Discussion.

Mr. W. H. PREECE, C.B., President, said that it was his duty to propose that a vote of thanks be given to the Authors for the admirable summary of the results of their observations in the United States. He could only wish that more of the members of the Institution would take some opportunity of visiting America. There was something in the very atmosphere of the United States that was exciting and encouraging, and more so on closer contact with that energetic nation. He had made three visits there, and had invariably returned with valuable information; but more than that, he had, by some process of contact, become infused with the energy of the people of the United States. What was lacking in England was that very enthusiasm which was so marked and so wonderful in America. An illustration of the effect of that enthusiasm was given by the admirable Paper which had been drawn up by the Authors, and the clear way in which it had been brought before the Institution. He hoped Mr. A. P. Head would convey to his father—whom the members were sorry not to see present, but who, under doctor's orders, was compelled to remain at the seaside—the feeling of gratitude, which he was sure all the members experienced, for bringing before the Institution so instructive a Paper. It was most remarkable to find that in the very short period of 3 years the export of pig-iron from the States, which, in 1895, was 3,668 tons, had risen in 1898 to 50,121 tons; and while in 1895 the export of rough steel was only 59 tons, in 1898 it was 29,807. Those facts must make some people feel uncomfortable when they considered the rapid strides which were being made by America, and the marvellous way in which the United States were beating England in the markets of the world. After reading the Paper he could not help thinking that there must be some cause and some lesson to be learned, and that engineers ought to be in a position to indicate to those that were at fault the reason why England was gradually getting beaten. He did not mind saying from his own observation, that where England was being beaten was in the labour world. There was a vast difference between the American workman and the English workman. The American workman was a trained, educated, technical man, who cared for nothing, and spared no labour, but

Mr. Preece.

Mr. Preece. worked with an intelligence and an enthusiasm that secured success. The English workman was an absolute slave to his union; a man of the same breed and of the same intelligence as the American, yet kept down by the rigid tyrannic rules under which he worked. He could not help thinking that means should be found in England for distributing among English workmen Papers like the present one in a very popular form. It was most remarkable that while in England free trade was preached and practised, in America it was neither preached nor practised, but in that country a principle of protection was applied to their own manufactures and products. The Authors had shown that there was a protective duty in the United States on pig-iron of 16*s.* 6*d.* a ton. Manufacturers did not care for that because they did not want to import pig-iron into America; but what they did want was to prevent importation into that country, if possible, of manufactured articles. What was being done in England, where free trade was preached and practised, and where politicians were crying everywhere for the doctrine of the open door? Absolutely, at the present moment the very worst form of protection was being exercised, preached and practised—the protection of labour. One class was being protected and favoured against the rest of the nation; and by protecting labour and adding to the cost of production as well as adding to the freight, such a result was promoted as that found in the Paper. One other striking feature in the Paper was the enormous distances that great masses of material were carried at small cost. What had the London and North Western, and the Great Northern and the Great Western Railways to say to the rates that were charged in the States? If English manufacturers could only make their men practically work twice as long, and if the English railway companies could be satisfied with half the present rates, then he thought there might be a chance that England would compete with even America in the other markets of the world. He begged, on behalf of the members, to tender a vote of thanks to the Authors for the Paper which they had prepared, and with which all the members were delighted.

Mr. Head. Mr. A. P. Head exhibited a series of slides illustrating the districts and appliances mentioned in the Paper.

Mr. Heathcote. Mr. C. F. Heathcote, although not directly interested in the iron industry, had visited the districts referred to in the Paper, to inquire into the methods of management and the mining and handling of ores there. The question of geology had been very wisely left untouched in the Paper, because until the district was

Mr. Heathcote.

visited neither its size could be appreciated nor the immense extent of the deposits; one mine, entirely underground, in the Mesabi range, had yielded an output in 1897 of 664,000 tons, and it was hoped that the output of 1898 would reach 1,000,000 tons. With regard to the methods of mining, the Authors described a kind of pillar-and-stall method, by overhead stoping for the stalls and caving for the pillars; there was another method of pillar-and-stall working in use in the Mesabi range, the stalls were taken by underground milling, the stall being made about 22 feet wide. A level was driven at the top of the ore deposit, and saddle-back timbering to cover the stall, like an ordinary bridge roof, was put in. The rises were then put up from the bottom level just as if it were at the surface, and the ore was brought down. That method was not very safe on the surface with some ores, and it could be imagined what it would be like if used on those ores underground, for if the roof timbers tended to cave there was no way of stopping them. It had been successfully and cheaply employed in some ores there. Another method of working which the Authors had not mentioned was that in use in the Adams Mine at Eveleth, which might be described as a system of long wall working by square-set timbering. The ore deposit was opened up by main levels driven sixteen sets apart, the sets being at 7 feet 6 inches centres; the cross levels were the same distance apart, and all were driven out to the boundaries of the ore, the mine being thus divided into squares, in plan. At every fourth set on the inside face of the boundary square a drive was put in out to the boundary, so that the square was broken up by drives four sets apart; these were stoped up to the surface rock so as to form a get-away for the men working in the face, to subdrives near the surface rock, through which timber was brought in. They were then worked back from the boundary, in chambers, three sets wide, leaving one set between each chamber. They were carried back as far as possible; with a little practice the men very soon knew when the timber was getting enough weight on it; they ripped out the single set pillars of ore that were left, faced up the ore with culled timber lagging, put a few shots of dynamite in, and the worked out part caved. That was also a good method. The Authors had stated that they thought the caving system preferable to the square set, chiefly on account of the price of timber. That depended on the class of ore that was being worked; in the case of sandy ore, the caving system was undoubtedly the best. At the height the Authors gave, 62 feet, the pillars would be too thin and would with most ores crumble away before the stalls could be worked

Mr. Heathcote. out by the square-set system; it would take too long to get it, in most of the mines. If the long-wall system was adopted, it had been used nine sets high where the ore was irregular, but it was never expected to exceed five sets, or 40 feet. In one of the largest mines, the Fayal, where the caving system was first introduced in the Mesabi range, by Mr. Wallace, the levels were only 33 feet apart. The greater heights were employed because the timber was employed for holding the ground only long enough to take the ore out, and re-timbering was always expensive. With regard to the caving system versus the square set system, the timber used depended on the class of ore being worked. It was not the cost of material, in a country where there was plenty of cheap timber, that was of importance—it was the cost of erecting it. Therefore, he thought, for some ores the square set was far away more convenient than the caving system. In the latter more than a fifth of the ground was got by driving, a small quantity by rising, and the rest was all got by side work. In the square set system, with the sets only five storeys high, less than a tenth of the ore was got by driving; only the ore on the bottom floor was obtained by side stripping, the rest of the ore was broken direct into the trucks; with the caving system it had to be all shovelled into the nearest shoot, and in many cases it had to be wheeled. Still, with sandy ores the caving system was undoubtedly the best, and a system that was carried out very cheaply; although the method was a little complicated to describe, it was wonderful how easily it was worked in practice. He had seen in one of the mines a slight variation from Fig. 10, Plate 3, namely, putting the cross drives at an angle of 45° from the main drive; that, it was considered, paid very well where most of the traffic was drawn by mules, allowing a train of tubs to be taken round the corners. Where a right-angle turn was used, single tubs were employed, and there were two men to each tub who could take it round the corner easily. With reference to working in the shovel mines, he had taken the times when he was at the Mountain Iron mine in 1898, where the shovels were really working best, and for filling a truck of 25 tons the time was between 1 minute 50 seconds and 2 minutes. The time occupied in bringing the shovel forward, which was always done between the trains, was 2 minutes; in another mine he visited, this occupied 6 minutes. The trains at the time he was there were working on the opposite side of the pits shown by the Author, and were made up of twenty-four cars each; the approach to the mine was on a gradient

of 200 feet at 3 per cent., and the exit was 1 in 100, so that there were great facilities for handling the ore. He noticed that time was saved in every possible way everywhere, for instance, by flying shunts on the railways. Mr. Heathcote.

Mr. J. STEPHEN JEANS had visited some of the deposits referred to in the Paper; but at the time of his visit the only districts opened up were the Vermilion, the Marquette, the Menominee, and the Gogebic very partially; the Mesabi, at that time, had not been developed at all. The conditions of the ore-supply were then entirely different to those existing at the present time; indeed it was not more than 20 years since the price of Lake Superior ore delivered at Pittsburgh was between 30*s.* and 35*s.* a ton, as against the remarkably low prices given in the Paper. The cost of freight alone about 20 years ago from the Lake Superior region to Pittsburgh was about 20*s.* per ton. A large number of those who were concerned in the iron trade in England had an impression that Great Britain might compete more successfully with the newer developments of the United States if the railway companies would do more for them. The matter under consideration was essentially a question of transport. It was known that the general range of railway rates in England was very much higher than in the United States; and he would venture to suggest that the best lesson railway engineers could borrow from American experience would be that of running wagons of very large capacity, and so reducing the enormous tare which was incidental to British transport. The Authors had stated that the tare on a 1,200-ton train-load in America was only about one-third of the live load. In England, the average tare would be almost equal to the live load. Mr. Jeans.

Mr. WEBB said it was only about one-half. Mr. Webb.

Mr. JEANS said the distance between the Pennsylvania coke region and Pittsburgh was not greatly different from that which separated South Durham from the Middlesbrough district, but the rates between the two districts would show an enormous difference; and it was owing to the reduction in the cost of transport rather than in any other direction that the Americans had been able to take the position they now occupied in international competition in iron and steel. The President had referred to the growth of the American iron and steel exports during the last few years; but it was not without importance to take note of the fact that the Pittsburgh district, which depended entirely upon Lake Superior ores, did not export pig-iron to England to any large extent, but that the imports which England Mr. Jeans.

Mr. Jeans. was receiving from the United States were almost wholly Alabama pig. The distance between the Alabama iron-making region and the port or ports from which the pig-iron made in that region was shipped was about 250 miles, and the cost of transport between the blast-furnace and the port was not more than $1 a ton. The Pittsburgh district sent to England the bulk of the export of steel, and no doubt the capacity of the United States in exporting such great quantities of steel was largely influenced by the circumstance described by the Authors, that they were able to produce such cheap pig-iron. He did not despair of a great deal being done in England to bring down the difference of about 20*s.* a ton; and he did not see why English ore should continue to cost as much as it was at present. It was not many years since the cost of Bilbao ore, delivered in England, was not more than 11*s.* per ton, and pig-iron makers were looking forward to being able to import from other sources, notably from the new deposits of Swedish Lapland, a considerable quantity of iron ore that would represent a lower cost per unit of iron ore than the sum named by the Authors. With regard to the fuel supplies upon which England depended, he was unable to understand why the coke should be so costly. The conditions of the getting of coal in England did not justify the present price; and if the coke manufacturers and the railway companies were only to act together with a view to relieving the British iron trade from some of the disabilities under which it at present suffered, he had no doubt that a very substantial difference could be made in the cost. If England failed to reduce the cost of its iron and steel by those or kindred means, there could be no other conclusion than that before many years were past the supremacy of the British iron trade, upon which Englishmen had been accustomed for so long to plume themselves, would have become a thing of the past. Last year the Carnegie Steel Company had made about $2\frac{1}{2}$ million tons of pig-iron and nearly the same quantity of steel. That meant production on an enormous scale; and Americans took a great deal more pains to keep their works fully employed, regardless of the cost of production, than the English were able to do with their limited markets.

Mr. Brough. Mr. BENNETT H. BROUGH had visited, in 1890, some of the mines described in the Paper, in which he read with great interest the account of the marvellous developments which had taken place since that date, owing to the opening up of the Mesabi mines. The Paper afforded a careful and accurate statement of facts which, unfortunately for the British ironmaster, could not be

controverted. He thought it would, perhaps, have been of advantage if a bibliographical appendix had been added, giving the titles of authoritative memoirs dealing with the subject. It was remarked by the Authors that geological authorities scarcely agreed on all points relative to the geological features of the region, but these had been very fully explained in a monograph that had recently been published by the United States Geological Survey.[1] That monograph, although it dealt more particularly with the Marquette region, was one of the most complete descriptions of an iron ore-mining district that had ever been published, and it was illustrated with coloured plates that were photographic in their accuracy. The memoir showed that the complex structure of those ore-fields had now been unravelled by the staff of the United States Geological Survey. The Authors' statement that the deposits were discovered originally by an observation of the variation in the magnetic needle seemed to show the very great value of that instrument in exploring for such deposits. In a Report to the Geological Survey of Michigan for 1873, Major Brooks had published an account of the very accurate magnetic surveys of Michigan he had made in order to ascertain the extent of the deposits. Having regard to the imperfection of the instruments which he employed, his results were certainly as accurate as any that had been made in Sweden with the finer scientific instruments now in use. It was stated by the Authors that the output statistics of the Lake Superior region seemed to prove that the development of the Mesabi range had had a detrimental effect on the others. The statistics for 1898 had now been published, and they showed clearly how the older mining districts, the Marquette and the Menominee, the hard-ore districts, were able to meet any demands that were made upon them. The average increase for the whole of the Lake Superior region last year, compared with the previous year, was 12½ per cent.; the Mesabi district had increased 8 per cent., which was below the average; whilst the Marquette district had increased 15 per cent., and the Menominee district as much as 30 per cent. Mr. Brough.

Mr. ELLIOTT COOPER had returned from the United States but a few days previously, and could well understand, not only from what he had seen there during the last fortnight but from the photographs which the Authors had shown, how difficult it was Mr. Cooper.

[1] Monographs of the United States Geological Survey, vol. xxviii.

Mr. Cooper. to compete with that country in many matters in which machinery formed an important part. The one great feature which must impress engineers in travelling through America was the remarkable manner in which every form of ingenious machine that could be used was taken advantage of to avoid the use of hand-labour. It had become a necessity, on account of the remarkably high wages that were paid in America for all forms of labour. When he stated that policemen received £240 a year, rising to £300, it would be appreciated that a skilled mechanic became an expensive person to employ, especially if a machine could be obtained to do the work much more efficiently. The illustration of the conveyor, Fig. 17, Plate 4, reminded him of the method he had seen adopted in a locomotive yard in America for depositing the coal for locomotives. In place of the English system of building the wall from the deposit almost entirely by hand-labour in the heap, the Americans had an ingenious machine which took the coal out of the wagon; instead of two uprights, as shown in the Fig., going across in a horizontal form, two shear legs were employed. The coal came out of the wagon, and climbed up the endless chain, and when the bucket, which was similar to the one shown in *Fig. 19*, arrived at the place where it had to deposit the coal for use in the yard below, it turned over and came back on an endless chain, so that the whole of the unloading was performed by machinery. It appeared to be almost the same system as that adopted in dealing with iron ore. The same thing applied in practically all the various methods of dealing with matters of that kind—where machinery could be used it was used. A great deal of trouble appeared to be taken to design special machines for any particular purpose for which they might happen to be required. The American people did not seem to be content to adopt some known form of machine, but they went out of their way to design a special machine for special work, even although the machine in the future might not be very largely used.

Mr. Price-Williams. Mr. R. PRICE-WILLIAMS had had occasion, when he was recently in the United States, to visit two of the localities which figured conspicuously in the Paper, Cleveland and Lorain, which were very fitly described as the receiving ports for the large shipments of ore forwarded from the remote end of the lakes, a very long distance. A great part of that rich ore was forwarded to Pittsburgh in the interior. He had also the opportunity during his brief stay in America to visit Lorain, which was about 30 miles to the westward, and of visiting the fine steelworks

Mr. Price-Williams.

that had recently been constructed there by the Lorain Steel Company, one of the confederated steel companies referred to by the Authors. Through the kindness of the president of that company he had the opportunity not only of visiting the works, but of being furnished with a great deal of most valuable and interesting information in regard to the labour-saving appliances and all the great improvements which had been constructed in those works. What he had seen and had been informed of fully corroborated what had been so well and graphically described in the Paper. The Authors stated as their conclusion that the great economies which undoubtedly had been carried out were mainly due to the ore of the Lake Superior districts and to the Pennsylvania coal. He did not in any way underestimate the great value that the Americans possessed in those rich and almost unlimited sources of ores; but he did not think that so much importance attached to that when compared with what was at the disposal of iron-founders in England. The main features of the Paper had reference to the economies that had been effected by the instrumentality of the great ingenuity and resources of eminent men in America. With regard to the first point, the vast resources of ore, taking into account the great distance from which they had to be brought, 800 miles, the considerable land transit—he gathered from the Paper that it was 75 miles to the port where the ore was delivered—the long water carriage, about 570 miles, and further to the fact that with all the mechanical appliances that rich ore had to be transported 150 miles to Pittsburgh, which was one of the great centres, if not

VALUE OF BILBAO ORE OF STANDARD BESSEMER QUALITY DELIVERED AT DOWLAIS.

	Per Ton.	
	s.	*d.*
Mining [1] 2*s.* 7·3*d.* and loading at mines 1*s.*[2]	3	7·3
Railway freight to port at Bilbao, 7 miles	0	5
Wharfage	0	3
Wagon hire	0	4
Freight Bilbao to Cardiff	4	9
Railway rate, Cardiff to Dowlais, 0·80*d.* per ton per mile	1	3·9
	10	8·2

[1] "The Iron and Steel Industry of Spain," Journal of the Iron and Steel Institute, 1896, No. ii. p. 6.

[2] "The Present Position of the Iron Ore Industry of Biscay and Santander," *Ibid*, No. ii., 1896, p. 44.

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the greatest centre, of the iron industry in America—taking all these things into account, he thought that in England the iron industry did not compare unfavourably with that of America. The distance from Bilbao, which was one of the chief sources of England's supply, by sea to Cardiff, the nearest point, was only 620 miles. The distance from the mines to Bilbao was only 7 miles; and the distance from Cardiff to Merthyr Dowlais and Cyfarthfa was only 21 miles. The Table on the preceding page showed the cost of 1 ton of Bessemer pig-iron at one of the principal ironworks in South Wales. He failed to see, therefore, except with regard to labour-saving appliances, that this country was at all in a worse position. Great Britain had a great advantage, as regards the more economical transport of the ore by water, and there was in this fact alone everything to encourage the iron industry, which was the great and staple industry of this country, and he considered the members were very much obliged to the Authors of the Paper for the disclosure of this fact. With regard to the figures they gave, showing the relative prices of Bessemer pig-iron at Pittsburgh and Middlesbrough, he did not know much about Middlesbrough, except from having occasionally visited it; he could speak, however, with more knowledge in regard to the industry of his own county, Glamorganshire. It appeared from the statement that the cost of the iron-ore at Pittsburgh, including all the economies and ingenious appliances for conveying, loading and unloading it, was, as compared with 12*s.* 8*d.* per ton at Middlesbrough, 15*s.* 2*d.* per ton. Taking the district he had been alluding to the charges were as follows:—Railway carriage from the mines to Bilbao, 7 miles, 3*d.* per ton; freight from Bilbao to Cardiff 4*s.* 9*d.*; railway from Cardiff to Dowlais, at 0·8*d.* per mile for 25 miles, 1*s.* $3\frac{9}{10}$*d.*; wagon hire and wharfage 7*d.*; and the value of the ore, including the cost of loading at the mines 3*s.* $7\frac{1}{3}$*d.*; altogether, roundly, amounting to 10*s.* 8*d.* In his opinion the Authors were not justified in adopting 2*s.* 1*d.* per ton (which formed part of this 12*s.* 8*d.* per ton) as the freight charge to Pittsburgh (page 92), inasmuch as under the head of Railway Transit, on the preceding page, it was stated that "the cost of conveying the ore under these favourable conditions is said not to exceed $\frac{1}{6}$*d.* per ton per mile," —the 2*s.* 1*d.* per ton merely representing the cost to the railway company at that low rate for conveyance of the ore for the 150 miles to Pittsburgh, so that at least another $\frac{1}{6}$*d.* must be added as payable to the railway company in respect of their charges for conveying it. That was stated by the Authors at $\frac{1}{6}$*d.* per

ton per mile, and in the estimate they included that $\frac{1}{6}d.$ per ton per mile as not merely the cost but as the cost of the loading, so that, in point of fact, it appeared from the Paper that the ore was carried 150 miles for nothing. Particulars were given of the cost of conveyance from the mine to the ports, varying between 75 miles and 100 miles, from which it appeared that the rate charged was about $\frac{1}{2}d.$ per ton per mile. The cost to another ore delivery port was over $1d.$ for a shorter distance. It was evident that the Authors had been misinformed as to the weight of the trains stated to have been hauled at a speed of 16 miles by the "consolidation" engines, the weight of which, including the tender (that of the latter not being given), was stated to be 127 tons. The fully equipped weight of the tender of engines of this class was about 34 tons, which would leave 93 tons as the weight of the engine itself, only a portion of which was borne by the eight-coupled wheels and was available for adhesion, the front part of the engine (including the cylinders, smoke-box, chimney, &c.) being carried by the leading wheels, which he estimated at at least one-fifth of its total weight. Thus the total weight of the engine available for adhesion, whatever the tractive power might be, would only amount to about 74 tons, which obviously, as the accompanying statements showed, would be incapable of hauling, even on the level and under the most favourable conditions of weather, the enormous train of twenty-five and thirty cars, each carrying net loads of 45 tons, at the speed maintained in the Paper. The line referred to was 150 miles in length and had a number of gradients against the load; some of them, near Pittsburgh, he knew, were steep and with sharp curves. He had, however, in the calculation on the following page assumed a ruling and comparatively easy gradient against the load of $\frac{1}{150}$. Such had been the shrinking of distance as measured by time, that he did not think, having regard to other and more remote sources of supply upon which this country might draw, that the iron-masters in England would find it impossible to obtain abundant supplies from the colonies that would last this country for centuries. He had only very recently returned from one of England's greatest mining colonies, New South Wales, where he had examined and brought home with him specimens of ores that would compare with any of the rich ores which had come from the United States. One thing he would venture to mention, as bearing closely upon this question, and that was the necessity of following the example of the iron-masters in America, of securing a reduction in the excessive

Mr. Price-Williams.

Mr. Price-Williams.

WEIGHT ON THE DRIVING-WHEELS OF A LOCOMOTIVE NECESSARY FOR ADHESION UNDER THE MOST FAVOURABLE CONDITIONS OF WEATHER, VIZ., TO ENABLE IT TO HAUL A GROSS LOAD OF 1,942 TONS AT A SPEED OF 16 MILES AN HOUR UP A RULING GRADIENT OF $\frac{1}{150}$.

Gross Weight of Train.

	Tons.	Tons.
30 wagons, net load	45 each.	
,, tare weight	15 ,,	
	60 × 30 =	1,800
1 brake van, say		15
1 engine and tender (tender, say, 35 tons)[1]		127
		1,942

Let W = weight on driving-wheels required for an adhesion of $\frac{1}{4}$.
T = train-resistance in lbs. per ton of train.

$\frac{16^2}{171} + 8 = 9{\cdot}50$, curve-resistance 3·50 . . . . = 13·00 lbs.
Ditto on gradient against load $\frac{1}{150}$ . . . . . = 14·93 ,,
27·93 ,,

say 28 lbs. per ton.

Then $$\frac{W}{4} = \frac{(1{,}800 + 15 + 35 + W) \times T}{2{,}240},$$

and $$2{,}240\ W = 4\ T\ (1{,}850 + W)$$
$$2{,}240\ W - 4\ T\ W = 7{,}400\ T$$
$$W = \frac{7{,}400\ T}{2{,}240 - 4} = \frac{7{,}400 \times 28}{2{,}240 - (4 \times 28)}$$
$$W = \frac{207{,}200}{2{,}128} = 97{\cdot}3 \text{ tons weight on drivers,}^2$$

otherwise, approximately—

$$W = \frac{1{,}942 \text{ tons} \times 28 \times 4}{2{,}240} = 97{\cdot}1 \text{ tons weight on drivers.}$$

The weight available for adhesion of the consolidation engine referred to in the Paper is approximately as follows :—

	Tons.
Total weight of engine and tender (p. 91)	127
Deduct weight of tender, say	35
	92
Deduct $\frac{1}{5}$ weight carried by leading-wheels not available .	18
	74
Maximum load consolidation engine is capable of hauling on gradient $\frac{1}{150}$ at 16 miles an hour under the most favourable conditions for adhesion, viz., $\frac{1}{4}$, would therefore be	Tons. 1,480
Maximum load under unfavourable conditions of $\frac{1}{7}$ adhesion	84·6

[1] Weight available for adhesion and necessary to enable a locomotive (whatever its tractive power might be) to haul a gross load of 1,942 tons at 16 miles an hour on the level under unfavourable conditions of $\frac{1}{7}$ adhesion would be 78 tons.

[2] The weight on driving-wheels required with an adhesion of $\frac{1}{7}$ in unfavourable weather would under similar circumstances be 177 tons.

railway rates charged in this country. He was glad to see that the low railway carriage rate of $\frac{1}{6}d.$ per ton per mile figured so conspicuously in the Paper. He had for many years past devoted a great deal of attention to the question of the cost of carriage of the heavy class of materials in this country; and the result of his investigations into the subject, to which the late Sir George Findlay drew attention in his report read at the International Railway Congress at Paris in 1889, clearly showed that the present rates could, with great advantage to the staple industry of this country, be largely reduced. He hoped that, as the Authors had brought this important subject before the Institution, so capable of dealing with the question, the matter would not be allowed to rest. He was quite certain that, with the skill and energy existing in this country, it would not be long before English iron-masters followed the example set them on the other side of the Atlantic, and made economy of transport a practical science. Mr. Price-Williams.

Mr. H. BAUERMAN had last visited Lake Superior in 1890, which, as developments now progressed, was a very long time ago; his previous visit was in 1865. There was no doubt that all the developments which had been made there had been placed before the Institution by the Authors in the most satisfactory way possible. He thought, however, that the brevity of the statements as to the occurrence of the ores might convey an idea of regularity and simplicity of structure in the deposits which was far from being generally applicable. For the most part they were masses of extremely complicated structure, similar in character to those in the older rocks in other parts of the world, notably in the great masses of iron ore in Eastern Algeria, India and Scandinavia, in crystalline schists all similar to the American, but especially to those in the old Marquette district. There were the same difficulties, that was, they were enormous masses of ore as long as they were in the open, but when they had to be looked for underground the conditions were found to be as complicated, and the difficulty of searching for them was as great as in other places. This country had enjoyed a great advantage in the amount of ground spread over, and the constant new discoveries, so that the older deposits were left for the new. Miners in England had never been reduced to any very hard kind of work, as they left the older places and went to new, and so it went on. He had been anticipated by Mr. Brough, in calling attention to the excellent work that was done by his old friend, Major Brooks. That officer, after serving in one of Mr. Bauerman.

Mr. Bauerman. the Michigan regiments in the war, went up into the iron-ore district, and worked a charcoal car-wheel iron furnace, somewhere in the neighbourhood of Negaunee, near the old pioneer furnace which Mr. Bauerman remembered in 1865. For some years he was in the habit of advising Major Brooks about the misbehaviour of that furnace when it would not make car-wheel iron. In those days there was no Bessemer iron made. Everybody in the early days of Lake Superior used to make charcoal car-wheel iron, and from that old furnace Major Brooks entered into a scientific study of the subject, and, in connection with Professor Pumpelly, undertook the survey of those mineral regions in Michigan. The work done by these observers had been very remarkable. It had been, in a certain sense, superseded by the work of Irving and others, and gradually by the more highly-organised United States Survey; but the pioneer work then done would always retain its value. He would like to ask one question of the Authors with respect to the low class ores of the Marquette district. When he was last there, in 1890, there was a question of working up the ore that was not sent away; because, in addition to the specular schists that were actually workable, very large quantities of siliceous ore, containing 40 per cent. to 50 per cent. of iron, consisting of alternations of thinly-banded specular schists with red jasper, were thrown away as waste. It was a question of utilizing these ores by establishing furnaces on the lake at Marquette or elsewhere, for making foundry iron, and a good deal was said about it; but he had not heard anything more of it since; and, as a matter of interest, he would be glad if the Authors could say if anything had been done in that matter. It was very curious that the original use of the Lake ores was in making close-grained charcoal iron for car-wheels; and it was only with the development of the Bessemer process in America, at a later date, that their real importance became apparent. In fact, the development was—only on a much extended scale—the same as that of the hæmatite ore on the West Coast of England.

Mr. Snelus. Mr. G. J. SNELUS looked with dismay on the advance that had been made in America in lowering the cost of iron; and he thought the Authors had done wisely, indeed, to call attention to the great strides that America was making, and to the way in which she was cutting the ground from under England's feet in one of her most important industries. It appeared from the Paper that 63 per cent. iron ore could be delivered at Pittsburgh for about 12*s.* 8*d.* a ton. He reckoned that would bring the cost of the ore to make 1 ton of iron to about £1.

Mr. Snelus.

In England there was iron ore which would produce 1 ton of iron, not exactly of the same quality, at a much cheaper rate —he referred to the Northamptonshire deposit. There the quantity of iron ore that would make 1 ton of iron could be raised for about 6*s.* a ton. The iron ore had to be delivered at the furnace, and he thought that was the main point where English manufacturers lost ground, because, as Mr. Price-Williams had pointed out, the railway rates were so high that they throttled the business. He could not help thinking that unless something was done to reduce railway rates in this country, it would be very soon found that the Americans would take away the bulk of England's export trade. Manufacturers might live in their own country; but they could not hope to compete with the Americans in foreign countries, or even in the British Colonies, unless something serious was done. There were opportunities of doing that; in the West Cumberland district, for instance, the cost of carrying coke from Durham was about $\frac{7}{8}d.$ per ton per mile. For a long time he had urged on the iron-masters in the West Cumberland district that they ought to do something to help themselves by promoting a purely mineral railway to carry the coke from West Durham to Cumberland. The Americans could carry it for $\frac{1}{6}d.$ per ton per mile, and the manufacturers in England would derive an enormous benefit if they could carry it at double that rate, or $\frac{1}{3}d.$ per ton per mile. It could be worked at that rate; for, only recently, he had had occasion to follow the railway rates in Natal, and the Natal Government Railway, which had been carrying coal for $\frac{1}{2}d.$ per ton per mile had quite recently reduced that rate by 33 per cent. If a young country like Natal could do that, surely it ought to be possible in this country. It could not be expected, however, that the present railways could carry minerals over their passenger lines in the same cheap way that minerals could be carried over a properly-constructed mineral line, and he thought that was a point where a mistake had been made. For instance, to turn again to West Cumberland, the coal from Durham had to be brought round three sides of a square whichever way it went. If it went from Crook to Newcastle, then to Carlisle and then to the south of Cumberland, three sides of a square were traversed; or if it came south from Crook it was nearly the same. Then again it would travel over a very expensive line, with all the cost of railway stations and the expenses necessary for passenger traffic; and unless English manufacturers attempted to make proper provision, as the Americans had, for getting their

Mr. Snelus. minerals cheaply from the point of supply to the point of consumption, they could not hope to compete with them. He did not think English manufacturers were so far out in respect to the cost of iron ore, although in Cumberland the present price of iron ore was certainly above 12*s*. 8*d*. per ton. Unfortunately that price could not be reduced, as it was in America, because the deposits were not as a rule of the same extensive nature. In the Hodbarrow mine the conditions were as favourable as in the Mesabi region, but the miners were not so go-ahead as the Americans. Although the Hodbarrow mine, he believed, lent itself to the method of shovelling the ore out, they still continued the old-fashioned way of driving levels and taking the ore out in layers, and timbering was still continued at very great expense. Unfortunately, he thought, that was about the only place he knew of in the north of England where that cheap method of getting could be followed. There were, however, in other districts places where the same method could be followed, and he referred particularly to the Northamptonshire district. There undoubtedly the ore could be shovelled up in the cheap way in which it was done by the Americans without the least trouble, but it had not been attempted, and the expensive process still went on. He thought the one point where the Americans at Pittsburgh had the advantage of the ironmasters of this country was in the cost of fuel. Undoubtedly the Americans had cheaper coal than in England, but, after all, it was not because the mineral itself was expensive, because coal could be raised in this country nearly as cheaply as in America. He was a Director of a colliery, and he knew the cost of getting the coal, and although it was cheap at the pithead it was very costly when it arrived at most of the furnaces, and for the same reason, because the railway carriage was so excessive. It was only when the fuel could be used on the spot that an advantage could be gained in that respect. He thought that ultimately other districts would have to be looked to much more largely than had been the case hitherto for supplies of iron ore, except, perhaps, in the Middlesbrough district and in the Midlands. There was no doubt that while there was a very large quantity of ore in Cumberland, yet the number of mines was diminishing, and the output from the bulk of them was decreasing. He believed, as Mr. Price-Williams had said, that there was still an abundant supply of ore which could be brought cheaply to the various districts. He had occasion not long ago to visit one of the largest deposits in the world, in Norway, where he traced the ore for a distance of about

12 miles on the surface. The deposit of ore was certainly between 100 feet and 500 feet thick, and he understood that the same beds traversed a district at least 20 miles in length. Then, again, as was known, ore was being obtained from Sweden, from Gellivara, at a comparatively cheap rate. The ores obtained from Sweden were comparable to the American ores, being extremely rich. He thought the English manufacturers might look forward to having a fairly good supply of ore at not unreasonable rates. But the manufacturers must do something more to help themselves, and if that was not done he was afraid English trade would diminish until it came to be a very small business indeed. Mr. Snelus.

Mr. RICHARD JOHNSON was impressed by the immense quantity of ore to be dealt with in America, as shown in the Paper. From Fig. 12, Plate 3, it seemed as if the ore was about 100 feet thick, and working the ore in the admirable manner adopted was like working a railway cutting. He was not sure whether the deposits of the Lincolnshire ore could be reckoned in anything like the bulk shown in the Figs. of the American ores. There was a good deal of open working of an ore similar to the Northamptonshire ore. The reference which had been made by Mr. Price-Williams to the railway rates rather touched an old railway man. He was not sure that Mr. Price-Williams bore in mind the great cost of English railways. Probably the railways on which that ore was conveyed in America were either largely on a falling gradient to the great lakes, or on a comparatively level country. The Paper described a train-load of about 1,000 tons. In this country 30 wagons of coal, with about 8 tons in a wagon, 240 tons, was a train-load. He was not sure that that could be carried at a lower rate than a $\frac{1}{2}d.$ per ton per mile. He did not think that coal or minerals could be carried in bulk unless a railway was made for the purpose. If railways were made for the purpose probably coal and other minerals might then be carried at a low rate; the members would remember some years ago plans were deposited for a railway called the Coal Owners' Associated London Railway—its initials were C—O—A—L Ry.—and Mr. Robert Baxter of Doncaster, who was the legal adviser to that railway, proposed to carry coal for $\frac{1}{4}d.$ a ton a mile, but he did not think, unless special railways were made, that rate could be approached. Mr. Johnson.

Mr. A. O. GRANGER (of Philadelphia) thought that the prominent fact brought out by the Paper was that the Americans, bringing their ore between 800 miles and 1,000 miles to the furnaces, and then making it into pig-iron, and manufacturing it into steel, Mr. Granger.

Mr. Granger. and then transporting it 300 miles or 400 miles to the coast, had been enabled to successfully compete in markets which the English had previously supposed were solely their own. He thought the reason for that was largely disclosed in the Paper, and that it was due, as there stated, to the extraordinary enterprise and ingenuity in the saving of time and labour. It was well known that the Americans were perhaps the most inventive people on the face of the globe. The owners of mines, the managers of railways, and the owners of manufacturing establishments, encouraged ingenuity on the part of everybody in their employ, from the general manager and the superintendents down to the foreman and the labouring people; so that all hands were on the look-out for some point where they could introduce a little improvement, which, on being brought to the proper authority, if found to be good, was adopted. Therein, in his opinion, was found the reason for the advance of the Americans. With the position which England occupied, he believed if the Yankees could be transported to England in a body, and take hold of the English mines and manufacturing, that, in the insular position of this country, its closeness to Bilbao and so forth, there would not be the least doubt that the Americans would hold the markets against the world. He remembered 20 years ago when he was building waterworks and gasworks in Canada, he came to Glasgow to buy the cast-iron pipes for the water-mains and gas-mains; he was surprised to find on talking with the manufacturers that the pipes were all 9 feet in length. He said to them that in America the pipes were 12 feet in length; it was an advantage to have the pipes that length because it saved $33\frac{1}{3}$ per cent. of the joints, the lead, the labour and the time in laying the mains; and he asked the manufacturers to make the pipes 12 feet long. They replied that they could not do it, that they had always made them that way, and that they could not alter their patterns to suit his views. He asked the members what would have happened if the conditions had been reversed. If an Englishman had gone to an American pipe-founder and found that pipes were being made in 9-foot lengths, and he made a suggestion to the manufacturer that he should make them in 12-foot lengths, and so improve the business by cheapening the laying of the pipes, that manufacturer would have adopted it at once, and the next day would have telegraphed to his salesmen to go out for orders, and compete with the other manufacturers, because he could make a pipe that would save $33\frac{1}{3}$ per cent.

Mr. Elwes. Mr. R. G. ELWES had visited a district a little south of that

Mr. Elwes.

referred to in the Paper, to examine some iron-ore deposits and to inquire into the cost of making iron on the site, and the cost of labour. He hoped members who had not been there would not be misled by Mr. Elliott Cooper's reference to the wages paid to a policeman. It must not be supposed that ordinary labour cost anything like the £240 to £300 a year referred to by Mr. Elliott Cooper. There were very few places in the United States where an unskilled labourer could not be obtained for between 5*s.* and 6*s.* a day. On other visits to the United States he had made many inquiries as to the effect of the high wages, and he came to the conclusion that cheap labour was the dearest labour. Although high wages were paid, even to the unskilled American workmen, the American workmen lived well and were able to do a larger amount of physical work than people who did not live so well, and they were very hard driven. They managed to get much more work out of the ordinary workman in America than from workmen in England. With regard to the high rates of carriage, he was at one time the Resident Managing Director of a railway in Spain, and iron-ore deposits were found on that line which it was hoped might be utilized if taken to England. The people who owned it asked him what was the least rate at which he could carry the ore to the port. He was extremely anxious to give them a rate at which it was possible to work the deposit. He considered the matter with the manager of the railway in great detail, and he found that what mainly prevented a very low rate were: first, that the gradients would not allow of sufficient load being taken; and secondly, that there was too much dead weight in the trains. On a visit to the United States about a year ago he had inquired into the cost of taking coal to a seaport in one of the southern States, and as to how it could be carried so cheaply. There, again, the two explanations were easy gradients, heavy trains and 30-ton wagons. If the gross weight of an English coal-train were taken, a train carrying 240 tons of coal, and compared with the weight of the corresponding American wagons that would carry the same amount, it would be found that the dead weight being hauled backwards and forwards in England was about 50 per cent. in excess of the dead weight that was hauled in America. Something like 50 per cent. more dead weight was carried in England in a given quantity than in America; that was, roughly speaking, the 30-ton wagon's dead weight would be 10 tons to 11 tons; and he supposed three nominal 10-ton

Mr. Elwes. wagons in England would weigh between 12 tons and 15 tons, and would carry only 24 tons to 27 tons. It varied according to the character of the traffic that was being carried; but, at the lowest estimate, there was a considerable excess of dead weight. Also the trains were longer, more difficult to handle, and so forth. Therefore, if it was required to get minerals carried at a cheap rate, two things must be provided, large wagons of low tare and good gradients.

Mr. Segundo. Mr. E. C. DE SEGUNDO thought the Paper prophetic in its character, and the prophecy of the Authors had been very quickly fulfilled. American locomotives had been supplied to English Colonies for some time past, but he had lately learned that the Midland Railway Company had placed an order with an American firm for locomotives for use on their line.

Mr. Robertson. Mr. F. E. ROBERTSON remarked, with reference to the railway rates, that if in England the luxuries of vested interests were indulged in—for which the early histories of the railways must be referred to—of Boards of Trade, Parliamentary contests, and light, numerous, and fast trains, they would have to be paid for. On the East Indian Railway, the line which had much the largest mineral traffic in India, the rate worked out to about a $\frac{1}{4}d.$ per ton-mile on large consignments. The tare of the wagons (four wheelers) was just under 7 tons, and the gross load 24 tons; 1,000 tons was the normal weight of train. The trades unions in England had a good deal to answer for the marches which America was stealing on England. Apart from strikes, he did not think the insidious and far more dangerous restrictions on output and work which the trades unions were in the habit of practising, were fully realized. The result appeared to be that a really good workman, who could do better than his fellows, and who, when the delegate called round, was told he must not do so, seemed to think that he had better strike camp and go to America. He was afraid that was happening very generally.

Mr. Head. Mr. ARCHIBALD P. HEAD thanked the members for the considerate manner in which the Paper had been received. The Authors had thought the Paper was already long enough, and as bibliographic appendixes were already in existence, they had considered such additions unnecessary. It was true that the relative advance of the Mesabi district had not been as rapid as the others; in fact, in the 1898 returns, the Mesabi district had the smallest relative advance, with the exception of the Vermilion, which had actually decreased. All the others had advanced. He presumed the £240 to £300, mentioned by Mr.

Elliott Cooper, must have been paid to a New York Irishman who was well in with the Tammany Hall authorities. But he doubted whether that could be taken as typical of wages for labour. From what he had observed in America, an unskilled labourer received about 25*s.* a week in the Pittsburgh district as against about 19*s.* in Middlesbrough. As to the price of the ore, the 12*s.* 8*d.* per ton of ore at Pittsburgh was a question of fact rather than of opinion. It was based on the market price of the 63 per cent. standard ore at Cleveland, which was quoted in the current technical press at 11*s.* 4*d.* a ton. But only two-thirds of that was used, mixed with one-third of Mesabi, which was 2*s.* 3*d.* per ton less, and adding on the 2*s.* 1*d.* for freight to Pittsburgh, the price of the mixture was 12*s.* 8*d.* per ton. Mr. Price-Williams' remarks as to Bilbao ores and the freights to Cardiff were perfectly true; he gave 8*s.* 1*d.* as the cost of Spanish ore as against 12*s.* 8*d.*; but 8*s.* 1*d.* was the cost price, he understood, whereas the 12*s.* 8*d.* was the selling price. The 8*s.* 1*d.* allowed nothing for profit, and in any case it was a poor ore, containing only 50 per cent. of iron in the cargo as against 63 per cent. Not only was the American ore richer; but being richer, less was needed per ton of pig-iron and less coke was required to smelt it, and altogether the furnace manager had better conditions. Then, as to the cost of conveying the ore to Pittsburgh, it was stated in the Paper that the cost was $\frac{1}{6}d.$; but that particular railway, the Pittsburgh Bessemer and Lake Erie, known locally as the Butler line, was, he understood, the property of the Carnegie Steel Company, and that had to be taken into account in considering the cost. With regard to the tractive power of the locomotive mentioned on p. 91, the train weighing 1,600 tons could only be hauled on the level, which, according to Mr. Price-Williams' figures, was quite possible. No doubt pusher engines were used at gradients. In reply to Mr. Bauerman, there was a particular mine near Ishpeming which he saw, called the Sawmill mine, which had been abandoned. There were some very beautiful specimens of jasper and iron ore mixed. As far as he knew that ore was not being used at present, as better work could be done with the ordinary legitimate ore. The average cost of freight on American railways was $\frac{1}{3}d.$ per ton-mile, $\frac{1}{6}d.$ being quite exceptional. The Pittsburgh Bessemer and Lake Erie Railway, on which it was only $\frac{1}{6}d.$ was a very peculiar railway in that it was only for minerals. There was no block system, no stations, and the signalling apparatus was of a most primitive description. There were no passenger trains, and everything was done for cheapness. That would not apply to a rail-

Mr. Head.

Mr. Head. way where there was mixed passenger and goods traffic. There was no doubt that the Galwara iron ore deposit in Swedish Lapland was destined to become a great factor in the English iron trade, especially when the railway at present under construction to the West Coast, where the sea was always open, was completed. At present the ore was shipped at Lulea, which was frozen up half the year, and was more expensive than it would otherwise be. As to the thickness of the Mountain Iron ore, a high authority on the American iron mining industry had reckoned there were 500 million tons of ore in sight in the Mesabi district alone. As to the cost of railways and the difference in railway rates, between England and America, the average capital invested in English railways was about £30,000 per mile of single line, as against £10,000 in America. There were obvious reasons for this, such as Board of Trade Regulations, which compelled the block system, the stations, and so on. In America bogie rolling-stock was used, which rendered sharp curves practicable, and steep gradients avoidable. After nine visits to the United States he was bound to say that he had the highest admiration for American inventiveness. Whether it came from their Puritan ancestors, who had to shift for themselves or be exterminated, or whether it came from the European race-mixture making a good national blend, he did not know; but the inventiveness was certainly there. It might be taken as true that in England the tare of freight cars was half the paying-load; in America it was one-third. He believed it was true that the Midland Railway had ordered locomotives, and so had the Soudan Military Railway, from American manufacturers. The English firms, he believed, quoted 25 per cent. more, and could not deliver under 11 months, whereas the American makers undertook to deliver in something like 7 weeks.

Mr. Preece. Mr. W. H. PREECE, C.B., President, desired to express the thanks of the Institution to Mr. Granger for coming to the Institution and speaking from the American point of view. He could himself speak in the same way from his experience in the United States, which he had visited three times. He had gone over there with the express purpose of learning, and he was bound to say that he had never paid a visit to the United States without coming back feeling that he was a wiser man. He invariably learnt something new, but more than that he had found—a fact due to the climate, or in the men—that contact with Americans always impressed one with more energy and more go. The moral of that was, that what English engineers really needed

was to send their men a little more to the United States to see how things were getting on there. Mr. Granger had referred to pipes. It was a remarkable thing that in this country manufacturers could not be induced to manufacture pipes in longer lengths than 9 feet. Perhaps he was the largest user of pipes in the country, and only in the last year he had sent over emissaries to Pittsburgh to inquire for the supply of 12-foot pipes. But he learned as soon as it was imagined that there was a probability of the British Government getting cast-iron pipes from the States, the manufacturers were beginning to talk about making them in 12-foot lengths. Sometimes, however, it was the other way about. There were some things in this country where Englishmen could teach their friends the Americans something, and especially in one direction with which he was intimately acquainted, the telegraphic business. At that very moment three experts from the States had been sent over to England to see if they could learn something, and they were learning a great deal. He was glad to be able to say that, because he had never failed to acknowledge that in his first visit to the States in 1877 he brought back the telephone, the quadruple apparatus, the sounder apparatus, and many other clever inventions. They had been impressed on the English system and had grown there, and when he visited the States some 17 years afterwards, he found that in that particular department the States had remained where they were, while England had advanced with leaps and bounds. He wished to express his great regret that more energetic defenders of the railway interests had not spoken that evening, because the real moral of the discussion was that the true culprits who were allowing the Americans to come and beat England in its own markets were the railway companies and not the inertia of English manufacturers.

Mr. Preece.