Mr. PATON begged to direct the attention of the meeting to some specimens of wood transmitted by the Surveyor of the Navy, exhibiting, if possible, more extensive ravages by the *teredo* than those from Southend Pier. It would be observed, that a piece of Jarrah wood, taken from H.M. Ship "Success," which was repaired in the Swan River in 1830, exhibited no appearance of injury from marine worms, although other kinds of timber, in close proximity with it, had suffered severely; that wood was stated, by the shipwrights at Deptford, to be of very good quality, and to resist the ravages of the worm, but he believed that, at present, there had been no experience of its resisting qualities in piles. In his opinion, these specimens established the important fact, that it was impossible, from observations in this country alone, to calculate on the effects which might be produced on timber, by the ravages of the *Teredo navalis*, and other marine worms, in other latitudes.

Mr. C. MANBY (*Secretary*), directed attention to some specimens of "Jarrah" timber from Western Australia; they had been furnished by Mr. R. W. Nash, who had informed him that this material most perfectly resisted the ravages both of the *Teredo navalis* and the *white ant;* sometimes the sap, or outer wood, was pierced by the insects to the depth of half an inch, but the red timber, constituting the main body of the tree, was never attacked by them, nor did it appear liable to decay from other ordinary causes, as some which had been used on its first introduction, about twenty years since, did not show any symptom of injury.

The "Jarrah" timber had been used in Western Australia for all the ordinary building purposes, as well as for hydraulic works, such as piers, jetties, &c., and for ship-building. In the whaling jetty, at Freemantle, Western Australia, though it had been erected for about sixteen years, the timber appeared in as good condition as when first used, and the colonial vessels built of "Jarrah" timber, had traded among the islands of the Indian Archipelago for many years without being coppered, in fact vessels built of that wood were only coppered to prevent the too rapid adhesion of marine plants.

The size of this timber was as remarkable as its other qualities, as the trees frequently exceeded 150 feet in height before dividing into branches; there were no knots or 'gum veins,' but there was a tendency, in growing, to pipe up the heart, which rendered it expedient, when selecting beams, to divide the tree down the centre, or to quarter it: this, however, owing to the naturally large size of the tree, would not be a disadvantage, as it would require to be divided before being used. The supply might be considered un-

limited, as it was chiefly derived from a dense forest occupying an area of about 20,000 square miles, and its present cost in England was £12. 10*s.* per load (of 50 cubic feet), but this would be much reduced if there was a more constant and regular demand.

The DEAN of WESTMINSTER thought that the paper contained matter of great interest to engineers. The Author had gone back as far as the age of Homer; but if he had been a geologist, he would have been able to trace the ravages of the *teredo*, and other boring marine animals of small size, on wood and stone, to much earlier periods. He produced specimens of wood which had floated in the waters of the tertiary seas, from the muddy sediments of which the London clay was formed. The presence of the petrified remains, of many hundred extinct species of plants and shells, and of bones of extinct reptiles and fishes, in the London clay, afforded to the geologist certain tests by which he could distinguish the real aboriginal London clay, from the more recently deposited mud-banks, derived from the detritus of cliffs composed of London clay; the difference consisted in the presence of the petrified remains of these extinct plants, shells, and fishes in the London clay, which were not found in mud-banks composed of the detritus drifted to form new banks of mud, at a distance from the cliffs, whose destruction supplied this mud.

The Reverend Dean then produced specimens of petrified wood from the green-sand, near Lyme, and Sidmouth, bored by ancient species of *teredo;* also from Bath, and from Doulting, near Shepton Mallet, specimens of oolite, with petrified corallines in it, pierced by boring shells. He then compared the more perishable character of the free-working Bath oolite stone, with the more enduring qualities of the Anston and Balsover magnesian limestone. The best kinds of oolite were those used six, or seven centuries ago, in building the Cathedral at Wells, the Abbey of Glastonbury, and the churches at Caen, and in other parts of Normandy, in the time of William the Conqueror; but more enduring than all, he believed, would prove to be, the magnesian limestone, or dolomite, used for the new Houses of Parliament, and for the repairs of the flying buttresses of Westminster Abbey.

He had specimens, showing similar borings by parasitic shells; they were taken from very ancient beds of oolite near Caen, from the marble of the mountain limestone formation, from Marquise, near Boulogne, and from Frèney, near Auxerre; likewise specimens of bore-holes made by modern pholades in chalk, and in the lias at Lyme Regis (Plate 3, Fig. 6.) Vast quantities of lias from Lyme, Whitby, and Dunraven, were brought to London, as sub-

stitutes for the septaria of the London clay, in making Roman cement.

The walls of the Cobb at Lyme Regis showed, that Portland stone resisted the boring of *pholades*, and of all lithophagous shells, and other boring marine worms; it had been repaired with rough blocks of Portland stone about fifty years ago, which were now as solid and free from boring animals as when first laid in the pier, nor had they been at all affected either by the frost, the weather, or the water. The use of Portland stone might, therefore, be recommended for breakwaters and all walls exposed to the sea; its quality of resisting the action of marine worms and of boring shells, might be attributed to the presence of a larger mixture of silica in its composition, than was found in the Bath stone. The Portland stone in a dwarf sea-wall, at least one hundred years old, and also in that on the west side of the old pier at Dover, called "Old Stone Head," was untouched by any boring animals, in consequence of the hardness derived from the silica which it contained.

Although the quantity of flinty matter, in the harder kinds of Portland stone, rendered it impenetrable by the *teredo* and other parasites, the greater number of calcareous rocks, including the hardest kinds of marble, were subject to the action of boring animals. The blocks of Devonshire marble used in the construction of the Plymouth breakwater were pierced by boring shells; but to no injurious extent. The under surface of some ledges of the same marble, on the land near Preston, has been drilled with holes from 2 inches to 3 inches deep, formed by the corrosive action of the slightly acid slime of snails, of the genus *helix;* doubtless, successive generations of snails had, during many centuries, resorted to the same spot, each individual thus unconsciously contributing, in a minute degree, to the making of a deeper and more convenient domicile for its successor. The Very Reverend Dean stated, that the amount of this corrosion was very small; but he would cite three cases, which might serve as chronometers, or measures of its extent. The first of these occurred on the under surface of a semi-calcareous string-course of Kentish ragstone, in the flint walls of the Roman castle of Richborough, near Sandwich, where the greatest perforation might be 1¼ inch in depth. The second was on the under surface of the horizontal top-stone of a large cromlech at St. Nicholas, near Cardiff, which was pierced by similar snail-holes to a depth of from 2 inches to 3 inches. The third was on the under surfaces of ledges of mountain limestone near Boulogne, the deepest of which did not exceed 4 inches. From these data he

inferred, that the rate of corrosion of such holes, was about one inch in a thousand years.

The mode of propagation and dispersion of the *teredo*, and of other boring animals, that were fixed for life to the same hole, either in wood or in stone, was similar to that of oysters, and of many other kinds of the lower species of marine animals, which were not locomotive in their last and most perfect state. The juvenile condition of these low creatures when they emerged from the egg, was that of minute free swimmers, which moved about by ciliæ, and, in many species, by more complex locomotive organs, and were also drifted by tides and currents, till they were brought into contact with a habitation proper for each individual, in its second and fixed estate; thus the newly hatched and locomotive young oyster was drifted, and swam about, till it adhered for life to something fixed. For instance, large oysters were to be seen firmly fixed to the vertical face and side walls of the docks at Havre. So also the young *teredo*, just escaped from the egg of its non-locomotive parent, must be a free swimmer, till tides and currents brought it into contact with some fixed pile, or floating tree, or with the unprotected sides of some vessels, to which it fixed itself, and forthwith became a non-locomotive boring creature, destined never more to quit the domicile, to which, in the first and only free and independent stage of its life, it had been drifted. Investigations of this kind, as to the manner in which destructive creatures found access to the wood of ships, piles, piers, cofferdams, &c., were highly important, as they gave that knowledge to engineers, which enabled them to apply remedies, for preventing the first inroads of the *teredo*, and other parasites, that were destructive to timber in sea water.

Mr. SIMPSON said, he was anxious to modify some of the statements in the paper, as to the alleged failure of the different modes of preserving timber. It was true that some timber piles, variously prepared, which had been sent to Southend and Hartlepool, had been destroyed; but he had since adopted, with apparent success, a process of Mr. Payne's, for the gates at Hartlepool, and his impression was, that they would not be affected by the *teredo;* although placed in a situation, where a pair of gates, made of unprepared timber, had been entirely destroyed in eight years.

The condition of the pier-head at Southend when he first saw it, was faithfully represented by the drawings (Plate 2), and it was a matter of surprise to him how it could be kept standing by such small support as was afforded by a few temporary piles, yet it had resisted, for many months, the force of the sea at the mouth of the Thames. This example more fully convinced him, that in situations exposed

to heavy seas, it was desirable to introduce as few piles as possible for vertical support, and only as much cross-bracing between the piles, and in the platform-beams, as sufficed to give stiffness to the structure; this opinion was confirmed by his observations at the Herne Bay Pier. Mr. Bird, the contractor for that structure, and one of the proprietors of it, had stated to him, that he thought the mass of timber there, by presenting too large a surface, formed a serious obstruction to the passage of the waves, and caused them to impinge with force upon it; they also involved an unnecessary expense in repairs. If wrought-iron piles, of small diameter, founded on Mitchell's screws, had been adopted, as at Courtown Pier,* the evils would have been avoided.

Trussed framing, or any complicated road-way, was evidently so objectionable, that he was induced to adopt, at Southend, plain timber beams, which met over the centre of each pile, and were supported by a corbel piece, firmly attached to the pile-head (Plate 2, Fig. 4). He had also adopted the old form of railing, so much used by Mr. Telford, both on account of the boatmen preferring it, and because it was a greater protection for the platform, which was of importance for a frequented watering-place.

He would explain why he had used timber piles at all, in a situation so notoriously affected by sea-worms. It must be borne in mind, that it was necessary to exercise the utmost economy in the execution of the works, and as a great portion of the piles would be dry for several hours during every tide, he thought, that by only average care in scrubbing and tarring them, the attacks of the worm might be prevented; and then by using iron for the outer piles, up to the water-line and timber above, the structure might be made secure. He was, however, sorry to say, that his instructions had not been attended to, and that in consequence of not exercising even ordinary care, the *teredo* and *limnoria* had already commenced their ravages, and unless something was done at once, the pier would not last for many years. The process of destruction would be like that at the coffer-dam at Sheerness, where after a time it was no uncommon occurrence to see several piles, apparently sound, floated away at each tide; indeed, they were so thoroughly perforated by the *teredo*, that in still weather, by putting the ear to the side of the pile, the worms could be heard at their boring labours.

The cast-iron piles had been very easily fixed, by swaying them to and fro, as had been explained in the paper, and he was somewhat surprised to see how accurately they could be placed, by the simple means adopted.

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* *Vide* Minutes of Proceedings Inst. C. E., vol. vii., for 1848, p. 126.

Mr. NEWTON said, that many piles in the Herne Bay Pier, were affected by sea-worms; their ravages appeared always to extend in a vertical direction. Several attempts had been made to protect the timber, by saturating it under various processes, with however only doubtful success. The simplest, as well as the most effectual plan, appeared to be that of forming round each pile a wooden casing, leaving a space of about an inch all round, which was rammed full of lime, or cement concrete. That process appeared to be perfectly successful, as the pier-master, who first adopted the method, stated, that some of the piles had been so treated for three, or four years, and although the worms had commenced their ravages, they appeared to have been checked, and not to have been able to exist when so enclosed.

Mr. EDWARDS thought, that the subject of the preservation of timber from the worm, was one of extreme interest to engineers. Various applications had been proposed for the purpose of protecting the timber; but he feared that none of them had been used for a sufficient length of time, to satisfactorily test their efficiency. He placed great confidence in the use of "scupper nails," which had been proved at Yarmouth, as well as at other places, to have protected timber for forty years; that process was, however, expensive, as it cost from tenpence to elevenpence per square foot. Cast-iron piling, another alternative, was still more expensive, and he considered further experience was desirable, as to the durability of that material in salt water, especially as to its peculiar property of conversion into a substance resembling plumbago.*

It was very desirable to pay more attention to the natural history of the animals, from whose ravages it was necessary to protect the timber, as engineers would be better able to devise means of remedy, if they knew the precise mode of their attacks.

On examination of the curious and beautiful boring apparatus, with which the extremity of the *teredo* was furnished (Plate 3, Figs. 3, 4, 5), there was strong evidence of the action, by which the holes were produced, being entirely mechanical.

The *limnoria* (Plate 3, Fig. 9) appeared to be furnished with a small mouth, and a few strong teeth, with which it bit out the softer particles of the exterior of the wood, entirely avoiding the knots and the harder parts. These animals had, he believed, never been known to attack teak, indeed, their operations appeared to be confined almost entirely to fir timber.

Mr. G. B. W. JACKSON said, he had been lately informed by

* *Vide* Minutes of Proceedings Inst. C. E., vol. i., 1840, p. 3.

Mr. Jesse Hartley, of Liverpool, that, although he had tried many methods of preserving timber, he had no faith in any of them, for none that he had employed had been successful.

The *teredo* attacked mahogany, teak, Havannah cedar, and sabrin, all very hard woods, and, he believed, it had been found in green-heart timber. At Calcutta the worm was found in timber piles full 6 inches, or 12 inches below the ground. Two years ago, being engaged, under Mr. Rendel, on works in India, he had, in conjunction with Mr. J. Bourne, tried several experiments, in order to test the possibility of preserving timber from the ravages of the white ant. Ninety pieces of wood, 9 inches long by 4 inches square, saturated according to the different processes of Burnett, Margary, and Payne, under the direction of the patentees themselves, were experimented upon, in five situations, one with a considerable amount of moisture and four dry; through inadvertency, Mr. Bethell's specimens were only tested in the dry positions. The result was, that where there was moisture the timber was entirely destroyed, whilst where they were kept dry the result was better, but still not satisfactory. The salt vessels plying on the coast of India used oil of tar, and a considerable quantity of castor-oil, mixed with cow-dung mortar, which, while it adhered to the wood, was an effectual protection for the sides of the vessels.

It had been supposed, that the jarring motion of a train on a railway, would prevent the white ant from destroying the timber-sleepers; but this there was reason to doubt, from the fact, that on a recent examination of the "Hindostan" steam-vessel, a considerable portion of her timber-framing was found to be eaten away by that destructive insect, particularly in the parts close to the engine and boilers, where there had been the greatest amount of vibration.

Dr. Lyon Playfair said, that Professer Forbes, Dr. Carpenter, and himself had been appointed by the British Association to examine into the natural history and habits of those boring animals, but they had not yet arrived at any definite conclusions.

If the boring action of the *teredo* was in reality a chemical action, engineers might have good hopes for expecting, by chemical appliances, to prevent their destructive ravages. The chemical theory supposed, that it was owing to the evolution of carbonic acid, either from the animal, or to that always existing in sea water, and that the action of this caused the solution of the different substances into which they bored. This theory was unsatisfactory for several reasons; it might well explain the action on limestone rocks, in which the *teredo* loved to dwell, but did not explain why they bored into wax, which acid water had no effect upon. The balance of

evidence, therefore, seemed to be against the chemical action. The other view, recently promulgated and entertained, was, that there were little siliceous particles which the *teredo* used, for mechanically boring out the different parts of the structure, but here the difficulty presented itself, that chemists were not able to find the siliceous particles, and it was not sufficiently borne out by any evidence of microscopical observations. In discussing this question, he wished to show, that the state of evidence was, at present, entirely of a negative character. They had been making collections for examination, and by next year would probably be able to arrive at something more positive. At present, he thought that protection from these ravages must depend on practical experience, the collateral sciences being unable to explain the action of these boring animals, on the various substances on which they operated.

The DEAN of WESTMINSTER said, he was not at all of the opinion that the *pholas* excavated its hole by chemical action. The specimens of holes bored by *pholades* in soft limestone, of the lias formation, from Lyme Regis, exhibited the marks of minute cuttings, in parallel circles, by the hard spines, set like the teeth of a file, on the outside of the anterior part of the shells. A succession of rasping actions on the stone, seemed to have been effected, by a movement of the shell backwards and forwards, on its longer axis, and the effects could not have resulted from chemical action: on the contrary, these minute ridges would have been obliterated, by any acid secretions from the animal; whilst the enduring state of these mechanical cuttings on the stone, indicated the absence even of the joint action of acids, co-operating with the rasping mechanical action of the spines of the shell. The experiments cited by Dr. Lyon Playfair, showed that the *pholas* would excavate its hole in wax, where acid secretions would not have any effect. If examined under a microscope, the holes bored in the specimens of lias stone, would exhibit the little cavities,' scooped out as if by a file, or a small graving tool. It was not necessary that animal matter should be siliceous to be hard enough to cut stone; for example, the external enamel of the tusk of the hippopotamus was harder than iron; if a file was struck on the enamel of the exterior convex side of this tusk, sparks would be produced, and incandescent particles of steel would be struck off, but the enamel would not be cut.

With respect to the *teredo*, the drawing of its working valves (Plate 3, Figs. 3, 4, and 5), represented the form of a most efficient auger. It had been stated, that if the ear was applied to the wood, whilst the *teredo* was in the act of boring, the sound of its auger

could be heard cutting the wood; circular cuttings, by this auger, were generally visible on the wood (Plate 3, Figs. 7 and 8), which would not remain, if the *teredo* worked its hole by acid secretions. He thought the auger of the *teredo* cut the wood mechanically, and like the mandible of caterpillars, as was the case with many elm-trees in Birdcage-walk, which were cut down some years ago, because they were perishing from the ravages committed by the mandible of the larva of the *scolytus destructor*. He must repeat, that he thought the boring action of the *teredo* was entirely mechanical.

With respect to the mode of preventing their ravages, he imagined all the processes for impregnating wood with chemical solutions had failed, because any poisonous, or preservative substance, which was absorbed in a fluid state into the wood, might be washed out again gradually, by rain, or sea water. The use of creosote, or oil of gas-tar, was, in his opinion, the only effectual protection for wood, both against rotting and the action of marine worms, for it was well known, that creosote was not soluble in water, and was poisonous to marine worms. The specimen exhibited, which had been cut from one of the piles at Lowestoft Harbour, had been injected with creosote, and was not bored, or touched by any kind of animal, though it had been exposed for upwards of three years; and he believed that as long as the creosote continued in the wood, it would be perfectly uninhabitable, and therefore would not be acted upon by any kind of parasite.

Mr. PETO, M.P., said, that in order to aid, as much as possible, in elucidating the interesting subject before the meeting, he had personally selected from Lowestoft harbour, specimens of timber-piles, creosoted and not creosoted, driven at the same period, at a distance of about 800 feet from the beach. The piece of unprepared timber was taken from a guide pile, which had been left, after the work was completed; it was sawn off at a certain depth, below low-water mark, of neap tides, and it was evident, that whilst the *limnoria* was attacking the surface, the *teredo* was destroying the interior. At the same depth, and close adjoining to the guide pile, he caused to be sawn off a piece of a creosoted permanent pile, which he also exhibited; this was evidently not at all affected by any worm but was perfectly sound; a piece of a creosoted cross-brace next to it, cut from 2 feet under water, was also entirely free from the worm.

From an accurate inspection of all the timber at Lowestoft, he was enabled to assert confidently, that not one piece of creosoted timber had been found to be injured; but so great was the damage

done to all the unprepared timber, that in several instances the gauge piles, which were only three years old, were so much eaten, that the slightest touch broke them. Timber properly prepared according to Mr. Bethell's process would, he believed, perfectly resist the worm, and last much longer under all circumstances; but the process must be well performed to be effectual. The timber at Lowestoft was creosoted by the air being exhausted, and the liquid forced into the timber under heavy pressure, and after remaining in the tank for nearly twelve hours it was taken out and used.

Mr. WHISHAW observed, that as allusion had been made to the white ant of India, it would add to the interest of the discussion, if an account of the nature of that insect, and of its attack on timber, could be brought before the Institution, with a statement of any mode which had been found successful for the prevention of its ravages. He was individually much interested in the question, being in treaty with the East India Company, for laying down a system of telegraphs through a portion of their territory. He had been requested to send out specimens of the gutta percha, with which the wires would be coated; for it was expected, that being a vegetable substance, it would be attacked by the white ant. Specimens which had been subjected to different preparations, had been sent out, and were then undergoing trial; in two or three months he expected to hear the results of the experiment, and would communicate them to the Institution.

Mr. LOVELL REEVE thought, an examination of the different species of the *pholades* and *teredines* would lead to a result, opposed to the theory of their borings being the effect of mechanical attrition. The outer surface of every species of *pholas* was covered with the most beautiful and delicate sculpture; it did not attach itself to the inside of the holes in the wood, or the rock, but left a certain space all round, between the shell and the affected substance, in order to allow a current of water to pass. These animals had been examined by Professor Forbes and Mr. Busk, and no indication of siliceous particles had been found. Monsieur Deshayes, on his return from Algiers, after making accurate drawings and careful investigations, came to the conclusion, that the borings were effected by means of an acid secretion. Mr. Thomson, of Belfast, had examined the operations of the *teredo*, on the pier at Port Patrick, and had arrived at the same conclusion. He had also mentioned the fact of the dock-gates, at Ardrossan, having been destroyed by the *xylophaga* (which was nearly allied to the *teredo*) in the space of eight years, entirely by the action of its acetose juices.

The shell at the extremity of the *teredo* was not, he submitted,

calculated to be used as a boring auger; it was a distinct bivalve, embracing the seat of animal life, as in the cockle, and covering the respiratory organs; while the calcareous sheathing, with which the animal lined its tunnelling in the wood, was immaterial to its existence, and was often dispensed with, as in the *xylophaga*. He must contend, it was utterly impossible, that the deep holes in the specimens of stone exhibited, could have been produced by snails, which only secreted a feeble acid, when under the influence of moisture.

Mr. SHEPHERD said, that at the Mill Bay Pier, on the coast of Devonshire, a raft of creosoted timber, which had been sunk for fourteen months, was only affected by the worm in one spot, where a vessel had rubbed against it, and taken off the outer portion of the timber, so that the worm had been able to penetrate, and had eaten into the heart of the wood; that timber was stated to have been well prepared, under a pressure of 150 lbs. per square inch.

Mr. BETHELL said, in reply to what had just been stated, that he had no doubt it would be found, that the timber had been merely brushed over with oil of tar, and had not been thoroughly impregnated. He had sometimes experienced great difficulty in impregnating the heart of timber; the ligneous matter was deposited from the sap in the longitudinal tubes, and as the tree grew, the long sap vessels were filled with this ligneous matter, and became hard wood, the sap no longer circulating through them. Young wood, in which the sap had recently circulated, was easily impregnated with creosote, or any other liquid. He had particularly advised Mr. Bidder, when adopting the process at Lowestoft Harbour, to use whole timber piles, because the sap-timber on the exterior, which was that most exposed to the worm, could be most completely saturated. All young wood received the creosote freely, and the external parts of the piles being well saturated, no worm or insect could possibly get at the interior, or heart of the pile.

A most searching examination, occupying many days, had been made upon every pile in Lowestoft Harbour, by the direction of Mr. Bidder, and the Report of Mr. Makinson, the Superintendent of the Lowestoft Harbour works, contained the following statement:—

"The following is the result, after a close and minute investiga-
"tion of all the piles in the north and south piers.

"*North Pier.*—The whole of the creosoted piles in the north
"pier, both seaward and inside the harbour, nine hundred in number,
"are sound, and quite free from *teredo* and *limnoria*.

"*South Pier.*—The whole of the creosoted piles in the south pier,
"both seaward and inside the harbour, seven hundred in number,
"are sound and quite free from *teredo* and *limnoria*.

" There is no instance whatever of an uncreosoted pile being " sound. They are all attacked, both by the *limnoria* and the " *teredo*, to a very great extent, and the piles in some instances are " eaten through. All the creosoted piles are quite sound, being " neither touched by the *teredo* or the *limnoria*, though covered " with vegetation, which generally attracts the *teredo*."

There was only one instance of a piece of creosoted wood, in Lowestoft harbour, being touched by a worm, and that was occasioned by the workmen having cut away a great part of one of the cross heads, leaving exposed the interior, or heart of the wood, to which the creosote had not penetrated. At this spot a worm entered and bored to the right, where he found creosote, it then turned back and bored to the left, but finding creosote all around, its progress was stopped, and it then appeared to have left the piece of wood altogether.

Mr. Brunel had assured him, that some creosoted timber which he had put into the sea seven years ago at Teignmouth, was untouched by the worms, whereas all the unprepared timber was more, or less affected.

Mr. Bethell then directed attention to the chemical effect produced on wood, prepared by the injection of soluble salts, such as corrosive sublimate, sulphate of copper, &c., premising, however, that the substances, which acted as preservatives to timber, did not always prove destructive to insects. The preserving property of these salts was considered to be founded upon their power of coagulating the albumen, and the sap of wood, thereby rendering that sap less liable to decay; but that very quality, of combining with the albumen, destroyed the activity of the poison of the salts. A given quantity of corrosive sublimate of mercury, which if administered to a dog would kill it, would when mixed with the white of an egg become coagulated, and if swallowed in that state would be perfectly harmless; so a piece of wood, saturated by those salts, could be eaten by a worm without injury. This property of albumen had been taken advantage of by medical men, in treating cases of poisoning by mineral salts.

Creosote, or oil of coal tar, was insoluble in water, and therefore could not be washed out; and it was so nauseous, that no animal, or insect could bear its smell. He would not venture an opinion, as to whether the *teredo* acted on the wood mechanically, or chemically; but he was firmly convinced, that it could throw out no acids which would operate on the creosote; this view was corroborated by the fact of properly creosoted timber never having been touched by the *teredo*.

The proportion of 8 lbs. of oil of tar per cubic foot, sufficed to

preserve railway sleepers from decay; the sleepers so saturated being, after a trial of several years, as sound as the day they were laid down. A deputation from the Irish Great Western Railway, had lately examined some creosoted sleepers, laid down on the Manchester and Birmingham Railway, in 1839 and 1840, and had found them perfectly sound; the same result had also been found on the Northern and Eastern Railway, where the sleepers had been laid down in 1840.

Timber intended to be exposed to the action of the sea-worm, should be made to absorb 10 lbs. of oil of tar per cubic foot. He was preparing a quantity of piles for Leith Harbour, by order of Mr. Rendel, and there the piles were all weighed separately before being put into the tank, and again on leaving it; and unless they were impregnated in the proportion of 580 lbs. of oil to 50 cubic feet of timber, or one gallon per cubic foot, he did not think the timber was properly prepared for permanent marine structures.

Mr. WARREN stated, that on the Northampton and Peterborough Railway, he had seen creosoted sleepers quite rotten when taken up. Creosote could not be injected into the hard woods, so as to saturate them in an effectual manner.

Mr. BETHELL assured Mr. Warren, he must be labouring under a mistake, as no sleepers had ever been creosoted by him, or as far as he was aware, by any one else, according to his process, for the Northampton and Peterborough Railway.

Mr. WARREN directed attention to Payne's process, which consisted in forcing into the timber two chemical substances, muriate of lime and sulphate of iron, in solution, which, acting on each other by double decomposition, deposited a hard insoluble matter throughout the cells of the wood.

It had been stated, that some piles, prepared according to Payne's process, had been destroyed by worm at Fleetwood; this he must explain had arisen from peculiar circumstances. Owing to being pressed for time, the piles were driven, whilst they were hot and fresh from the tank, and in a rapid tideway; the effect of this was, that the combined material in the wood, which ought to have had some time for crystallizing, was washed out of the timber, and then the worm attacked it. The value of the process was however demonstrated, even under these unfavourable circumstances; as the prepared piles were but slightly affected, while some unprepared piles, driven about the same time, were nearly eaten away.

At Hartlepool, where the dock-gates had been prepared under this process, a considerable quantity of sulphur being also used, the most perfect success had been attained.

It had been stated that a specimen of creosoted timber destroyed by the worm had been procured from Lowestoft.

Mr. PETO must repeat his conviction, that not a single instance would be found at Lowestoft, of a creosoted pile being eaten by the worm. He had personally examined upwards of a thousand piles, without finding one that was affected.

Some gentlemen had certainly procured from the harbour works, a specimen of timber destroyed by the worm; he, therefore, made a point of inquiring into the facts of the case, and found that to earn the money offered for a specimen of timber affected by the worm, a workman had cut away a portion of one of the unprepared guide-piles, such as had been shown to the meeting, and had thus imposed on the persons making the inquiry.

Mr. RENDEL, *V. P.*, observed, that he had given much attention to the subject, and as the best evidence he could offer, he would read part of a letter he had received from Mr. Doswell, who had the conduct of experiments on different descriptions of wood, at Southampton, where the river was so full of the worm, that piles of 14 inches square had been eaten down to 4 inches in four years. The specimens mentioned in the letter, had been exposed at that part of the pier where the worm had been found most destructive, and the result was thus stated by Mr. Doswell:—"From my "examination, last spring tides, of the specimen blocks attached, on "the 22nd February, 1848, to some worm-eaten piles of the Royal "Pier, I am enabled to report, that Bethell's creosoted timbers all "continue to be unaffected by the worms; that the pieces saturated "with Payne's solution, continue to lose in substance by their ravages, "and that the unprepared timbers diminish very fast, except the "American elm, which stands as well (or nearly so) as that pre-"pared by 'Payne's solution.'"*

* In a communication since received from Mr. Doswell, are the following detailed particulars:—

Bethell's creosoted blocks, placed February 22, 1848.

Memel, at low-water of spring tides . .	Unaffected by worms.
Red pine, at low-water of neap tides . . .	
Yellow fir, at high-water of neap tides . .	A few barnacles.

Paynized blocks, placed April 6, 1848.

Red pine, at low-water of spring tides . .	Worm eaten.
American elm, at low-water of neap tides .	A few barnacles.
Fir, at high-water of neap tides	A few barnacles.

Unprepared blocks, placed April 6, 1848.

Memel, at low-water of spring tides . . .	Much worm eaten.
American elm, at low-water of neap tides .	A few barnacles.
Fir, at high-water of neap tides	Much worm eaten.

Sec. Inst. C. E.

The efficacy of any process depended entirely on the care bestowed on it; he had, therefore, adopted the plan which had been explained by Mr. Bethell. At Leith he had not been satisfied with the ordinary test of the quantity of creosote absorbed by the timber, but had insisted on every pile being weighed, on going into and coming out of the tank, and if it had not absorbed the full quantity of 10 lbs. per cubic foot, it was rejected. He would strongly advise every engineer, who anticipated a good result from the use of creosote, to adopt the same plan. He was so fully convinced of the efficacy of creosoting, when the process was thoroughly performed, that he now adopted it in every large work with which he was connected, and he should continue to do so, until he had very convincing evidence that it was not a trustworthy process.

Mr. C. MANBY (*Secretary*) stated, that in accordance with Mr. Bethell's recommendation, he had written to Mr. Hemans, requesting the particulars of his investigations into the merits of creosote for preserving timber, and had received from him the following reply :—

10, *Rutland-square, Dublin,*
December 7, 1849.

MY DEAR SIR,

HAVING resolved on laying the permanent way from Mullingar to Galway, on the system already adopted from Dublin to Mullingar, namely, a combination of longitudinal with cross sleepers, all of foreign timber, my attention was directed to the consideration of the use of creosote for preserving it, by the perusal of Mr. Mark Huish's Report to the London and North Western Board, where its use is strongly recommended, on the authority of the eminent engineers connected with that line. After several inquiries, I felt quite satisfied in my own mind, that creosote was a good thing to use; as derived from and mixed with oil of tar, it must be repellant to moisture, and not capable of being washed out of the timber, even by the action of running water, which impregnations of all kinds of salts or minerals are liable to be; besides which, its more natural affinity to the substance of the woody fibre appeared to me likely to cause its being retained in the pores with greater tenacity. I, accordingly, recommended the Directors of the Midland Great Western Railway, of Ireland, to use creosote for preparing all their timber. I found, however, that the strongest prejudice prevailed against using any preparation, and instances were quoted where other substances had failed, while it was observed, that if it did fail we should be committed to a less durable timber, by the purchase of white pine, and should have paid more for it, including the creosote, than for the best Baltic timber. With much difficulty I succeeded in getting a deputation appointed to investigate with me, and two Directors went over to Liverpool with me on the 29th October last for the purpose. They did not conceal, that their preconceived opinions were, to use their own words, "breast high" against using creosote, on account of its expense, and, as they imagined, its doubtful merits.

We waited on some high railway authorities in Liverpool, who gave my views no encouragement; they had not used creosote, and did not seem to think

much of it from hearsay. Our next step was to Manchester. The line from Manchester to Crewe was, as we were informed, opened to the public about nine years ago, the sleepers being chiefly creosoted; but as the line was used by the contractor some time before the opening, I looked upon the state of those sleepers as giving an experience of ten years. Receiving every assistance from the resident engineer and other officers of the line, we opened the ballast in several places at random, both at joint and middle sleepers; there were cross sleepers of white pine 12 inches by 6 inches at the joints, and intermediate ones of half-round larch and white pine. I examined carefully the ends of the sleepers, and the seat of the chair, where decay generally commences. I had deep incisions made with a chisel, and in every instance the timber was sound, and the pieces cut out smelled very strongly of creosote. Whilst some sleepers close at hand to those previously examined, but laid at a later period and not creosoted, having replaced others already decayed which had not been creosoted, were in many instances rotten. We next directed our attention to a heap of creosoted sleepers taken up from the line and laid aside, which looked suspicious; these were minutely examined, and cut across in several places, but they turned out to be perfectly sound. These cast sleepers had, it appears, been laid on parts of the line where many alterations had taken place, so that they were much cut up by bolt-holes and chair-seats; the crow-bar had also been at work upon them, and many were split, which was the cause of their removal.

I here noticed particularly, a great degree of toughness in the fibre of the wood, which was apparently derived from the creosote. A stop bar, on a siding, unpainted, which appeared to have been exposed to the weather for about ten years, was next examined; this, though greatly bruised and dinged with constant blows of waggon-wheels, showed no sign of decay, although the rain must have soaked for a long time, through the dinges and cracks caused by the blows.

On the following day we proceeded to London, and were there directed to the Eastern Counties Railway, Cambridge line, where cross sleepers of both prepared and unprepared timber had been used (it was stated) since 1840. We got out at the Burnt Mill station, and walked some distance along the line, inspecting the sleepers both in wet and dry places; here they were all chiefly of half-round timber, some creosoted, others not; in every instance the creosoted timbers were sound, and smelling strongly of the oil when cut, but the other sleepers were, in some cases, black with rot, and in most instances considerably decayed.

On the succeeding day, the 3rd November, we went to the Gravesend and Rochester line, where creosoted and other sleepers had been laid, as stated to us, four years previously, on a very wet soil, on the banks of the Thames and Medway Canal. Here we found precisely the same results, the creosoted sleepers being sound, the uncreosoted rotten. The Directors accompanying me now pronounced themselves perfectly satisfied, and, since their return home, have joined me in a Report to the General Board, strongly recommending the use of this preparation for all our timber, and the suggestion is adopted, subject to the arrangement of satisfactory terms with the patentee. The cost to our Board is at present, represented to be about 6*d.* per cubic foot, and the quantity of material to be used 30 gallons per load of 50 cubic feet. It is probable, however, that the erection, by the Company, of pressure tanks of their own may achieve the operation at a cheaper rate. I must observe, by-the-by, that we were in-

formed, that the sleepers on the Manchester and Crewe Line were not prepared with pressure, but merely steeped in the liquid, and Mr. Dockray informed me that he is now trying a hot solution in open tanks without pressure, in confident expectation of successful results. I had not time to investigate the powers of creosote in resisting the *teredo*, but I am informed it has successfully done so in some sea-piling; I should anticipate its being very effectual, as probably some mineral salts might be, if they were not liable to be gradually dissolved in the water, and so leave the timber defenceless. This, however, is an experiment, which I should think capable of quicker and more satisfactory trial, than the resistance to decay, as the worm will immediately enter any timber, unless deterred by some substance inimical to its existence.;

I am, my dear Sir,
Yours very truly,
(Signed) G. W. HEMANS.

To C. Manby, Esq.,
Sec. Inst. C. E.

He also read the following letter, addressed by Dr. Mantell to the Rev. the Dean of Westminster:—

19, *Chester Square, December* 4, 1849.

MY DEAR MR. DEAN,

HAVING heard that you have taken part in the discussion, respecting the habits and economy of the *Teredo*, at a late meeting of the Institution of Civil Engineers, which I was prevented the pleasure of attending, I think it may interest you to know, that a few years ago, I had an opportunity of examining some live *teredines*, in a mass of wood that floated up the Thames. I was at that time particularly interested in ascertaining the presence of *infusoria* in the digestive organs of *mollusca*, having just detected most of the forms prevalent in the fossil state (in the Richmond earth) in the stomach of the *pecten maxima*.

I examined again and again the contents of the digestive canal in the *teredines*, and found nothing but vegetable fibre in a state of extreme comminution; not the slightest trace of animal organization. I believe the *teredines* are purely herbivorous; and it is not at all probable, as some writers assert, that they ever live on animalcules.

With the highest respect and regard,
My dear Mr. Dean,
Believe me most faithfully yours,
(Signed) GIDEON ALGERNON MANTELL.

The Very Reverend the Dean of Westminster.

Mr. BIDDER said, as Payne's process had been mentioned, he must state, that on the Preston and Wyre Railway many sleepers had been prepared under that process, and that nearly all of them had entirely failed.

Mr. Warren was in error in stating, that the sleepers on the Northampton and Peterborough line were creosoted; the fact was, that in consequence of Mr. Bethell not having been able to supply the proper material, another preparation had been used which had

SOUTHEND PIER

SPECIMENS OF WOOD PERFORATED BY TEREDO NAVALIS.
Fig. 7.

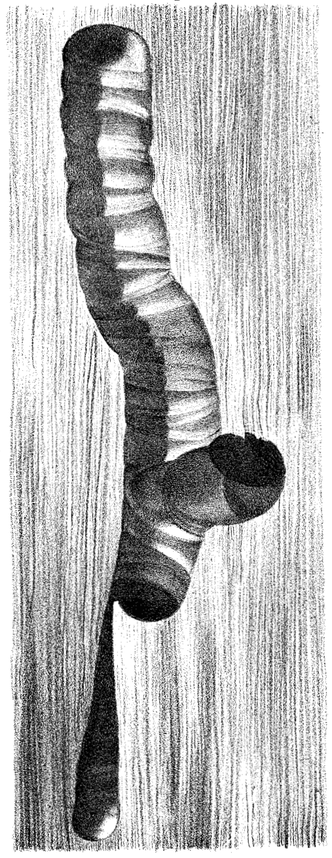
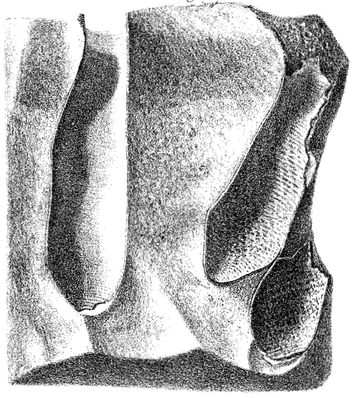


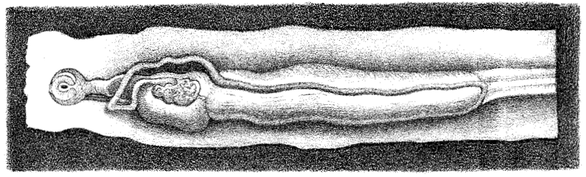
Fig. 8.

FOSSIL TEREDINES
Fig. 6.



TEREDO NAVALIS.
Fig. 1.

Fig. 2.



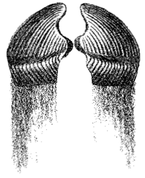
OUTER SKIN REMOVED.

Fig. 3.

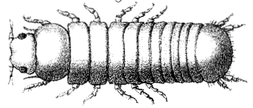
HEAD OF TEREDO NAVALIS.

Fig. 5.

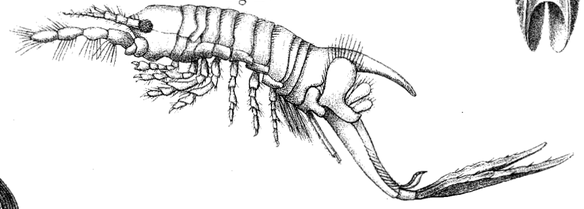
Fig. 4.



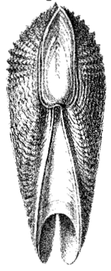
LIMNORIA TEREBRANS
Fig. 9.



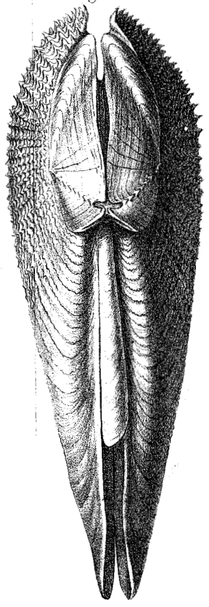
CHELURA TEREBRANS
Fig. 12.



PHOLAS CANDIDA
Fig. 11.



PHOLAS DACTYLUS
Fig. 10.



J. Dinkel lith.

Day & Son, Lith.rs to The Queen.

failed, but Bethell's process had certainly never been used at all on that line.

Mr. WARREN said, he had examined many specimens of timber which had been impregnated by Payne's processes, and he could most positively contradict the assertion of a failure having occurred in any sleepers so prepared; indeed in every instance he had found them in a comparatively perfect state.

Mr. BETHELL, in answer to questions from Members, said, the cost of preparing railway sleepers was about fourpence-farthing per cubic foot; that of preparing timber to resist the ravages of the worm was nearly sixpence per cubic foot. He exhibited a piece of creosoted timber cut from a pile at Lowestoft, which had been four years in sea water; the young wood had taken the creosote thoroughly, and all ravages of the worm had been prevented, but he did not consider that the log had been thoroughly prepared, as the heart was not saturated; perhaps only 7 lbs. per foot, instead of 10 lbs. per foot, had been absorbed, but even this had sufficed to form a perfect envelope of poison, through which the worm could not penetrate to the heart of the wood.

He always recommended the use of whole timber piles, on account of the facility with which the sapwood could be saturated with creosote.

December 4, 1849.

JOSHUA FIELD, President, in the Chair.

The following candidates were balloted for and duly elected:—

Mark Jones, and Thomas Cramond Gunn, as Members; James Allan, Henry Orlando Bridgeman, Capt. Joseph Estridge, B.E., and Thomas Abercrombie Hedley, as Associates.

The discussion upon the paper No. 804, "Description of the Old Southend Pier-head, and extension of the Pier; with an inquiry into the nature and ravages of the *Teredo navalis*, and the means hitherto adopted for preventing its attacks," by Mr. Paton, was continued throughout the meeting, and precluded the reading of any other communication.
