Mr. Clark said he had not ventured to broach any theory, or to advance ideas which required defending, or which could be attacked; indeed the Paper was more tentative than anything else. He had been struck with the extraordinary difference in the durability of materials under varying circumstances, and he had alluded to the iron roofs in Geneva and St. Petersburg, the temples in Italy, and other instances, which clearly illustrated the fact, that the durability of materials depended much more upon the circumstances in which they were placed than on any other cause. Many other interesting examples of these apparent paradoxes might be mentioned.

Mr. S. B. Boulton wished to direct attention to a curious fact connected with the durability of timber, a material to which he had devoted a good deal of attention during the last eighteen years. In the course of a previous discussion at the Institution, a piece of creosoted timber was exhibited,[1] which had been attacked by the teredo, and it was said that the timber had been creosoted at Amsterdam. By a singular accident, he happened to be in Amsterdam two or three months after, and while visiting the Royal Museum was shown a piece of the same pile. This had been attacked by teredines, which had penetrated through the uncreosoted part of the wood, and had worked their way into the interior. It was his opinion, however, that if the wood had been creosoted under better conditions, the same circumstances would not have occurred. A few months afterwards, twelve pieces of fir, twelve of beech, and six of poplar, being the kinds of wood used by the engineers in the construction of the dykes, were sent to this country, and were thoroughly creosoted. They were then returned, and were placed in the same position as the piles which had failed, that was to say some at Nieuwe Diep and the rest at Stavoren. About a year afterwards, he received one of the printed reports of the Commission appointed by the Government to report upon the ravages of the teredo, from which it appeared that the specimens were then perfectly sound. The first year a piece had been cut off the timber, to see that no cells of the teredo had been formed in it, and it was then replaced in the water. In the subsequent year another slice was removed, and the wood was still found untouched, and had remained uninjured. Another series of experiments was made by the Ingénieurs des Ponts et Chaussées in Belgium, who had also turned their attention to the subject of preparing timber against the attacks of the teredo. These experiments extended over a period of ten years, when it was found that creosoting was a preservative against the attacks of marine insects. The Belgian Government had adopted creosoting not only for wood

[1] *Vide* Minutes of Proceedings Inst. C.E., Vol. xix., p. 665.

placed in sea water, but also for sleepers for the State railways. Another series of similar experiments had been conducted for the French Government, for a number of years, by M. Forestier, Ingénieur en Chef des Ponts et Chaussées du département de la Vendée. A creosoting establishment had been placed at his disposal at the Port of Sables d'Olonne, and he had found the same results follow. M. Forestier had published a pamphlet, which was almost an exhaustive treatise, on the subject of this destructive worm, in which he laid great stress on the fact that, hitherto, the wood had not generally been impregnated with a sufficient quantity of creosote. The French Companies and the Belgian Government paid particular attention to the wood being well dried before it was creosoted. It was stacked in yards for from four to six months before the preparation took place; and in order to insure this being done, as dry sleepers or dry timber of any kind could not be procured, unless those who provided the wood were interested in getting it stacked for the proper length of time, the system was adapted of examining the wood as it arrived from foreign ports, and, upon approval, of paying over at once to the contractors from four to five-sixths of the total price of the sleepers. These were then stamped with the Company's mark, whose agent saw that they were properly stacked; and after some months, when thoroughly dry, the sleepers were creosoted, and the balance of the price was paid.[1]

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[1] In connection with this subject, Mr. BOULTON presented to the Institution the following official pamphlets, together with English translations of portions of them:

1. "Préservation des Bois contre les attaques du Taret (Teredo Navalis)." Notices par M. Forestier, Ingénieur en Chef des Ponts et Chaussées du département de la Vendée."

In this pamphlet the Author narrated his own experiments with wood prepared at the Creosoting Works of the French Government at Sables d'Olonne, and which he had found to resist the attacks of the teredo when exposed to its action in the waters of that port. He related the results of similar experiments at a number of other seaports in different countries of Europe, including (at pages 27, 28) an account of the fact mentioned by Mr. Boulton as to the successful results obtained with creosoted wood in Holland. The pamphlet was dated April 10, 1867, and the following was a translation of its concluding remarks. "The efficacy of creosote consequently appears to us to be an established and incontestable fact, with the sole condition that it be of good quality, and that it be injected into the wood in sufficient quantity." M. Forestier (at page 32) estimated this sufficient quantity for timber in sea-water to be at least 300 kilogrammes per cubic mètre of wood, which was equivalent to about 19 lbs. per cubic foot English measure. By a subsequent letter M. Forestier stated that he had, on March 6, 1868, re-examined all the specimens of creosoted wood at Sables d'Olonne, and that this inspection confirmed his previous convictions on the subject.

2. "Verslag over den Paalworm." Three pamphlets, dated 1863, 1864, 1865, being the fourth, fifth, and sixth reports (the latter being the last as yet published) of a Commission of Engineers and other members of the Royal Academy of Sciences of Amsterdam. They were appointed, under the authority of the Dutch Government, to investigate into and report upon the dangerous and destructive ravages of the teredo navalis upon the timber used in the construction of the dykes

Mr. H. Conybeare agreed as to the necessity of thoroughly drying timber before creosoting it. At present the creosote generally penetrated but little more than skin deep, for when damp timber was operated on, it was obviously impossible under any

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or embankments round the coast of Holland. The Commissioners report as to the results of their experiments during six consecutive years with greenheart and a great variety of other hard woods, procured from different tropical countries, also with wood impregnated with a number of different substances. In their several Reports, No. 4, page 3; No. 5, page 15; and No. 6, pages 5 and 19, they allude to the success of the creosoted timber sent to them by Mr. Boulton. They arrived at the conclusion that the hardest and best tropical woods which they had been able to procure, including greenheart, American oak, &c., were not exempt from the action of the teredo. They related several instances of creosoted wood having failed, in each case establishing the cause of failure as arising from imperfect preparation. They recorded also the success in every case of wood properly injected with creosote. They reported the failure of a variety of other substances with which they had either impregnated or coated over the timber. And in the last Report, pages 5, 6, and 19, they confirm their previous conclusions and resume in these words:—"That a good preparation by means of creosote preserves wood from the attacks of the teredo."

3. "Sur le Taret et les Moyens de préserver le bois de ses dégâts." By E. H. Von Baumhauer, of Harlem, one of the Members of the Commission above mentioned.

This pamphlet gives a résumé of the foregoing reports, and adopts the conclusions of the Royal Commission; it contains also a detailed description of the natural history of the teredo, and its manner of working, accompanied by engravings. By a letter dated the 2nd of June, 1868, M. Baumhauer states that the creosoted wood in the port of Nieuwe Diep was inspected in March, 1867, by the Engineer-in-Chief of the province of North Holland, and was found exempt from the ravages of the teredo, after exposure to its attacks for more than seven years.

4. "Notes sur la Préparation des Bois," by M. Charles Coisne, Chef de Section à l'Administration des Chemins de Fer de l'Etat Belge. This Report gives a description of the mode of creosoting wood, for the use of the Belgian Government, from 1858 to 1867, at the establishments of Messrs. Burt, Boulton, and Haywood, at Ghent and Ostend, and at that of Mr. Bethell at Antwerp. M. Coisne (page 22) recommends the adoption of creosoting for all railway sleepers, and advises an injection of 250 litres per cubic mètre.

5. The Report of M. Crépin, Engineer of the Belgian Ponts et Chaussées at Ostend, was contained in the pamphlet of M. Forestier, commencing at page 9. M. Crépin gave the result of a series of experiments extending over ten years, from 1857 to 1867. He found that unprepared woods, and wood prepared by sulphate of copper, were rapidly attacked by the teredo. His first experiments being made with wood insufficiently prepared, he found the teredo penetrated the uncreosoted part, but left untouched the part creosoted. By order of the Belgian Government, a number of pieces of wood were then creosoted at the Ostend Yard, by Messrs. Burt, Boulton, and Haywood, with a very complete injection of creosote. These timbers had been entirely successful. M. Crépin concluded (page 18), "you can affirm, that as far as concerns the experiments made at Ostend, the creosoted timbers there are completely preserved from the action of the teredo."

The same conclusion might be arrived at from all these experiments.

1. That timber should in all cases be thoroughly dry before creosoting.

2. That for timber exposed to the action of marine insects, a much larger quantity of creosote was required than had usually been adopted in England.

The limnoria terebrans did not appear to infest the Dutch, Belgian, and French ports referred to in these Reports; though it was probable that the increased quantity of creosote, which had proved so effectual against the teredo, might also succeed if tried against the limnoria.

pressure to force the solution into the pores, which were already pre-occupied by an incompressible fluid. To prepare sleepers, they should be stacked and dried beforehand in a heated shed or hot chamber, as the rifle-stocks were dried at Enfield, till every particle of moisture was thoroughly evaporated. They should then pass directly from this hot chamber into the creosoting tank, which should not at first be quite filled with the solution, in order that a vacuum might be established by an air-pump, until bubbles had ceased to rise from the sleepers, and the tank should then be filled and hydraulic pressure applied. This would insure the thorough permeation of every pore with the solution. Mr. Brunel's opinion was on record that timber, thoroughly creosoted, would last forty years; and no engineer ever gave more attention than he did to the processes for preserving timber, or applied them more successfully, as the long duration of his timber viaducts proved.

Mr. George Farren considered that an accomplished engineer should be not only a good mathematician and physicist, but a good mineralogist, chemist, and geologist as well. He thought, however, that chemistry had not hitherto occupied its proper position in the education of the Civil Engineer, and it appeared to him that it was to this that the Paper seemed directly to point. The Author had drawn together a number of interesting facts, some of them most contradictory at first sight, showing the different and occasionally unaccountable behaviour of the same materials when placed under somewhat different circumstances: but all these differences could be undoubtedly traced directly to chemical action. To the slender and simple list of materials enumerated in the Paper, which the engineer was to use, and therefore to study, the element oxygen should be added, for among the elements it was the most abundant, forming no less than one-third by weight of the world, and it was by far the most active of all. In his opinion it was one, the action of which should occupy an important place in the consideration of the Civil Engineer, as to its incessant action might be more or less directly traced many of those influences upon which the consolidation or perfection of work depended; but which influences, unless properly guarded against or intelligently controlled, no less assuredly were also the most powerful agents in the destruction of it.

He would take this opportunity of mentioning an interesting and curious fact, relating to the behaviour of iron, which had been pointed out to him by Professor Bloxam, of King's College and Woolwich Arsenal. It was well known that dilute nitric acid had a strong action on all but two of the metals, and on iron amongst the number, but if a piece of bar iron was first immersed in pure nitric acid for a length of time, and was then immersed in dilute nitric acid, the latter would be found to have no effect on the iron.

It seemed to be altogether protected by having been first immersed in the strongest nitric acid. Many purely chemical applications had been devised for the purpose of protecting iron from oxidation without attaining perfect success, and whether this curious action of nitric acid on iron might some day furnish the clue to the discovery of a preservative of iron was more than he could say.

Mr. SHOOLBRED observed with regard to the durability of zinc in this country, that it was principally used in sheets as a roofing material, and also as sheathing for vessels. British zinc was mainly derived from spelter, which was found in Cornwall; and zinc was also extracted from the mines of the Vieille Montagne Company in Belgium, Germany, and elsewhere. Generally speaking, from what had come under his observation in this country, it was acknowledged that the Belgian zinc was superior to the British in its wearing power and durability, and this was shown by the former costing about £1 per ton more than the latter.

He had been furnished with a list of the roofs of buildings put up in this country by the Vieille Montagne Company,[1] and he would mention three examples to show the durability of the zinc.

In the case of the cloisters of Canterbury Cathedral, the ecclesiastical architect stated that he had inspected them, and found they were in a perfect state of preservation, after having been up more than thirty years. Another instance was the dockyard sheds at Portsmouth, where, after a period of over seventeen years, three specimens taken from the roof, were found to have lost, on an average, only ½ oz. per square foot by oxidation, the original weight having been 16 oz. The third example was at Swansea, in an atmosphere which, it was feared, would do much harm to the zinc, in consequence of the chemical properties of the gases from the copper works with which it was polluted. In this case a roof, which had been up more than ten years, had been lately examined, and found in a state of perfect preservation.

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[1] VIEILLE MONTAGNE ZINC MINING COMPANY.

List of Buildings covered for some years with Zinc.

The Cloisters, Canterbury	33 years.
Portsmouth and Devonport Dockyards (Slip Shed)	24 ,,
Great Western Railway, Reading Station	20 ,,
Blackwall Railway, London Terminus	20 ,,
South Eastern Railway Stations	20 ,,
Tunbridge Station	15 ,,
South Wales Railway Stations	15 ,,
Greenwich Royal Hospital	15 ,,
Abingdon Railway Station	14 ,,
Oxford and Rugby Railway (Banbury Station)	12 ,,
Wilts and Dorset Railway (Frome Station)	10 ,,
Oxford, Worcester, and Wolverhampton Railway	10 ,,
Works at Swansea	10 ,,
Woolwich Arsenal	5 ,,

For sheathing vessels, the Belgian zinc likewise presented a superiority over the British spelter, as he was given to understand that the ordinary British zinc required to be removed after each voyage, averaging about twelve months, whereas the Belgian zinc lasted, on the average, three years, and sometimes six years or seven years. He had never heard of paint being used as an antidote against oxidation; and he believed the Vieille Montagne Company never, under any circumstances, used it, nor had they found any necessity for so doing.

The injury sustained by galvanised iron had been attributed to the destruction of the zinc; but in the cases which had come under his notice, it seemed rather to arise from the detachment of the coating of galvanised metal from the rest, by the corrosion of the layer of iron immediately beneath it, which therefore allowed the galvanised one to peel off.

Mr. J. M. Heppel said, when in charge of the Madras Railway, he observed that rails which were stacked in the neighbourhood of the sea decayed rapidly, whilst rails laid down in the immediate vicinity of the station in Madras, and exposed to the traffic of frequent trains, did not perceptibly suffer deterioration. This attracted his attention so much, that he had caused some rails which had been stacked for several years to be carefully cleared of all the product of corrosion and weighed, when he found that they had lost nearly 3 lb. to the yard, whilst others close by, exposed to the same atmospheric influences, but subject to the passage of trains over them, had suffered no apparent diminution of weight. Many other engineers had observed the same fact; but he had never heard any one able to account for it.

Mr. Beardmore believed that rottenness depended on damp, or, in other words, absence of evaporation, as when the temperature of the dew-point was equal to that of the air. The dampness of a cellar was proverbial; but in many cases the cellar was no more damp than any other place. The temperature of a deep cellar would be about 50° Fahrenheit in England; and if it were exposed to the free access of a saturated current of air above this temperature, the result would be a deposition of moisture. So, if rails or timber were stacked in such a position as to be shaded, the interior parts were frequently cooler than the atmosphere around; when under such conditions, the air being nearly saturated with vapour, there would be a deposition of moisture, and the iron or wood would become damp, and decay. Both iron and wood, when well exposed, proved durable, but either of them, if screened from the sun, and from proper circulation of the air, were liable to destructive action.

In places far removed from the sea, where the rainfall was small, as on the broad plains of Western America, or of Eastern Europe, or

Siberia, the decay of iron and wood was very slow. It was marvellous how hammered thin iron plate, unprotected by a coating of tin, or even fir-timber, in favourable situations, lasted in Russia, although greatly exposed to the elements. This was owing to the excessive dryness of the climate, and the consequent absence of deposition of moisture.

Mr. W. H. Barlow did not think the presence of damp quite sufficient to explain the decay of iron rails. It was not only in rails that were stacked, but in rails laid in a siding not much used, that this was observed. The great difference between the effects shown upon rails laid in a siding and rails laid in the main line was, that the one by the wear of the traffic had a polished surface, and the other had not; and he thought it was quite possible that a galvanic action arose between the polished and the unpolished surfaces, which tended to preserve the general body of the rail. In no other way could he account for the preservation of the rail; but it was an undisputed fact, that rails in sidings decayed by rust much sooner than in the main line.

Mr. Beardmore attributed the fact of the plates used for roofing throughout Russia resisting the damp so well, to the extraordinary amount of hammering given during their manufacture.

Mr. G. J. Symons remarked that a series of experiments had been conducted at the cost of the British Association,[1] with the view of testing, not only the relative wear of rails in use and out of use, but also of rails in and out of the magnetic meridian. No doubt damp had a great effect on the durability of zinc and other metals; but, inasmuch as rain and dew were not pure water, for they contained various acids and salts in solution, he imagined that it was not water alone, but water with the addition of the salts which produced the effect. The Author had referred to the destructive agency of damp, as distinguished from moisture, and had half hinted at the possibility of there being some kind of minute sporules, which ultimately developed into fungi; he could corroborate this opinion, as he knew of instances in which such sporules were excessively numerous, and were readily detected by passing a large quantity of air through water. Within the last few days it had been suggested to him as not at all improbable, that the slow oxidation of metals exposed to the atmosphere might be advantageously applied to obtaining some of the softer tints in engraving, which it was almost impossible to obtain by the ordinary process of passing a layer of acid over the plates.

Mr. H. S. Bethell observed, that Papers had recently been read before the Manchester Philosophical Society, in which it was stated that, not only were insects found in the atmosphere in cases of disease, but that the fungi which occasioned mildew had also been

[1] "Report of the British Association for the year 1849," pp. 88—112.

found. Drawing a distinction between decay of ligneous fibre, and the dry-rot or putrefaction which originated in the sap, he thought that temperature had a great deal to do with the effect of damp in causing putrefaction of timber. Suppose a close room, where decay had already commenced; that was to say, where an oxidation of fibre, and an absorption of water had taken place. By such chemical and mechanical means considerable heat would have been generated, and the spores of the dry-rot fungi in the air would be found in a hot and damp atmosphere, like that in the time of the carboniferous period, when plants, which under ordinary circumstances would grow very slowly, were developed with surprising rapidity. In his opinion, putrefaction of timber only occurred in confined situations, where decay or oxidation had taken place, and in a soil suitable for the spores of dry-rot fungi to germinate, where heat favoured their rapid development. Few cases could be shown in which putrefaction in wood had taken place where there was a draft of air, though in such situations decay had often occurred.

It was necessary for the preservation of wood, that all water and air should be drawn out of the pores, and that the exterior fibres should be more or less coated with a waterproof material, to preserve them from oxidation, or decay. To prevent putrefaction it was also most important to remove all water and oxygen from the pores, because the water which got into the wood in those foreign countries whence most wood came contained decomposed and putrefactive matters; and the air in the holds of ships was of a damp tropical temperature, and so favoured the growth of dry-rot fungus. No doubt a great deal of the wood imported into England was not only decaying, but positively putrefying on its arrival.

Mr. Pole stated that he had considerable doubts as to the durability of wrought-iron bridges, owing to their liability to be damaged by rust. It was very much the practice in the present day to use wrought iron for bridges of all kinds, even in cases like arches, to which it was less favourably adapted than cast iron; indeed, the substantial class of iron-arch bridges, of which the Southwark was so fine an example, might be said to have become obsolete, a result, he thought, greatly to be regretted. It had also become the custom now, to form the bridges of bars and framing of light section, a plan, which, while he admitted it gave much scope for skill in design, and for economy in first cost, was the worst adapted for durability, inasmuch as the surfaces of these small bars offered increased opportunity for the oxydizing action. Moreover in the places where the bars or frames crossed, or were bolted or riveted together, the speedy destruction was rendered almost certain, as the water got into the interstices, and the motion of the parts, caused by the traffic, hastened the corroding action.

Painting was, no doubt, a great preservative, in the exposed parts, but in many cases (particularly on railways not prosperous in their finances) there was no security for its being properly carried out and renewed when necessary: and at the best it would not preserve the joints and surfaces of contact. He was glad to hear so good an account of the present state of the Britannia Bridge, but he feared that the more modern structures would be less fortunate, and that the lapse of a comparatively short period would find them in a condition to give cause for much disquietude. He thought it a grave question for the profession, whether the use of light wrought-iron structures was not being carried too far.

Mr. Pole would add his testimony to the value of this class of Paper, embodying the result of thought and reasoning. He would on no account disparage Papers of a descriptive character, which were of great practical utility; but he hoped the example set by the Author would be followed, and that Essays involving high attainments would be produced which would serve to elevate the scientific character of the Institution in the eyes of the world.

Mr. J. W. Bazalgette approved of the adoption of cast iron in preference to wrought iron in situations where structures were peculiarly subject to decay. He had lately built a wrought-iron aqueduct for conveying sewage. He had found, by the result, that it was not a wise selection, and he had since adopted cast iron for similar structures, because, at any rate, a thicker material was thus provided at a less cost.

Mr. Vignoles, Vice-President, remarked that formerly a great deal was written as to the benefits that might arise from the impregnation of timber by various compounds of metals, creosote, and so forth, though latterly the subject seemed to have been lost sight of. Long experience and reflection had left him in greater uncertainty than when he began, thirty years ago, to consider the subject; and he was doubtful whether any rule had been yet arrived at, by which it could be ascertained how far creosoting or the other impregnations of timber by metallic agents could be depended on. He could quote instances of uncreosoted timber that had lasted very many years, and of creosoted timber that had not lasted five years.

It had been insisted on latterly that iron sleepers were better than timber sleepers; but he did not agree with that opinion. No doubt many instances had been brought forward in which they had proved successful; and the general result appeared to be this, that where there was a sand or gravel embankment, and good dry ballast, the iron seemed to be superior to timber. If, however, iron sleepers were substituted for timber sleepers, there was a loss of elasticity, so that the gain in the one case was counterbalanced by an increase of expense resulting from the other. On the whole, he preferred timber sleepers.

As regarded the application of wrought iron and of cast iron, he fully agreed with Mr. Bazalgette, from experience acquired in a great number of instances, beginning with the iron bridge at Southwark. There was yet much to learn, and much to apply. The various positions in which the iron should be placed ought to be considered; and the strains and counter-strains to which it would be subject. Generally speaking, for moderate spans, cast iron would suffice; but when the span was large, wrought iron was preferable.

Mr. A. Giles said, his experience was precisely the reverse of what had been stated as the result of experiments at Amsterdam. He had creosoted piles so well that, by great pains being taken, 10 lbs. of creosote to the foot were absorbed by the timber. Those timbers had remained sound for the first four or five years; but after that time had yielded to the ravages of the limnoria terebrans, and, after having been only twelve years in the water, were now reduced to about one-quarter of their original bulk below low-water mark. He believed that when creosoting was not carried out to the extent of 10 lbs. of creosote to the foot, nothing like so good a result could be obtained. He had also tried Kyan's process of pickling timber; and, as some works under his charge were little better than fungus pits, he had taken the opportunity of placing the prepared timbers in them, and had found that the Kyanised timber decayed as fast as any other. His experience in that work was that the duration of timber was from twelve to fourteen years.

It was a matter of general observation, that where rails were in constant use, from trains passing over them, the loss from rust was very small; the waste was simply due to the abrasion of the wheel. At the same time, in iron steam vessels, where there was constant vibration from the engines, corrosion took place to a serious extent. That could only be remedied by frequent painting, or by covering the inside of the vessels, as was now commonly done, with cement.

Some remarks had been made on the durability of timber on the Continent of America; but it was notorious that American sleepers generally lasted only about six years. The timbers of the roof of Westminster Hall were quite sound, and they had been there hundreds of years; and in Germany, he himself had seen in Brunswick several houses with the date of about 1400 cut on the timbers, and those timbers were unimpaired.

Mr. T. Marr Johnson believed that the duration of wrought-iron plate bridges was a mere question of care: if kept clean, well painted, and otherwise properly tended, they were practically imperishable; if neglected, they were proportionately short-lived.

He could bear testimony to the extreme care which the Americans and Canadians take of their wrought-iron structures. The Niagara and Cincinnati wire bridges, for example, were constantly cleaned, repaired, and painted. He had recently passed through the Victoria Bridge, at Montreal, and found it in first-rate order; it was roofed over with tin, and appeared to be well maintained; as far as he could judge, it had lost nothing by oxidation, except perhaps in the bottom plates, resulting from the drip of the locomotives. He thought, however, that lattice or other open work would be more durable in the climate of Canada than plate sides, as it would permit the sun's rays to act more equally upon the two sides of the bridge, which the plates would not, one being in the shade of the other, resulting in unequal expansion, and causing somewhat injurious strains upon the parts of the tubes.

He was surprised at the great difference in duration of the timber bridges, so extensively adopted in the United States, when roofed in, and when exposed to the weather; in the latter case he was credibly informed that their life was but seven or eight years, but when covered in, the same bridge would last thirty years or more; the reason they were not more generally covered in was because the money could be more profitably expended in extending the railway into new country than in protecting the existing works. These bridges were excellent examples of carpentry; were frequently made of pitch pine, not painted or tarred, and were most commonly on the Howe truss principle, the compression members of which were proportioned to bear maximum strains of 700 lbs. to 1,000 lbs. per square inch.

It was true, as had been stated, that sleepers in the Western States lasted but six or eight years; they were of oak or black walnut, round timber, a large proportion of which was sap; they were frequently used very green, and were exposed to a good deal of hard usage, the rails being generally attached to them with dog-spikes, and not being very accurately bedded. The ballast was often very scant, and of inferior quality, which facts might account for their short duration.

Mr. E. B. Webb knew of timber which endured even better below than above ground in damp situations. He had seen timber-posts which had stood in damp ground for upwards of one hundred years, the part above ground having received injury from the weather, whilst that below was perfectly sound, and retained the marks of the axe as well defined as when first made. The statement, therefore, that dampness was destructive of timber required qualification. The timber to which he had alluded grew in Brazil, and it could be obtained in considerable quantities in the interior of that empire. The best kind was called Grauna, but there were several descriptions of similarly durable wood. Although he had referred to wet ground, yet the same timber appeared indestructible in any kind of ground or position, except when placed in the sea. He would add that the sleepers on the Panama Railway were of timber apparently indestructible, called

Guayacon, and were, for the most part, taken from the forests on the banks of the Magdalena River: and large numbers of the sleepers on the Cuban railways were obtained from the same source, and were looked upon as indestructible.

Mr. J. Brunlees had often heard that the Britannia Bridge was suffering much every year from rust; and he hailed with satisfaction the assurance which had been given that such was not the case. The test that had been applied was the surest proof that the iron in the bridge was not suffering from decay.

To preserve cast iron, he had been accustomed for the last fifteen years to boil it in a preparation of tar and asphalte. He believed Dr. Angus Smith had recommended this process to Mr. Bateman for coating the pipes used in the Manchester waterworks; but while Mr. Bateman used a spirit in connection with the tar and asphalte, he used those ingredients alone, as he found that the spirit made them too hard, and the surface produced was likely to be broken from chipping and other accidental causes. The iron was dipped when warm in the preparation, which was heated to near the boiling point. He had also used the same preparation for wrought iron, but the work had been principally sent to foreign countries, and he could not yet speak as to the result. He had specified that the rails for the San Paulo Railway should be coated with the same mixture, and when he was in Brazil he had found them as fresh as the day on which they were sent from the works. Although many of the rails were alongside of and some in the water, yet both on the quays and on the works he found them in perfect preservation, and he would therefore recommend the use of a similar coating before rails were sent to foreign countries.

Mr. E. W. De Rusett observed, that the use of distilled water was the first cause of the destruction of marine boilers, as no scale could form on the plates, from the want of lime or other earthy matter to be deposited; consequently the plates were subjected to the action of the fatty acids, and copper, &c. collected by them when passing through the tubes of the surface condenser, as well as to the constant friction of any insoluble matter in the boiler. This was remedied by introducing a sufficient quantity of sea-water to produce scale, either above or below the tubes, in the surface condenser, so that it was pumped into the boiler with the feed-water. The surplus was blown off as in ordinary practice.

The theory that the vibration of passing trains preserved the rails from rust did not apply to steamvessels as some persons seemed to think. Steamvessels were certainly subject to vibration, but it was not produced by concussion as with the rails; and besides, rails were exposed to the drying action of currents of air, not so the holds of vessels; consequently any saline particles which found their way into the vessel were not evaporated, hence the rusting. This was obviated to a considerable extent by the use of red lead or asphalte, care being taken to scrape the plates thoroughly, so that the paint should be in close contact with the metal.

Another source of destruction, if the plates were not sufficiently protected, was the constant wash of the bilgewater, which soon eat off the heads of the rivets, when they too were washed with the water, and grooved out the exposed plates evenly between the frames, as though a cold chisel had been dexterously used. In the P. and O. S. S. "Ripon," after fourteen years' service, the exposed plates, originally $\frac{11}{16}$-inch thick, were worn to $\frac{3}{16}$-inch, and the landing edge of the inside strake was worn to a knife-edge. As a preventive, Portland cement was laid in the bottom between the floors, as high as the limber holes, so that the water might not stagnate, but flow to the pump strum and be pumped out. This system likewise prevented leakage, as the cement, if properly applied, adhered firmly to the iron.

Another cause of decay was external friction combined with rust, of which a remarkable example was afforded by the P. and O. S. S. "Bengal." After fourteen years' service, the strakes were examined by drilling small holes in various places, and gauging them. The loss of thickness in the plates was as follows:—

	As Built, 1853.	After 14 years' service.	Loss.
	inch.	inch.	inch.
Garboard Strake	$\frac{14}{16}$	$\frac{14}{16}$	0
Garboard to 4 feet water-line	$\frac{12}{16}$	$\frac{12}{16}$	0
4 feet water-line to 6 feet water-line .	$\frac{12}{16}$	$\frac{10}{16}$	$\frac{2}{16}$
6 ,, ,, 12 ,, ,, .	$\frac{10}{16}$	$\frac{9}{16}$	$\frac{1}{16}$
12 ,, ,, 16 ,, ,, .	$\frac{10}{16}$	$\frac{7}{16}$	$\frac{3}{16}$
16 ,, ,, 18 ,, load water-line	$\frac{10}{16}$	$\frac{6}{16}$	$\frac{4}{16}$

It would be seen that internal rust could have had but little to do with such results, as the loss varied so greatly. In the flat of floor there was no diminution of thickness; but it was above the turn of the bilge, or from the 12-feet water-line, that the greatest amount of loss occurred, and particularly at the 18-feet line, where it was $\frac{4}{16}$ inch.

Mr. E. A. Cowper remarked that the grease in boilers in which distilled water was used became so acid by continual boiling as to be nearly as destructive as sulphuric acid, and the holes corroded were sometimes as large as split peas or beans. The neutral base or glycerine was taken out of it by the water. A little chalk lime or magnesia put into the water, prevented that, as the lime combined with the acid, and thus formed an insoluble soap of lime. The lime, or magnesia, might come from the sea water if the boilers were worked with salt water. He added that a timber pile in good sound clay would in his opinion last one hundred years.

Mr. Clark said, in replying upon the discussion, that he had purposely made no allusion in the Paper to the various methods of preserving timber or stone, because he wished to keep it as theoretical as possible. He would endeavour to give some explanation of the cause of rust in rails lying alongside a line and not in use, while those in use and subject to vibration were free from it. In the course of the construction of the Britannia Bridge about one hundred thin plates were delivered, which were not used on account of some error in their dimensions. They were left on the platform alongside the Straits, exposed to the wash and spray of the sea; and, after about two years were literally so completely decomposed as to be swept away with a broom into the water, not a particle of iron remaining. As plates in every respect precisely similar suffered no corrosion when put into the tubes, it was natural to inquire into the cause of this great difference. The circumstances were identical, except that, in the one case, the plates were united into a solid mass, and in the other the plates were unattached and were separated from each other by flakes of rust, and so were more or less insulated. Chemical action was invariably accompanied by electric action. It was, therefore, probable that the difference in the electrical conditions, or rather the different electrical capacities of the large and small masses, might explain this great difference in their durability. To test this, he cut two pieces of plate 4 inches square and $\frac{1}{4}$ inch thick, and after cleansing them carefully, attached them to the outside of the western tube, but with this difference;—one of them was riveted to the tube, so that it was in direct metallic communication, and formed part and parcel of the tube; but the other plate was separated from the tube by a thick glass insulating rod. The difference in the oxidation of the two plates was evident, as in the course of eighteen months, the plate in communication with the tube was scarcely affected by rust, whereas the plate insulated by the glass arm was decaying rapidly. Unfortunately in painting the tubes, a platform was put up which destroyed the two plates, and so the experiment ended. It was, however, evident that the more rapid decay of the small insulated plate was due to its insulation. It might be said that, in a railway-siding, the rails were in the same position as in the main line: but in the main line, from the continual passing of the trains, the rails were brought into electrical contact with the chairs and each other, and they formed part of a mass; while in the siding, rust, which was a good non-conductor, accumulated sufficiently to separate the rails from the chairs and each other.

It had been very properly remarked that wrought iron was not necessarily a durable material. The durability of the Britannia Bridge was entirely due to the great care taken for its preservation. The Bridge was not painted now and then, but it was continually being painted. There was a man there to watch, and as soon as there was the slightest discoloration, before any spot could turn yellow, it was at once scraped and painted, though no doubt if this were neglected, the damage would soon become but too evident. He was sorry to say the rule appeared to be not to preserve iron structures at all. It was painful to see the large number of magnificent roofs and bridges rapidly going to decay for the want of care and a constant small outlay in paint. Many iron girders, built within his time, had been renewed, and there was great danger of serious accidents some day occurring from the neglect of these wrought-iron structures. The lower flanges of bridge girders were frequently covered with ballast and vegetation, and the mischief was not visible; but, if the rust and mould were scraped off, the extent to which the plates were corroded and damaged would be found to be much greater than was imagined. Similarly, iron roofs were generally carelessly painted in the first instance, and then totally neglected; the rods were covered with large flakes of rust, which fell away, while the corrosive atmosphere in the station found always a new surface to act upon, and produced a rapid decay; and many stations were suffering severely from that cause. He regretted that so little care was taken with wrought-iron structures; wrought iron, although an excellent material when properly attended to, was not only a bad, but a dangerous material when neglected; and it was inexcusable not to protect that which was so easily protected.

Galvanised iron was not suitable for the corrosive atmosphere of many of the manufacturing districts; but in the country, and in a purer atmosphere, there was no material more valuable or useful. A wrong estimate of its value had been formed from the fact of its being used for roofs in places where it ought not to have been used. Other materials were much better adapted for such situations, as slate, glass, and timber, which were not liable to damage from a corrosive atmosphere.

Mr. Gregory, President, thought that the Meeting would agree with him that this Paper was a highly suggestive one, from which all might learn a valuable lesson, while it was marked by that practical philosophy which might be expected from its Author. The great lesson to be learnt from the Paper was to look a little deeper than the mere surface for the causes of those actions with which engineers had to contend. With regard to the operation of water in the deterioration of materials, the suggestions of the Paper were very useful, pointing out as they did that condition of dampness which was the most injurious, and the principles upon which protection should be applied. Again, the permanence of materials which suffered from a damp atmosphere, when exposed in an air generally dry, was well illustrated by the durability of the tinned roof coverings common in Geneva and St. Petersburg, and, as many of them knew, in Canada. As engineers they were accustomed to trace the analogy between the elements of animal action and the combustion which worked the steam engine; but the analogy pointed out between decomposition and combustion would probably be new to most of them, and might afford the key to many of the phenomena of decay, which had hitherto been inadequately studied, and which for that reason had not been traced to their true causes.

He alluded to these as simple illustrations of the valuable lessons to be derived from this Paper, (discursive as it might at first appear), by pondering well the observations that had been made by a man known not to be a mere theorist, but to have well applied theory to practice. He was sure all had heard with satisfaction that the Britannia Bridge, which was not only a fine application of wrought iron to structural purposes, but a monument of their greatly-lamented Past-President, Mr. Robert Stephenson, was not undergoing anything like decay. He did not think any amount of watching over structures of that sort could be vain and superfluous; because he was sure, as had been admitted, that structures of wrought-iron plates, unless very carefully watched and protected, possessed in themselves the elements of serious deterioration, and ultimately of danger. Panics were apt to arise in this country, and he thought that this failing extended sometimes to the profession of engineers. Perhaps at one time they were driven into the use of wrought iron with rather unreasonable haste, from a fear of cast iron, arising from its undue or injudicious use in a few instances where it was expected to do more than it could, and where it consequently failed. Every now and then the question of the comparison of wrought iron and cast iron cropped up in the Institution; and he was glad to hear a man of the experience of Dr. Pole raising a warning voice against the indiscriminate use of wrought iron, however great its popularity and its real value and facility of application, unless it were applied under conditions where its permanent security could be insured or watched over, to save it from greater failures than had attended the use of its neglected predecessor, cast iron.

He might have ventured to offer a few illustrations of some of the valuable truths brought forward in the Paper, but he felt that these would suggest themselves to those who would study the Paper itself; and he thought he might, on behalf of the Institution, express the hope that this Paper would be supplemented by others of a similar character.

Mr. Gregory, President, observed that, as the last business meeting before the recess had now arrived, he might perhaps be allowed to say that during this session, 1867-8, the increase of members had been certainly beyond what might have been expected, in times not the most brilliant or encouraging for the engineer. There had been an increase of 45 Members, and 105 Associates. The Register of the Institution now contained the names of 16 Honorary Members, 641 Members, 914 Associates, and 123 Students; in all, 1,694 as against a total of 1,449 of the various classes at the same date last year, including, at that time, 20 Honorary Members, 596 Members, 834 Associates, and 4 Graduates. The class of Students had been created during the past year. The Council took great interest in the advance of that class, and if the Students had not had their own evening meetings during the past session, it was not the fault of the Council. Let him remind those Students who were present, that the Council, as they had announced at the beginning of the session, were anxious to see them bringing their Papers forward for discussion among themselves in that room, under the eye of some one deputed from time to time to preside over the meetings, not actually as a teacher, but to take care that those discussions were conducted in such a way as to be for their benefit and advantage. The Council hoped that, at an early period after the recess, the Students would have sent in several Papers, so that they might have the pleasure of seeing the Students meeting, like themselves, during the next year, and strengthening their powers of thought by the discussion of professional subjects, he would not say in that room as it was then, but in that room very much improved and enlarged.

May 19, 1868.

CHARLES HUTTON GREGORY, President,
in the Chair.

The following Candidates were balloted for and duly elected:—Thomas Login, William Teasdel, and Edward Williams, as Members; Henry Samuel Ellis, Charles Higgins, William Hurst, Samuel Joseph Mackie, and John Palmer Smythies, as Associates.