

Mr. PENISTON said, he was glad to avail himself of the opportunity that was afforded him of collecting a few facts for the information of the Institution. Although physically unable to take part in the discussion himself, fortunately those who had assisted in the collection of the facts were present, as were also the representatives of several large establishments connected with works in Brazil, who were well qualified to take part in any discussion that might arise. He should also be happy to supply any further particulars which it might be in his power to do.

Mr. E. DE MORNAY, as one of the Concessionaires of the Pernambuco (Recife and São Francisco) Railway, would avail himself of this opportunity to state, although he had not then with him the details of the survey, so as to enable him to give the exact length of the lines to which the estimates referred, that the line estimated by Mr. Borthwick was divided into four sections, and that the estimate of the concessionaires related to the first three sections only. The concessionaires considered, a railway might be made in Brazil upon the American principle, involving only a moderate outlay, with immense advantage to that country; and although it had not been carried out upon that principle, he wished to explain why they had advocated that view. In the first place a return of 7 per cent. was, during construction, to be secured to the shareholders; and it was thought as that guarantee of interest was made good at the expense of the shareholders' capital, it would be of great advantage that the line should be cheaply constructed, and that the works should be completed within the shortest period of time. Instead of that the line had been many years under construction: and it was for those who were more able to do so than himself, to calculate how far the capital subscribed for the railway ought to be expended in the payment of interest to the shareholders. Under those circumstances it was considered important by the concessionaires, that the line should be made at a low cost. It had always appeared to him, that an expensive railway in a country like Brazil would be a calamity rather than a benefit; and in his opinion the only lines that could return a fair interest to the shareholders, and conduce to an extension of the railway system in Brazil, would be those which were constructed at a moderate amount of expenditure.

Mr. C. B. LANE said, so many topics had been referred to in the Paper, that it was difficult to speak upon them without previous consideration. He would, however, in the first place allude to the question of the employment of native timber. When he first went to Brazil, about ten years ago, as the Government Engineer, he made a point of studying carefully the various building materials of the country; and the conclusion he arrived at, after two, or three years, was, that if railways were to be con-

structed in that country, upon the alleged economical principle of using the native timber, as it was found, it would be better not to make them at all. Timber employed in railway bridges and in viaducts was destroyed so rapidly, in that inter-tropical climate, that their maintenance and renewal would more than eat up the receipts which should go to diminish the onus of the Government guarantees. Although he fully agreed in the advantages of reducing the first cost, yet economy was a relative term. The first railway in Brazil was opened in 1854. It was a short line, leading from Mauá, in the Bay of Rio de Janeiro, to the foot of the great 'Serra' of Petropolis. It passed for a considerable part of its length over a low muddy swamp, full of mangroves—a most uninteresting spot, the only thing to enliven the scene being an occasional alligator. Various water-courses were crossed, for which timber was employed; the best timber no doubt available, at that time, having been selected for the purpose. About two years after that line had been opened, he inspected the water-passages and bridges: for after that short time it had become necessary to rebuild them with other materials. He could not more graphically describe the condition of the timber, than by stating that in one case upon giving a transom under the railway a moderate kick, his foot was buried in it up to the instep. With the timber in that condition, after two, or three years, it was manifestly better not to make railways than to use such materials in their construction. He did not doubt, that in Brazil there was a great abundance of valuable timber: but as yet there were no certain means of getting at that timber, or being sure of its quality and properties when it was obtained. There was also abundance of gold, copper, and other valuable minerals in that country; but the time had not yet arrived when they could be made available. It was the same with regard to the timber. It would be cheaper to send from Brazil to Liverpool for a stick of timber, even though it was first imported from America to Liverpool, than to cut one in Brazil half a dozen miles from where it was required to be used. All the timber he had seen in Brazil—though good for many other purposes—was inapplicable for railway sleepers; the quick-growing woods being too perishable, and the hard woods too brittle. There was a specimen of timber upon the table which felt like a piece of porcelain, and yet after five years' immersion in the waters of Rio Bay it was completely riddled by the teredo. It was totally unfit for railway sleepers, being too brittle. On an inspection he made of the Pernambuco Railway, three years ago, he found that the wear and tear of the imported creosoted sleepers on the first section had not amounted to more than about 1 per cent. during the two years that the line had then been open for traffic. He could not state exactly the amount of depreciation of the

sleepers of native wood laid on other sections of that line; but from what he saw he had no doubt it would turn out to be equal to that which was stated in a Paper by Mr. Mc'Master¹ read before the Institution a short time ago, to have occurred from using native timber on the Madras Railway,—that was, to 33 per cent. in the first year, or two. This in the matter of sleepers was a very heavy item in the maintenance of a railway of small traffic. On the Bahia Railway it was stipulated in the concession that only native timber should be employed: but very soon after the works were commenced, it was found impossible to procure suitable native timber for sleepers: upon which the Engineer, Mr. Vignoles (M. Inst. C.E.), and the Company petitioned the Government to have that particular clause of the concession altered: and under his (Mr. Lane's) advice it was altered, and creosoted North of Europe timber was substituted. He had given that advice in the full belief, that there was great difficulty in finding proper native timber, and also that the creosoted timber offered as a substitute was a very superior material. In advocating his views relating to the employment of other material than native timber in bridges and viaducts, he had encountered much opposition from parties interested in the execution of some of the lines of railway; but he had ultimately succeeded in having the correctness of these views duly recognized, and the rule now was, that all such railway structures should be constructed of "stone, brick, or iron, singly or combined." Greaves' 'pot' sleeper had been introduced on about 10 miles of the Pernambuco line. It was also used on the Mauá Railway, and was being employed by Mr. Brunlees (M. Inst. C.E.) on the San Paulo line. He believed it would be found to answer well in Brazil, India, and in other inter-tropical countries, with the present amount of traffic; but he felt convinced that if the time ever came when such heavy trains were run and at such high velocities as prevailed in England, the iron 'pot' sleeper would have to be relinquished, as it was too rigid for high velocities.

The labour question was no doubt a very important one. As far as his own experience went, he thought, under the best circumstances, it would be found that the labour of Europeans in an inter-tropical climate was very nearly that determined many years ago by the well-known French philosopher and Engineer officer Coulomb, who in employing French Sappers and Miners in the Island of Martinique, where the thermometer was seldom below 77°, and similar troops in France, stated the efficiency of their labour to be less than one half in the tropical climate: and in the inter-tropical portions of Brazil with which he was acquainted, the thermometer was seldom below 77° during the day.

¹ *Vide ante*, page 241.

With regard to the mason work, his own experience (which was chiefly at Rio de Janeiro) differed from that of Mr. Peniston. In employing Portuguese, as masons, the work was done extremely well, and he had rarely seen men work a quoin more truly; but they were slow as compared with English workmen, in England. The worked stone brought from Lisbon, referred to by Mr. Peniston, must he thought be only that for ornamental purposes, because the neighbourhood of Lisbon supplied beautiful marble which was not found in Brazil.

Mr. JAMES T. WOOD remarked, that the engineering part of the subject had been so fully discussed in the Paper that he would not further touch upon it. He would therefore direct attention to a few circumstances, which five, or six years hence would be more interesting than they were at the present moment:—that was to the development of the traffic of a country where land was of small value, and where labour was scarce—to trace what would be the result in a few years of increased facilities of transit throughout the country. One great result he thought would be, the bringing of the population and the changing of estates, to localities in the immediate vicinity of the railways, in consequence of the proprietors of slave labour migrating, and clearing the lands adjoining the line, in the same way as the borders of navigable rivers, in all parts of the world, had been selected for cultivation. When he was in Brazil he took a journey of above 70 miles from the coast. He there met a most intelligent man, the schoolmaster of the district, who gave a history of the large number of farms and estates that had been brought into cultivation, by cutting down the trees in the neighbourhood of the line, and in anticipation of the present terminal station. He thought that five, or six years hence, if the statistics could be obtained, they would be of great interest, as showing the movement of the population towards the localities where improved means of communication were provided.

Another point, which was a most material one, was that which had reference to labour. As far as his experience went, a labourer who could read and write was very scarce in the Province of Pernambuco. During the period of slavery there, certain acts of labour were performed solely by slaves, even down to the carrying of a parcel; and the main distinction between the people was those who were slaves, and those who were not, the latter being too proud to do slave work. The railway was consequently deprived of the useful class of men from which the porters in this country was obtained. During the last twenty years that feeling had been going out, and in the course of time it might be possible to find intelligent men amongst the labouring classes of the country, who could read and write, and whose services would be of the greatest value to the country. It was his opinion, that the

gradual extension of the line, say at the rate of 20 miles a year, might be executed. But it was of importance that the surveys and the exact direction of the extension should be judiciously and accurately prearranged, so as to give time and opportunity for the adjoining land to be brought into cultivation, during the progress of the railway works. He also considered there was ample field for branch feeders to be made; but as the traffic on these branches could not pay any company an adequate return for the capital expended, they should be made at the expense of the proprietors whose estates would be benefited. He was happy to bear testimony to the excessive kindness and hospitality to Europeans, which prevailed all over the country.

Mr. E. B. WEBB said, about three years ago, he had the honour of reading a Paper before the Institution, "On the Means of Communication in the Empire of Brazil,"¹ and he referred, in that Paper, particularly to the use of timber, and to the cost of labour upon the works. Since that time professional engagements had caused him to revisit South America. He had traversed the greater part of the eastern coast of that continent, and had visited all the railways which were in course of construction. The opinions he expressed three years ago in reference to Brazilian public works had been confirmed. He had an opportunity of inspecting timber structures, which, when he left Brazil, in 1858, were apparently in a sound condition, and he found them, last year, in ruins. The specimen of timber laid on the table by Mr. Lane, was a portion of a pile driven under his direction in the Bay of Rio de Janeiro, in 1854. That piece of timber was removed about the year 1858. It was a fair sample of the material in a pier of some magnitude; and the destruction caused by the 'teredo' was complete. He had no hesitation in saying, that all timber, taken in large quantities from the forests of Brazil, and driven in the littoral waters of that country, would, in a short time, be reduced to a similar condition.

With reference to sleepers of native timber, he was of opinion that, on the ground of economy and convenience, their use was most imprudent; because scarcely any timber, that could be obtained in sufficient quantity, size and condition, would endure the wear and tear of the climate much longer than two years. The loss and annoyance resulting from an early decay of sleepers, would be felt by the Companies and not by the contractors. In the Brazilian forests there were countless varieties of timber, and specimens might be produced by the hundred; but the difficulty of selecting, collecting and transporting to the works a sufficient supply of durable timber, could only be correctly estimated after

¹ *Vide Minutes of Proceedings Inst. C.E., vol. xix., p. 240.*

an experience in the country itself. The forests of Brazil, unlike pine forests, never presented a number of trees of the same description in one spot; and serviceable timber was very limited. It was frequently necessary to make a selection of one tree only in the midst of several hundreds of no value whatever. In fact an Engineer, standing in the magnificent primeval forests of Brazil, might paraphrase the words of the Ancient Mariner, and exclaim—

“Timber, timber everywhere,
And not a stick to use!”

When visiting the Brazilian railways last year, he was sorry to find that native timber was being largely used as sleepers. He saw, for instance, on the San Paulo Railway, large piles of native timber sleepers. These sleepers were made up of many varieties of timber, more or less durable; they were of irregular scantling, and being exposed to the sun and weather, they were splitting freely. He believed that the greater part of those sleepers, after being down for two years, would be found to be decayed; and long before the lapse of two years the spikes would become loosened, on account of the tendency of the timber to split. The result of his experience, in the use of timber in Brazilian soil, made him regard its employment as something like putting “ashes to ashes.” He knew of no instance of any attempt to creosote the native timber, which, when worth anything at all, was hard, and had a tendency to split. On the same railway timber telegraph posts were being erected. Now he knew for a fact, that on the Dom Pedro Segundo Railway (Rio de Janeiro) three several sets of timber telegraph posts had been put up; and the Company, after having incurred very great expense and annoyance, were now erecting posts of iron, notwithstanding that their line passed through some of the most magnificent forests on the face of the globe. Considerable experience induced him to draw the general conclusion, that the use of native timber sleepers in all such countries as Brazil, was very unadvisable, first on account of the difficulty in selection, and secondly on account of the trouble and expense in keeping the permanent way in a proper state of repair. In such countries, for years to come, high velocities would not be required; and with moderate speeds iron sleepers were safe and economical, and they might be considered as indestructible.

Mr. F. W. SHEILDS said, four, or five years ago he went to Brazil to lay out works of some magnitude. At that time he inspected the works on the Pernambuco Railway, with the view of applying the experience gained upon that line, to a railway at Bahia, then about to be commenced. The conclusion he came to was, that all works of art in Brazil would be more safely estimated and more satisfactorily carried out, upon the supposition that the materials should be designed and be prepared in

England, in such a manner that they could be put together, with the least trouble and labour, after their arrival in Brazil. He was led to this conclusion, not only on account of the perishable nature of the timber, and the generally inferior quality of the masonry, but also because, in a hot climate, little reliance could be comparatively placed upon the labour of even the English workmen sent out there, as their nervous system was generally debilitated by the effects of the climate. It was therefore far safer, as a general rule, to design works of art, in the simplest form, with English materials and have them erected in the country, no matter in what part it might be. He might add, that in the course of his explorations, he examined some rude bridges which had been erected about three years, and on breaking the surface of the timber, which he could easily do with his foot, he found the interior of the timber filled with white ants. This satisfied him that the use of native timber was generally to be avoided in permanent works. With regard to iron work, it appeared to him, that the use of corrugated iron, so much employed here for roofing, would in a country like Brazil be a great mistake. The native tiles laid upon the rafters, with no ceiling underneath, formed the best kind of roofing for that country, as, although it made a heavy roof, it was not only the best protection against the heat of the sun, but it also afforded the best means of ventilation. In a large railway viaduct, which had been intrusted to him to design, and to arrange for the execution of, cast-iron piles were required to be used, at a considerable depth in sea water. It was for some time a question, whether the salt water and other elements would not have a very deteriorating effect upon the cast iron; but he had recently received a report stating, that immediately upon the iron being put down into the water, it became so thickly encrusted with marine shells, as to form a complete protection against the action of the salt water, so that there was every probability that these cast-iron piles would endure for a long period. In using wrought iron, in situations exposed to the atmosphere, in these climates, care must be taken effectually to protect it, by thorough painting. Such a construction as a bridge, with wrought-iron girders, must be constantly painted and carefully protected from the influences of the climate, which possessed the peculiarity of an excessive degree of heat, combined with much moisture, the corroding effects of which, upon wrought-ironwork, were remarkably rapid.

Mr. J. WHITFIELD, in reply upon the discussion, for the Author, said with regard to timber, there was a great variety of wood in Brazil which would be useful and would endure for a long time under any circumstances; other descriptions under the most favourable circumstances would not endure for twelve months. There were some varieties of timber the outside of which was ex-

ceedingly perishable, but the interior would last for a long time. He had known instances of timber, which had been in use for fifty years, both in and out of water. That was proved to be the case in some old buildings he had examined ; and he found that some descriptions of timber would last sound for a long time. It was quite true that wrought iron when put under sea water rapidly became encrusted with marine shells, which protected it to a great extent : but wrought iron when exposed to the atmosphere, near the coast, if not kept well painted, was very quickly corroded and destroyed. In the interior of the country, where the atmosphere was drier, ironwork properly painted would last as long, if not longer, than in England. It was a great mistake to suppose that the whole of Brazil was like that part of the country, near to the sea-coast. The hygrometric state of the atmosphere had a powerful effect upon materials near to the coast ; but it was different in the interior. Some materials of construction might therefore be usefully employed in one situation, which would perish rapidly in another locality.
