holes have been as easily stopped, and more easily, expeditiously, and less expensively repaired, than in wooden ships.

The great advantage which the author claims for iron over wood is its indestructibility by incendiary shells of any kind. It is now admitted, he says, by the experienced naval officers with whom he has conversed, that a close engagement between two ships of the line must be a question merely of five minutes as to the total destruction of either or both. "The practical conclusion from this state of things is," he goes on to say, "that such an action has become impossible; and, therefore, if no better means of defence had been discovered, wooden walls have ceased to be an effective defence." This conclusion is, we think, reached rather too hastily, although we think it must be ultimately accepted. Before wood is utterly condemned as a worthless material for ships of war, it ought, we think, to be inquired whether, by a new mode of combination, or by a new system of construction, timber could not be better adapted to resist fire than it is at present in our ships. Most certainly it could, we think. Two things are requisite for the combustion of wood—the wood itself and oxygen, or, we may say, air. A timber structure, to the various parts of which air has free access, when once lighted, will speedily be destroyed. But exclude the air, and it is not easy to burn it, nor is it at all possible to burn it rapidly. As ships are now built, the air has free access to her timbers and planks through thousands of open spaces, and she therefore burns quickly; make her hull solid throughout, and it will be very difficult indeed to consume her by fire. Ordinary shells would not fire her: nor do we believe red-hot shot would; we are doubtful if even molten metal would often do it. These considerations are ignored by Mr. Russell; but they must be borne in mind if the subject is to be argued exhaustively.

When all these things are considered, however, much remains to be said in favour of iron. It is a native product—may be had in abundance—is certainly fire-proof—can be fashioned into any required form and of any required size—and can be made to afford any requisite degree of impregnability. Mr. Scott Russell contends that, in addition to these advantages, an iron ship of a given size and strength may be made much lighter than a wooden one; and, therefore, if a steamer, may be made to carry fuel for much longer voyages. This last is a very important point, and one respecting which Mr. Russell is known to hold exceptional opinions. He is pre-eminently the advocate of *lightness* in the hulls of iron ships. On this subject he is practically at issue, we believe, with nearly the whole shipbuilding profession. We by no means mention this disparagingly; on the contrary, after a good deal of consideration, we believe him right, and the profession wrong, on this point. It is a matter, be it remembered, on which it is very easy indeed for a class of men to err. In the first place, when people put plenty of material into a structure, they think they are sure to be "on the safe side." This consideration exerts a continual influence in favour of weight of material—in disregard of scientific considerations, often enough, as we have seen over and over again in engineering constructions. Then, again, there is the influence of precedent. When a class of men once begin to do a foolish or an ill-considered thing, they are sure to imitate it, and are very likely to go on imitating it for years out of mere regard for precedent. If no obstinately-original man happens to arise among them, to reason them into a wiser course, or to shame them out of the foolish one, they will come at last to look upon their practice, however absurd it may be, as little less binding upon them than a law of nature. We do not mean to say iron shipbuilders are so bad as all this; on the contrary, they have been steadily improving their practice ever since they commenced it. But we do say that a great deal of iron is put into ships in a most unavailable manner, and we think Mr. Scott Russell deserves immense credit for the clearness and persistency with which he has advocated a better disposition of material in iron ships. The Great Eastern is both the lightest and the strongest ship in the world for her size. Although of 23,000 tons burden, her hull weighs but 8,000 tons; yet she went through the unprecedented trials of her launch—through "long months of torture," as Mr. Russell phrases it—in a manner which completely established the soundness of the principle upon which she was built, in so far as her longitudinal strength is concerned. We desire to be very explicit on this head, because, as the thoughtful reader will see, the advocacy of lightness in the hull of a ship is likely to be resisted by builders from many causes, and from no cause more commonly than from a want of such a degree of sound mechanical knowledge as is essential to the investigation of a question of this kind. It requires considerable scientific knowledge to enable a man to grasp such subjects; but we must not, on that account, check improvement—nay, on that very account, we must labour all the more to strengthen the hands of every real improver. It must be acknowledged, however, that Mr. Russell tries the confidence of his professional brethren very severely by the extreme to which he seems to push his principle. The hull of the Orlando, a wooden frigate, weighs, he says, 2,500 tons. "The weight of an iron ship of equal tonnage is 1,500 tons. . . . On an equal draught of water the wooden frigate can only carry equipment and stores amounting to 3,000 tons, while the iron vessel can carry 4,000 tons." It is exceedingly probable, however, that he has good grounds for his estimate, and that 1,500 tons of metal is amply sufficient to build an iron ship as large as the Orlando, and even stronger than she.

In another article we may discuss the "Future Fleet of England," which forms the subject of the concluding chapter of Mr. Scott Russell's very interesting essay.

OCEAN TELEGRAPHY.

THERE is, perhaps, at the present moment no art in immediate connection with science so much open to the charge of empiricism or the imputation of the absence in practice of a scientific basis, as that of electro-telegraphy. There is no doubt that it is far behindhand with electricity, considered as a science, although great and important progress is now imminent. This disparity between theory and practice is an unfortunate consequence of the fact that the best electricians, even were they disposed to leave their own sphere of abstract science, are by no means fitted to become the best electrical engineers. The former generally regard scientific facts without any reference to ways and means; the latter often lose sight of science amid the more material considerations connected with its application. Thus it is that telegraph engineering has had a tendency to remain in *statu quo*. It is, however, an infant and a growing application of science, and we have reason to expect that its practice should become greatly modified and improved by our present experience. It was perfectly comprehensible at the onset that practical electricians, like doctors, should in some cases disagree, and that opposite opinions should be upheld on equally good authority until one or the other was proved to be a misapprehension. Thus certain telegraphists—on abstract grounds which appeared from the first, and were ultimately proven to be, contrary to the first principles of electrical science—may have advocated fine wires and "intense" currents without serious detriment to their reputation when the expediency was recognised of employing the "quantity" current, and reducing the resistance of the conductor accordingly. At the present moment the advantages of light over heavy telegraph cables may, with some show of reason, be upheld upon theoretical considerations, although these advantages may appear to be negatived by practical results. There are even now many reasons for diffidence and caution, as well as for some diversity of opinion, in the new and important profession of the electrical engineer. But we must state that, while in some instances there have been few external indications of prudential misgivings on the part of the professional authorities who have been called upon to influence the disposal of capital, there has been manifested an unaccountable degree of reluctance to initiate improvement. When the responsibility of failure may be traced to an innovation, it may be natural to endeavour to follow the safe and beaten track which has led to success. But in ocean telegraphy no such path has yet been trodden out. Past experience has shown rather what is to be avoided than what is to be followed. Innovation is required to effect improvement; and successful innovation can alone, at present, constitute the test of merit. Of caution and circumspection there is ample need, but these must be exercised in a broader field than that of adherence to the past. This will be until electric engineering becomes so nearly a *science parfait* that success is better to be achieved by a strict adherence to its established rules than by the best considered innovations.

All this means simply that in this particular branch of engineering men are required of an original stamp—careful in theory, fearless in carrying new ideas into execution. We would not lead any of our readers to infer that we doubt the fact that such men are to be found among the electrical engineers of note at the present day. But we would strongly deprecate the tendency to conservatism, not to say imitation, which has been manifested in carrying out our latest telegraphic enterprises. There is no adequate reason why any proposed telegraph cable should be, with little exception, the exact copy of a former one. In every case there will be reasons to the contrary, until a cable be laid which may be referred to as a near approach to perfection. We need not insist upon the fact that at the present moment perfection is emphatically a question of degree. Opportunities for improvement are without doubt to be found in the manufacture and management of every new cable; and there are certainly grounds for considering that many of these opportunities have hitherto been neglected. In many cases practice has run counter to the best established theory in refusing to recognise or give effect to improvements sanctioned by the results of scientific investigation and experimental trial.

We would refer more particularly to the continued use of the "deadly coils" of external iron or steel wire, and to the exclusive employment of gutta-percha for insulation, as instances of the tendency which has prevailed to ignore improved appliances which are obviously necessary for the progress of ocean telegraphy. The disadvantages of the spiral coil arrangement of the strengthening wires have long since been pointed out; and nothing, as far as we know, has ever been advanced in favour of the same, beyond the fact that expensive machinery had been provided for the manufacture of cables according to this plan. There is reason to fear that similar considerations have in several instances been allowed to interfere with the efficiency of telegraph undertakings. It is well known and understood that the spiral disposition of the outer wires not only causes the insulating material to be powerfully compressed, and forced into the interstices of the metallic covering; but by rendering the latter capable of extension, throws the tensile strain in laying the cable upon the conducting wires. This is precisely what is to be avoided by the adoption of an outer wire covering. If, as stated by Mr. H. C. Forde in a report to the Treasury, the shrinkage of a hemp covering (as recommended by the late Mr. Robert Stephenson, for the Gibraltar cable), is sufficient to injure mechanically the gutta-percha core, it is somewhat surprising that the effect of the enormous pressure exercised by the spiral covering under tension should have been pertinaciously overlooked.

The exclusive employment of gutta-percha in insulation is equally difficult of explanation. Compared with other available insulators, pure and vulcanised caoutchouc, and various compounds of the gum, it is found to be inferior in every respect. At 180 deg. Fah., or even at 212 deg. Fah., the mechanical and non-conducting properties of pure caoutchouc remain unaffected to any material extent. In gutta-percha these properties become considerably impaired, even at a temperature of 100 deg. When we consider the liability of a telegraph cable to be exposed to the action of heat previous to its submersion, the importance of this consideration cannot be overrated. The mechanical properties of caoutchouc appear to render it peculiarly adapted to resist the strain and compression to which the insulating material is exposed. Under the pressure of 1,000, or even of 1,300 atmospheres, the insulation of the caoutchouc covering remains perfect. When submerged under water its durability appears to be at least equal to that of gutta-percha. According to a report of Mr. C. F. Varley, the insulation of caoutchouc appears to be from 50 to 70 times more perfect than that of gutta-percha. The superiority of insulating power in caoutchouc is attested by Professor Wheatstone, Mr. C. V. Walker, Mr. W. H. Preece, and other electricians. Its specific induction is also less, a fact of immense importance in respect to the rate at which the line can be worked. According to Messrs. Werner and C. W. Siemens, the specific induction of gutta-percha being taken as unit, that of india-rubber is equal to 0·7 only, and that of Wray's mixture 0·8. But we would observe that sufficient evidence of the superiority of caoutchouc existed previous to the commencement of the last great enterprise carried out under Government supervision. It is worthy of comment, now that the results of the Government experiments to determine the relative merits of insulators are pretty generally known, that, with the exception of the late Mr. R. Stephenson, not one of the electrical engineers called upon to report in the question of the construction of the Gibraltar cable made any reference to the possibility of employing this gum as an insulator. The attention of practical electricians must now necessarily be directed to it, inasmuch as the increased impurity of the samples of gutta-percha, and the diminution of the supply consequent upon the method of collecting it, render it problematical whether the latter can be employed with advantage in any point of view.

STRENGTH OF IRON.

THE value of one description of iron, as compared with that of another, should, it is to be supposed, depend upon its comparative strength. There are cases, it is true, where iron is employed as much for its mere weight as anything else, inertia or the stability of ponderosity being of more consequence than absolute strength. For such purposes lead would, of course, be preferable to iron, could it be had at the same price. But in a majority of the applications of iron, its own weight is a load, *pro tanto*, upon its power of resistance, and, in bridges, it is easy to calculate the span at which the structure would be destroyed by its own gravity. If, then, there were one invariable standard of cohesive power in all iron, or if it required, let us suppose, ten tons to pull asunder one square inch of cast-iron, and twenty-five tons to part a similar section of wrought-iron—no matter of what make—our whole practice of construction in iron would stand in a very different position from what it now does. From the data contained in the majority of our engineering books it might be supposed that this uniformity of strength actually existed. Many engineers assert that "there is no great difference in iron," and their practice is apparently conducted upon this assumption. Mr. Robert Stephenson assured the Iron Commission of 1848 that there was not probably a greater range than five, six, or seven per cent. either way from the medium strength of all the irons in this country. The same distinguished engineer, however, sent in to the Commission a table of experiments made under his authority to determine the iron best suited to the construction of the High Level Bridge at Newcastle, and of the large number of 1 in. square bars tested on 3 ft. supports, the transverse breaking weight varied all along from 518 lb. to 1,072 lb., the average being something like 800 lb. or 850 lb. Thus, of ninety-six specimens, three bore between 500 lb. and 600 lb., one between 600 lb. and 700 lb., nineteen from 700 lb. to 800 lb., thirty-four from 800 lb. to 900 lb., twenty-eight from 900 lb. to 1,000 lb., whilst eleven specimens bore more than 1,000 lb. The Government experiments, completed last year at Woolwich, comprised 850 samples of cast-iron, all sent in for a competition which was to determine the best iron for ordnance, and in which it is probable that every one sending samples selected such as he believed to be his best. These experiments, as is known, disclosed tensile strengths varying from 9,417 lb. to 34,279 lb. per square inch, the results ranging variously from nearly 14,000 lb. under to 11,000 lb. above the general average. The strongest iron was, therefore, 3⅝ times as strong as the weakest iron. Then, again, there are Messrs. Napier and Sons' experiments, carried out more than a year ago at Glasgow, of ninety cast and puddled steel bars, the range of tensile strength was from 148,294 lb. down to 42,564 lb. per square inch. Of 195 wrought-iron bars, the strength varied from 68,848 lb. to 44,453 lb. Eighty steel plates ranged from 108,906 lb. to 62,435 lb., and 150 iron plates showed a range of tensile strength from 62,544 lb. to 32,450 lb. Of thirty samples of Acadian charcoal cast-iron, tested in December, 1858, at Woolwich, the tensile strength varied from 43,928 lb. down to 15,071 lb. per square in., the variation in strength being, as in all the other experiments referred to, promiscuous, and with no apparent tendency to any general standard. In Lloyd's experiments on rivetted iron ship plates, made some time since at Woolwich, some of the butt straps opened at a strain of but about 4 tons per square inch of actual cross section, and the ⅝-in. plate parted generally at from 5 to 10 tons per square inch of solid iron. After the fatal explosion of a locomotive boiler, in 1858, at an engineering establishment in Manchester, Mr. Fairbairn tested several of the plates, one of which broke under a strain of 4⅜ tons per square inch. Those familiar with iron are aware