

Discussion.

The PRESIDENT, in tendering the thanks of the Institution to the The President.
Author for his communication, remarked that it was a Paper which would go home to many at the present time when so much thought and attention was being given to improved methods of production and construction, and when the Institution had recently set on foot a committee for standardizing the various sections of iron and steel, which committee was now investigating many subjects connected with the question of standardization.

The AUTHOR observed that the illustrations in the Paper were The Author.
not intended to be working-drawings, but simply diagrams to make clear his meaning. He had endeavoured to state the facts as he had found them and not to draw any more deductions than were absolutely necessary. He had limited the Paper entirely to a description of the Pencoyd works, because those works were an example of very good American practice, and certainly showed remarkable results in the way of large output and low cost. At Pencoyd he had been looking after the construction of twenty-six viaducts for the Uganda Railway, made, not to American standard patterns, but to designs prepared in Sir Alexander Rendel's office. The amount of work, per annum, usually done in England as compared with the figures given in the Table (p. 61) were—draughtsmen, about 1,000 tons; men in bridge-shop, 20 tons to 30 tons; templaters, about 500 tons. He based those figures on his own experience, and they had been checked by one or two men who knew something about the matter in this country. The figures were such that anyone conversant with the subject could easily check them from his own experience. It would be observed that draughtsmen turned out a little more in England than they did in America, but in America more work was put into the drawings, and to illustrate this he exhibited a few blue prints of actual working-drawings made at Pencoyd. A table was given on each drawing showing the sizes of all material required; and the steel was ordered from those drawings. The table went into the works with the drawing, and the workman could pick out his material from the list, there being thus much less possibility of error and no delay. In England the output of a man in the bridge-shop was between 20 tons and 30 tons per annum, but at

The Author. the Pencoyd works the average for the past six years had been 115 tons. At Pencoyd the templaters accounted for 2,366 tons per annum, while in England the figure was about 500 tons. Those figures showed that there must be something radically wrong with the works, the management, or the workmen in this country; whatever it was, it must make competition extremely difficult when one set of men turned out five times as much as another. But the whole question of cost was not confined to the cost of labour only. Workmen in America were paid between two and two-and-a-half times as much as those in England, and they turned out five times as much work; so that labour there was much cheaper than in this country. For the sake of argument it might be taken that the capital value of works would be approximately proportional to the number of men employed; and, on that assumption American works not only turned out five times as much work per unit of capital as works in England, but, as they worked day and night, they really turned out ten times as much work. The great bugbear of the manufacturer in every country was the fixed charges, which had to be added to every estimate, viz., interest on capital, taxes, expenses of management, office establishment, advertising, etc. Working on the American system the fixed charges were only about one-tenth of the amount of such charges in England per ton of work turned out; and the charges for coal, water, oil, depreciation and repairs, probably only one-fifth. Totalling up the cost of labour and charges, the American manufacturer could work at a much cheaper rate than the English manufacturer. In conclusion he wished to express his thanks to Sir Alexander Rendel, K.C.I.E., M. Inst. C.E., for the loan of the drawings, and to Messrs. Wölfel, Cadmus and Frosell of the American Bridge Company for the facilities they had afforded him for viewing everything that could be seen, and for furnishing him with the statistics of output; also to Mr. J. T. Daly, of the Horseley Company, who had kindly furnished him with figures corroborating those which he had quoted.

Mr. Robertson. Mr. F. E. ROBERTSON thought the Paper was a valuable contribution to the discussion on foreign competition, which he feared could not be settled by roundly asserting that all foreign manufactures were so bad that they were put quite out of court. A sufficient explanation of the cheapness of American manufactures appeared to be found in the labour-charges and the fixed charges, which fell much more heavily on the smaller output. Probably the smaller output which appeared to obtain in England was equally due to want of system and appliances in the shops, and to unwise

action on the part of trades-unions. He remembered a striking instance of the former in connection with a very large contract for bridgework with which he had been connected some years previously. The firm which had taken the order had been an excellent firm as regarded the quality of their work, but their plant and methods had been antiquated. They had had a very poor collection of drills of all sorts and sizes, and but one steam riveter to do the whole of the work. After the work had gone on for a short time, he had been obliged to show them, by simple arithmetic, that at the rate of progress their resources admitted of they would be some years over the job, and that consequently, unless they took steps to lay down a reasonably adequate plant the delay clauses of the contract would have to be enforced. Thus constrained, they had laid down a number of drills and some hydraulic riveters; and shortly afterwards they had candidly admitted that the expenditure was the best investment they had ever made. Lately another instance of inadequate appliances had occurred in the case of a tolerably large contract for trestle viaducts very similar to those alluded to in the Paper. Here again the contractors had been a very good firm, and there had been nothing to complain of with regard to the quality of their finished work, but they had proceeded to make the butts of the trestle legs by the time-honoured process of chisel and hammer and file, although the designs had been made expressly with a view to cheapen the work by duplication. He thought it could scarcely be contended that that was an adequate arrangement; or that work done in such a way would be as good or as cheap as work turned out by proper plant. Another point in which the bridge-yards in this country seemed to be deficient was in the want of adequate covered space, a defect which in the English climate was a constant source of delay and expense. The way in which bridge-yards had grown from small beginnings formed a reason for that; but there must be a point at which it ceased to be a reasonable excuse. Waiting on the rolling-mill was also a disadvantage from which the British bridge-builder suffered, and from which the large American yards, having their own rolling-mills, were tolerably free. He did not think that higher railway charges were of much weight because the American rolling-mills were on the spot at the bridge-yard. The detailed and, as he believed, unprejudiced statements in the Paper formed a good standard by which to criticise British methods in those points where the British output seemed to fall short of what was obtained in America.

Mr. Gribble. Mr. T. G. GRIBBLE remarked that he had had something to do with bridge-design and construction in the United States some years previously, and he thought that one of the reasons which militated strongly against the standardization of plant with the manufacturers in the United Kingdom was the difference between the systems in vogue in the two countries. Bridge-works in this country had no designing engineers on their staffs, while in America some of the best engineers were connected with bridge-building firms, and in many cases, except, perhaps, in the most important works, the independent engineer designed only the general lines of a structure and gave the stress-sheet to the bridge-works, leaving all detail to its engineering staff. Such procedure helped the American shops to standardize; they knew just where their own types of stiffeners, eye-bars, etc., could be put in. In England the continual complaint was that the great diversity of design, even in common girder-work, greatly hampered a firm having a few useful machines. Sometimes there were grievous complaints about unworkable designs, especially in regard to those received from municipal engineers, who often appeared to be architects doing a little engineering by the way. They would put in, say, a little flange angle with a 1-inch rivet in it, with no possibility of putting a cover on. He did not think it would prejudice the profession of the civil engineer at home if methods somewhat similar to American methods were adopted here. In America the bridge-engineer had plenty of scope, whether he went into the service of a bridge-company or acted independently.

Mr. Webb. Mr. F. W. WEBB, Vice-President, observed that he had used for some years the lifting-crane described by the Author, for lifting heavy plates, and had found it very useful. He had not had much experience with ordinary bridge-building, but had had some breakdown jobs, especially in August, 1879, when the Llandulas viaduct on the London and North Western Railway in North Wales had been washed away. He had manufactured, from the pig-iron, the steelwork for the reconstruction of this viaduct, spanning a distance of 224 feet, in the course of seven days; and he thought that would compare very favourably with any work done before or since. An account of the rebuilding of this bridge, with illustrations of the work in progress, had been published.¹

Sir Douglas Fox. Sir DOUGLAS FOX, Past-President, remarked that he had had a great deal of experience of American and English design and manufacture in connection with bridgework. One point often

¹ *Engineering*, vol. xxviii. p. 343.

forgotten was that the circumstances under which American bridges were designed and used were generally very different from those which surrounded bridges designed for an old and densely-populated country like England. It was true that, from London, bridges were sent almost all over the world, and British designs for use in the Colonies and India would compare in simplicity and in interchangeability with any that could be found in the United States. When dealing, however, in this country with intricate questions of differing angles, of a few inches of span, of limited headway, and the many other questions of that kind which continually arose, standardization was absolutely impossible. When some six hundred spans on the Liverpool Overhead Railway had been handed over to his firm by the Dock Board, he had been told that they had been standardized, that the plans had been so arranged that it would be necessary to have only three types, and that about six drawings would do the work. Before the work had been finished the drawings had numbered over one thousand. English engineers could design simple bridges for simple circumstances, for the Cape or elsewhere, and could send out 150-foot, 100-foot, 40-foot, or 30-foot spans, which could be put up anywhere. Every part of those bridges was interchangeable, and the parts could be assembled with the greatest ease; but that was an impossibility when dealing with bridges in places like London, where the engineer was tied by all sorts of clauses and conditions. In an old country it was exceedingly difficult for bridge-builders or other manufacturers to be up-to-date. It was a very serious matter for them, and engineers sympathized with them, and as far as possible tried to simplify the work for them. He was quite sure there was a great effort on the part of the engineers in Westminster to meet that difficulty, and if the bridge-builders would only put their shoulders to the wheel and have the best possible arrangements in their works, he had no fear but that Great Britain could hold its own against the world.

Sir Douglas
Fox.

Mr. R. MORELAND, JUN., remarked that his firm had been engaged in constructional work for some years, and having decided three years ago to enlarge their works, they had taken 5 acres of ground at Silvertown. They had erected overhead gantries of 45 feet span, served by electric cranes. At one end of the site was the river, at the other end the Great Eastern Railway. Most of the material was brought by the river, and unloaded by the electric cranes, of which there were four, the longest gantry being 600 feet long by 45 feet wide. The stock-yard consisted of two bays of 45 feet span and 230 feet long, and two bays of 45 feet span and

Mr. Moreland. 140 feet long. Next came the machine shop of about the same size, served by overhead electric cranes. All the machines in the machine shop were driven electrically. At the other end was a loading-yard 200 feet by 45 feet. The shop had been put down with a view to giving quick delivery. In 1900 the firm with which he was associated had been asked to design the steel construction of the Imperial Theatre, under the architect, Mr. Frank Verity. On the 22nd December, 1900, instructions had been received to proceed with the work, and 1 week had been allowed for making the drawings. On the 1st January all the drawings had been in the shop. The constructive work had consisted of two tiers and part of the roof, as the Imperial Theatre was an old house with a new interior. The work had been completely finished by the 14th February, that was, in 7 weeks. Since then the firm had completed a large job at Harrod's Stores, comprising 1,100 tons of constructional steelwork. The order had been given on the 30th July, 1901, and erection had been commenced on the 26th August; three floors, containing 600 tons of steelwork, had been completed in 5 weeks, and the remainder had just been finished and erected.

Mr. Rigby. Mr. H. RIGBY observed that, as General Manager of Messrs. Joseph Westwood & Co., Limited, he had read with considerable anxiety, and sometimes with much pleasure, many of the statements that had appeared in the Press from time to time during the past two years with regard to American competition, especially in bridge-work. Many of them were undoubtedly of no value at all. The Americans started bridge-building with the British manufacturers' experience behind them, and it was only those who possessed very large capital who could put down a bridge-yard similar to that described by the Author. It would probably be found that many of the operations which the Author had described were now, and had been for the last 40 years, carried out in this country. Thirty years ago, when he was with the firm of Lloyds, Fosters & Co. (the Patent Shaft and Axletree Company), many of the up-to-date arrangements described in the Paper had been tried and discarded because they had proved to be unworkable. Multiple drilling had been tried, but so many drills had been broken in the process, and the machines had had to stop work for so long a time, that it had practically had to be discarded. The better and more workmanlike process was to assemble the punched work under single radial drills and drill right through; in this way Messrs. Westwood & Co. could drill twelve or fourteen plates at a time, and if it was possible to drill fourteen holes in 45 seconds, he did not think that was much behind American practice. With regard to the

Author's remarks as to the expensive part of bridge-building, Mr. Rigby. angle-smith's work, he had need of an angle-smith perhaps once in 3 months, to do an odd job. The whole of the smith's work was done by modern hydraulic machinery, and work which a short time ago had cost 2s. 6d. could now be done for 2½d. American competition was a serious subject, and one on which his directors and the workmen had had many conversations. As to riveting, he remembered a time when a day's work in this country had been considered by the Society to be thirty-two score, and men had only been allowed to work time-and-a-quarter, eight hundred rivets being the maximum day's work. It was no uncommon thing now at his yard—where Union rules were not adopted and prices were arranged with sets of men—for a set of four men to earn in one week £16 in wages, and the firm were pleased to pay the money, because the men earned it. A piece-work price was settled with the men, and if they could earn more than had been supposed, the firm was satisfied to let them do so. The yard referred to occupied an excellent position in regard to prices. The firm paid high wages to its men, but at the same time it obtained a corresponding amount of work out of them, and, as the firm and the men worked cordially together, they formed a happy and united family. What was good for the men was good for the masters, and vice versa. If that principle were carried out more generally, and if the managers and foremen made themselves better acquainted with the men and the work they were doing, competition would be on fairer lines than it was at present. The Uganda viaducts which had been mentioned had been tendered for by his firm, but their tender had not been accepted. No one had yet heard how much profit the American bridge-builders had made out of the work. The bridgework referred to by the Author was a first-class piece of work, one of the finest jobs he had ever seen turned out of Westminster, and he had tendered for it very keenly indeed. One reason for the loss of contracts was that many English firms did not care to send their workmen out of the country and take the responsibility of erecting a very large bridge in, say, Central Africa. Many contracts such as that simply meant loss to a firm and brought it to bankruptcy. He would be glad to hear what became of the American bridge-builders who took a contract and lost £60,000 or £70,000 over it. He had it on good authority that the American firm which had built the Burma viaduct had lost such a sum on the work. He had never heard of a bridge-builder in England who could afford to do anything of the kind.

Mr. Rigby. From what he had been able to observe, and to ascertain from those who visited the United States, he thought American competition need not be feared. He had been requested by his directors to visit the States for a couple of months to see what he could find out, and, when he could get the time, he intended to do so. If bridge-builders in this country would only keep level-headed and apply themselves to their work, there was no need for them to lose anything. At the time when so much had been heard of bridge-building in America, Sir Benjamin Baker had asked him to submit a price for the centre span of the Hopetown Bridge, a pin-connected link type of structure, full of work, even the floor being composed of corrugated plates ornamented with circular plates on the outside, forming a kind of cornice. Such a bridge had a very large amount of work in it and little weight. Sir Benjamin had required the bridge within 6 weeks, and Messrs. Westwood and Company had undertaken the work under a penalty. In 18 days the bridge had been passed, and in 28 days it had been shipped and paid for. Sir Walter Peace, the Agent-General for Natal, had asked him to build thirty-nine bridges at the time when the Boers had destroyed a considerable quantity of bridgework in northern Natal, and in competition he had undertaken to do it in 13 weeks. It had been done in 12 weeks and 4 days. The Author spoke of a bridge-yard turning out 6,000 tons to 10,000 tons of bridgework per month, but the whole thing was absolutely ridiculous and preposterous, and in saying that he was speaking as a bridge-builder and not as a joist-manipulator. It was easy to obtain a quantity of joists and put two or three holes in them, and work turned out under such circumstances on the other side of the Atlantic might well amount to 60,000 tons or 70,000 tons a year; but speaking of bridgework in the ordinary way, what did 60,000 tons or 70,000 tons represent? It all had to be planed, riveted and drilled, and where was it possible to find riveting-plant of a capacity of 60,000 tons or 70,000 tons per annum to start with? He admitted that owing to the standardization of American bridges there was probably half the weight in links, which brought the figure down to 40,000 tons. If two thousand rivets per day were put in by one machine and 40,000 tons of bridge-work was turned out, it meant at least thirty riveting-machines working night and day, and he could say without hesitation that at Pencoyd they had not a tithe of the number. The Author said that much of the plate material used in America had milled or rolled edges. A gentleman who had spent a long time at one of the bridge-works in America had assured him that in plate girders they never

cared there about the butt joints, and that he could put his hand Mr. Rigby. edgewise between the butt joints, from the top to the bottom of a plate-girder web. That was workmanship in America: in this country the first time the inspector came round that job would be scrapped. It was not possible to throw the work at a few machines and say, "Make that." Work must be manipulated by manual labour. The best machines the world could produce had to be guided skilfully and intelligently by the best labour obtainable. The cause of non-success in bridge-building in this country was the fact that manufacturers were hampered by too many varieties of requirements, with absolutely unworkable specifications often written by men who had never been inside a steelworks and knew nothing whatever about the subject. Clauses were put in with regard to machining and manipulation which would be all very well if they could be carried out, but they could not; and the manufacturer was at his wits' end to know how he could show the work to the inspector when he came to examine it. He hoped the time would come when the manufacturers would have more help from the engineers of Westminster than they had had in the past. There could be no doubt that the finest bridgework that had ever been turned out had been made in this country, and it had been brought to that state of perfection by men who knew what they were about. What had been the condition of bridgework before Sir Alexander Rendel had taken it in hand? The structures of Sir Douglas Fox were structures any manufacturer could tender for with pleasure; and the work of Sir Alexander Rendel was so plain that no working-drawings were required. Five thousand tons of work might be ordered from such designs in one morning. In some other cases it would take 5 years. Those difficulties did not crop up in America.

Sir GUILFORD MOLESWORTH, K.C.I.E., remarked that from his own Sir Guilford Molesworth. examination and from the reports of his officers he could entirely corroborate Mr. Rigby's statement as to the excellence of the work turned out under his supervision by Messrs. Westwood & Co., a firm which had supplied a large number of bridges to the Indian State Railways. The work had left nothing to be desired either in workmanship or in finish. He thought that if all the English workshops had been under such managers as Mr. Rigby, with non-union men, freed from the paralyzing influence of trades-union rules, less would have been heard of American competition. He wished he could lay the flattering unction to his soul that American competition was, as Mr. Rigby had said, of no account; but ugly facts constantly cropped up which brought home the

Sir Guilford Molesworth. conviction that it was a serious evil, and one which was on the increase. It was common knowledge how the Americans had carried off in competition contracts for important works in India, Burma, Egypt, and Uganda; and that seemed to be going on with increased intensity, for a Reuter's telegram¹ from New Zealand dated the 30th December, 1901, stated: "The Manawatu Railway Company recently invited tenders for a steel viaduct. The price quoted by American builders was one-fourth of that demanded by English firms. In consequence of this the New Zealand Government has decided to send to America all future orders for steel bridges." The difficulty was not confined to bridge-building; it pervaded more or less—in most cases more—nearly all British trades—iron, steel, cutlery, wire, tin-plate, electrical appliances, textile fabrics, boots and shoes, and innumerable other articles. As to locomotives, the Americans had not only supplied India, Egypt, and Uganda, but they had actually invaded the English railways and had sent locomotives to this country. In 1890 upwards of 300,000 tons of tin-plate had been exported to America, but that export trade was now almost extinguished, and the Americans were importing into England a large quantity of tin-plate. It was folly to be blind to these facts, because by so doing the way to improvement was barred. He held that British manufacturers and British workmen could still hold their own if they had a free hand: but they had not a free hand; they were handicapped in every way. Great Britain was too apt to neglect the teachings of the past. In these vaunted days of the Twentieth Century, although many advances had been made in science, the masses seemed to have made very few advances in common sense. Twenty-five to thirty centuries ago Æsop had tried to impress upon his countrymen, by means of his fables of "Killing the Goose that laid the Golden Egg" and the "Belly and the Members," how the interests of capital and labour were identical, and that if they were hostile the result was disastrous. He might refer to an episode which was not quite ancient history, but nearly so, viz., the great strike of the Amalgamated Engineers in 1851. At that time he had been an apprentice at Sir William Fairbairn's works, and had been a "knobstick" as it had been termed then, or a "blackleg" as it was called now—in other words, one who worked while the other men were out on strike—and he had had to be personally conducted by the police to and from the works. During the interval between the first warnings of the strike

¹ *The Times*, 31 December, 1901.

and its actual outbreak it had been almost the only subject of conversation among the workmen, and he had had many opportunities of talking with them on the matter. Their discontent at the proceedings of the trades-unions had been very great, and their repeated remark had been: "Why cannot they let us alone? We are doing very well as we are." He had asked one of the most intelligent of the men why he and other men like him did not get on to the Councils of the trades-unions and infuse some common sense into them, and the man had replied: "What can we do? When we have done our day's work we want to go home to our wives and families; we do not care to go blethering about in the pot-house. It is the pot-house chap with the gift of the gab who influences the Unions." He had invariably found that those men who talked the loudest about the rights of labour and the wrongs of workmen were the idle, dissolute men—the inferior workmen. It was not surprising that when inspiration was drawn from such sources the policy of the unions should be narrow, and that an endeavour should be made to place limitations on the output of labour. The demands of the trades-unions at the time he referred to had been for the abolition of overtime, of piece-work, and for several other things which tended to the limitation of labour. He had been told by many of the men that overtime was very popular; it enabled a man with a large family to tide over difficulties which otherwise he would have been unable to meet. Piece-work was extremely popular with the good men, as it enabled them to take small contracts, and by degrees to raise themselves from the position of workman to that of master. In evidence before a Select Committee of the House of Commons on the subject of strikes he had given the following extracts from one of the rules which had caused the strike:—

"RULE NO. 224.—SYSTEMATIC OVERTIME AND ITS DISCONTINUANCE.

"*Piecework.*—(1) In order to secure to our members the general prospect of employment we repudiate systematic overtime as being the cause of much evil, through giving a number the privilege of working more than a legitimate week's time; whilst so doing deprives other members of situations, producing much domestic misery, and causing a great expenditure of the Society's funds. We therefore authorise the Executive Council to take steps for its immediate discontinuance by issuing a General Order for all districts simultaneously to adopt this resolution. Any member refusing to comply with this resolution renders himself liable to be excluded. (2) That the same steps be taken to abolish piecework, to destroy the practice of working more than one lathe or machine."

The concluding words referred to the self-acting machines, of which one man could work several. Exclusion involved not

Sir Guilford
Molesworth.

Sir Guilford Molesworth. only loss of all previous subscriptions, but also social ostracism. The men were tied hand and foot by the unions. The strike in question had gone on, entailing a terrible amount of misery on the men and ruin on the masters, and it had enabled America to get its first grip of the trade. Fortunately, the Amalgamated Society had been badly beaten, for if the demands had been conceded the trade must have been ruined. Within the last decade, the same society had acted again in the same way, the struggle having the same result; but again America had been enabled to get a tighter grip on the trade of this country. It was extraordinary how the labour-leaders openly preached the doctrine of the limitation of output. He had seen, on the authority of the secretary of the National Free Labour Association, that Mr. John Burns, M.P., had stated to an audience of workmen that it was their business to sell their labour at the highest price, and their duty to work as few hours as possible. Mr. Keir Hardie, M.P., had told an audience of men that their best interests lay in the direction of getting as much money as possible for as little work as possible. When such principles prevailed, how was it possible to compete with the foreigner? Mr. Schwab, the president of the Steel Trust in America, at a great labour-conference at New York in December, 1901, had declared that labour-unions would fail in the same way as trusts had formerly failed, so long as they adopted as their fundamental principle the restriction of output; and had expressed his belief that English labour-unions had been the cause of the decadence of English manufacturing industries. Again, according to the Press, Mr. Schwab had also recently said that the attitude of labour in England would never permit mills and factories to be worked as they were worked in America, and that careful survey of the whole field seemed to show that the English workman received on an average less than one-half of what the American received year in and year out; and yet the cost of production had been nearly doubled, solely by the action of the labour-trusts which predominated in England. The same policy pervaded other industries. The following rule appeared upon a bricklayer's card :—

"RULE 5.—You are strictly cautioned not to overstep good rules by doing double the work you are required and causing others to do the same in order to gain a smile from your master. Such foolhardy and deceitful actions leave a great number of good members out of employment the year round. Certain individuals have been guilty who will be expelled if they do not refrain."

The result was limitation of the number of bricks laid. While 450 bricks per 9-hour day was said to be the average work of

the British bricklayer, Mr. Stewart, an American working at Manchester at the Westinghouse works, had got out of his men 1,800 bricks per 9-hour day per man, and 2,500 bricks per day per man on the plainest work. He was informed that the London County Council was content with 330 bricks per day. In the boot trade there had been recently a riot in Northamptonshire. Managers had been stoned, and the men had definitely decided to go out on strike if the manufacturers persisted in retaining the machinery imported from America. That might be contrasted with what was being done abroad. He noticed that in Vienna in December, 1901, the Minister of Commerce, acting on the advice of the National Council of Labour, had decided to buy American machinery for manufacturing boots and shoes, and to supply that machinery gratis to Austrian manufacturers, as the only means of saving from utter ruin the Austrian boot and shoe trade, owing to competition with America. Foreigners were carrying out the opposite policy to that which was carried out in this country. Apart from the actual limitation of labour the loss by strikes was appalling. The labour-reports stated that the amount of labour lost in 1893 in strikes had amounted to 31,200,000 days; and that figure did not represent the losses to the manufacturers, for a strike curtailed their capital and prevented them from launching out into that expenditure which was so necessary in carrying on works in competition with America or other foreign countries. He thought trades-unions would be very useful if they kept to their proper sphere, if they were defensive instead of aggressive. British labour was the best labour in the world, and the British master was the best master in the world, if these were only untrammelled; but as it was, the British labourer, under the paralyzing and degrading influence of the trades-unions, was becoming a slipshod man who took no interest in his work; a degraded man who made the labour of England the most expensive and at the same time the least efficient labour in existence. If British trade was to be saved, the only thing to be done was for masters and men to enter into a strong combination to throw off the terrible tyranny which was killing the country's trade.

Mr. EWING MATHESON considered that it was extremely useful to Mr. Matheson, have international comparisons made, and especially interesting when the other side was the United States. He was very sorry to hear Sir Guilford Molesworth accept, to begin with, the superiority of the United States as a matter to be taken for granted, and as one that, though it might be excused a little or explained,

Sir Guilford
Molesworth.

Mr. Matheson. was none the less a fact. Sir Guilford had spoken of a bridge in New Zealand which had been supplied at one-fourth of the price any British manufacturer would offer, but he had mentioned nothing with regard to the conditions. It would be interesting to know what kind of bridge it was, of what design, and what were the conditions. A bare statement that the contract had been taken at a quarter of the price was not evidence one way or the other. With regard to the Paper, the whole question seemed to be dominated by labour, and it was continually being said that the American workman was superior to the British workman. Mr. Matheson had been in the United States often and in many of the principal shops, and he had really come across very few American workmen. All the best men were from Great Britain. The man at the steam-hammer came, say, from Middlesbrough; the man at the rolling-mill came, say, from Sheffield or Workington; and the engineer from Leeds. The manufacturer wanted the best emigrants he could get, and he looked upon them as capital out of which he could make money. Still they were British craftsmen who did much the best work in America. They were stimulated by the climate, had meat three times a day and used up their lives quickly; but they had no more total energy than the workmen of this country. It was all taken out of them by the time they were forty-five, and then other emigrants arrived from England to take their places. The proprietors of the works had the men ready to their hands, men who worked desperately hard and better than those who had served an apprenticeship in America, and they received better wages. It was very interesting to those members who were concerned with bridge-building to see the plan of the Pencoyd yard (Plate 1), which was very conveniently placed between a railway and a river. He would not himself have cared to choose such a site, because it was wedged in tightly between two places of different levels where it was impossible to extend a foot sideways, although there was room to extend lengthwise. The Paper was entitled "Workshop Methods," and he observed that the diagram referred to a bridge-yard, but it was not a bridge-building place at all. It was a place where certain girders and pieces of girders were made, which, when carried away, could be built into bridges. In this country manufacturers were asked by engineers, rightly or wrongly—he thought rightly—to make the bridges and to show them as such, and then to take them away and put them up in place. To compare the tonnage of work of the size turned out in that yard with what was done in this country was fallacious, or, at any rate,

the comparison was not complete. The Author said that he Mr. Matheson. had had considerable experience in England before going to Pencoyd, and Mr. Matheson would like to know the length of that experience and the kind of works in which it had been obtained. There was too often a tendency, in visiting a new country, and coming under the glamour of new and interesting objects, to compare the new things favourably with those of more ancient date in the country from which the observer came. There was not much in the Pencoyd works that was new, although the arrangement of the processes was extremely good. A rotary planing-machine was shown as if it was something novel and peculiarly American, but such machines had been seen in England in considerable numbers, and on the whole were not considered very successful. With regard to the crane-hooks for lifting beams, he hardly knew a quarry in Great Britain where stones were not lifted by these self-acting grabs. Reference was also made in the Paper to the wonderful machines in America for upsetting eye-bars, or, as they were called in this country when they were used, links. Some of the machines in America were very powerful, hydraulic pressure of nearly 1,000 tons being used sometimes for upsetting the end of a bar. Between 1865 and 1875 there had been a large output of bridge-links in this country. He believed that the late Sir George Berkley, K.C.M.G., Past-President Inst. C.E., in his time had shipped no less than 30,000 tons of such links to the Great Indian Peninsula Railway and other railways in India under his control, all the links being made at one works in London on the Thames, which had been abandoned long ago. The process and machines used in that works had been far better and cheaper than anything existing in any of the American workshops. The works in London had been closed owing to the retirement of the proprietors and to the sale of the site; and as links were no longer ordered in large numbers by English engineers the trade had come to an end; but if they were wanted again he believed they could be made in this country better than in America. The "upsetting" referred to in the Paper crushed the fibre of the steel and was not a good beginning for a link. Any one walking on the footpath across Charing Cross bridge would notice that the tension members, both horizontal and diagonal, were links, and they had been made in the English fashion entirely in the rolling-mill, where the fibre was treated to its best advantage. The Author compared the quality of steel in America with the quality of British steel, but Mr. Matheson did not think comparisons were necessary, because the same kind of

Mr. Matheson, steel was used in both countries—a steel having a tensile strength ranging between 28 tons and 32 tons per square inch. With regard to the workmanship of American bridges, it was always difficult to compare the conditions of one country with those of another, or to present to the manufacturer of one country conditions which were usual in the other. Manufacturers were necessarily guided by the wishes of their clients, the engineers—usually members of the Institution. He had been reading a report from a member of the Institution, an engineer engaged on public works in India, who had had the erection of many bridges received from England and from the United States, the American bridges being made on English lines, with rivets and not with pin-joints. In order to insure the erection of American bridges not put together in the works of the manufacturer, greater latitude had been allowed than would be permitted in England, and the engineer had reported that, unless the rivets were put in in a particular way, so as to fill the large holes, the American bridges were not so substantial. There the difference had told the other way, the Americans having had to conform to British conditions. Sometimes in an American specification there was a difficulty, because the whole of the workshops and processes in England had been made for the conditions which manufacturers were obliged to work under here. With regard to percussion riveters, there were four kinds of riveting-machines used in British bridge-works, steam, hydraulic, compressed-air, and pneumatic percussion machines, and each of them had its proper place. It was quite fallacious to say that one of them was better than another under all circumstances. No doubt the percussion riveter, namely, one which worked like a rock-drill, with a large number of percussions per minute, was useful for rivets of small diameter and where no very tight work was required—in light structures, for instance; but in boilers to be caulked steam-tight, or in other cases which occurred sometimes, when rivets $\frac{7}{8}$ inch in diameter had to go through three, four, or five plates and angles, and a tremendous grip had to be obtained on the plates to hold them together for riveting, a percussion machine of that kind would be quite inappropriate and useless. Therefore, unless information was given as to the kind of work to which the riveter was applied in America, it was impossible to make any comparison of it with the English system. The arrangement of templates was different in America because of the large amount of duplication. In this country the manufacturer was entirely in the hands of the engineer, and if the same conditions prevailed here it would be

found that there were manufacturers as enterprising as any in the *Mr. Matheson*. United States; at any rate, enterprising enough to go to the ends of the earth and put up bridges. But it would be found that, whenever specifications and conditions had been presented to an American manufacturer in competition with an English manufacturer, those specifications and conditions had been altered, and the two countries were not allowed a practically fair comparison. Bridges as designed in this country could not be made in the Pencoyd bridge-yard. Girders of 70 feet or 80 feet span with plate-webs 5 feet to 8 feet in depth, were not thought of in America. They were all made in pieces, articulated very carefully, and put together with pins at their destination. It might or might not be a better system than that prevailing in this country, but the two things did not admit of a fair comparison. It would be far too long a business to attempt to discuss the question of labour and strikes; but he fancied it was not all joy and happiness in the United States, and that there might be labour-troubles there also. He was very sorry to hear the Author assume that Great Britain was beaten in everything. Some Englishmen thought that when it came to good quality, the British manufacturer could still hold his own; and that when the consul or the enterprising missionary, whose knowledge of engineering was not very deep, talked about adapting English methods to the demands of the buyer, giving him what he wanted—giving him sixpenny pocket-knives instead of good Sheffield cutlery, because the Germans did so—some Englishmen were still prepared to stand on their merits, and believed that in the long run, if the consumer wanted something good, he would come to this country for it.

Mr. ARTHUR MUSKER congratulated the Author on the excellent *Mr. Musker*. example he had given of how bridges could be built, and his clear and concise description of the system of building, which hardly left much to be said. He considered that underlying the subject of the Paper there was one leading factor which made competition real and strong. It was an important matter, and was becoming more recognized every day; and he thought that where attention was paid to it this country could easily compete with foreign countries. The point was that foreign competitors built and equipped their works to turn out large quantities of machinery of one class and produced goods by special machinery; or, in a few words, they specialized, standardized and multiplied. Unless this country did the same it was impossible for it to compete. The point for discussion was how to achieve the methods necessary; and in the

Mr. Musker. first place he would criticize the Author's conclusions. He did not agree with the Author with regard to the workmen, because he maintained that if the works were equipped according to special and modern methods, and if there were in those works foremen and managers who knew their business, the British workman was equal to the foreigner. That fact was proved by competitors coming over to this country and laying down numerous large works, relying solely on British labour. He agreed with the Author in his other conclusions, but believed he did not go far enough. The question British manufacturers had to ask themselves was, why they did not equip their works in the same manner? The answer was that financial men did not realize the necessity, and managers and foremen had not learned to carry on the work in that way. Financial men were wanted who could realize that more capital was required if factories were to be carried out in a specialized manner. More working-capital was necessary, because larger stock was needed. Managers were wanted who could initiate economical methods of manufacture and who could direct their foremen. Foremen were necessary who could carry out specialized work and who could get the best value out of special machinery, and at the lowest price get the best work on the piece-work or bonus system. Given the money and such men, there need be no fear of any competition. That raised the question of how to produce the men, and quickly. To his mind there were only three ways of doing it. In the first place, men must be bought from competitors and charged with the superintendence of the workmen here; or else men must be bought from competitors, to teach foremen and managers. If that could not be done, managers and foremen must be sent where the work was carried out, to learn the methods adopted. To go on as manufacturers were at present doing would take too long. It was better to take advantage of the experience of competitors than to buy that experience dearly. He advocated, not the teaching of the British workman, but the teaching of his more intelligent superior, because it must be remembered that one manager could, and for his own benefit would, teach twenty foremen, and each foreman for the same reason would teach forty or fifty workmen; whereas if an effort were made to educate a workman or a youth, it was only dealing with a unit, and very slow progress would be made at the wrong end. One thing was certain, namely, that technical education would not produce such men; and the sooner it was realized that something more practical was required the better it would be for British trade. A large amount was being expended all over the country on technical and secondary

education, but the money was being spent by men who did not realize what was required, and the youth of the country were being educated by men who were not themselves practical. He suggested that the Institution, the members of which did know what was required, should determine what was necessary, and should let those who were spending this money know its views, so that proper steps might be taken and followed up. Another matter requiring consideration was the English apprenticeship system. Mr. Stewart, of the Westinghouse Company, maintained that the system of apprenticing a boy for 5 years or 7 years and paying him a settled rate of wages, running up to 12s. or 14s. per week when he was twenty-one, was very bad, as it gave the boy no inducement to improve himself or to work hard, and was entirely opposed to the American methods, where the boy was paid according to what he was worth. With regard to capital, a point not fully realized in this country was that all improvements had to be taken out of capital and not out of profits; otherwise, how was it possible to throw on one side obsolete machinery and replace it with modern? Investors must also learn to put their capital into entirely fresh ventures, relying solely on the fact that large quantities of any class of goods or machinery might be manufactured and sold at a profit if produced in a proper manner.

Mr. H. F. DONALDSON observed that it was satisfactory to hear Mr. Donaldson. manufacturers adopting Mr. Rigby's view that all and everything was very well. On the other hand, it seemed that there was a decided danger in being too well satisfied with the present state of things. That English manufacturers had very strong competition to meet could not be denied. It was absolutely useless to talk about American contractors undertaking work for advertising purposes only, and being satisfied to lose £70,000 two or three times over simply for the sake of advertisement. If the books of those companies were looked into it would be found that there was not a loss, but a comfortable profit. The wish that competitors should lose their money on new ventures was perhaps father to the thought. He read into the Paper three main points for which he might give three main words—standardization, specialization, organization. Standardization was a matter upon which much had been said, and on which much more would be said in this country before long. The Institution had, to the joy of many of its members and of manufacturers, set on foot a Standardization Committee in connection with many matters relating to bridges, roofs, ship-building, etc.; and personally he looked for very great benefit from the results of the Com-

Mr. Donaldson. mittee's labours. Standardization required to be taken up in much smaller matters than he had mentioned, and he might cite one point with regard to which there was a great deal of difference in practice, particularly in the manufacture of machinery—namely, whether the dimension of the spindle or that of the hole was to be the leading dimension. He hoped that some day there would be standardization which would enable manufacturers to know whether a 1-inch bolt was to be 1 inch in diameter or was to go into a hole of that diameter, within limits. Specialization enabled one works to produce large quantities of the same product of the same size. Circumstances and environment in this country did not lend themselves to that sort of production so much as in the United States. At the same time there was a class of specialization which might well be carried out in this country more than was done; that was, the adoption to a larger extent, for more varied uses, and in more shops, of the kind of thing exemplified by the Author's description of machines which worked with stops, marking arrangements, and so forth. Such machines could be made to apply to a great many articles which simply required holes of the same size but with different spacing, or spindles of the same size but different lengths. Such specialization depended upon the design of the machinery; and if the machinery was capable of being adjusted for a large range of dimensions, this country would attain something more in the way of specialization than it had at present. He did not mean that foreign competitors had a monopoly of that sort of thing; there were works in this country which were second to none in their equipment, but there were not enough of them. One of the reasons why so much was heard of American productions was that there were more go-ahead firms, more people ready to put down capital quickly in order to save the labour-bill, than there were in this country. That there were backward firms in the United States he thought was undoubted, and some of them he believed were worse than the worst of those in Great Britain. With regard to organization, it was the organization of a shop which arranged that the sequence of the operations upon any piece should involve its travelling in one direction only, or at most in two directions, which should never cross. In the instance described in the Paper the movement of the pieces was lengthways of the shop and across the shop, never going backward, but always forward. That was a point which was overlooked in many classes of work in this country, with consequent confusion, extra labour in handling, and extra selling-price. He

spoke with some knowledge, for it was his duty to keep himself Mr. Donaldson. well informed as to what different manufacturers were doing in engineering works, and his remarks embodied what had struck him in many of his visits. The Author referred to one man handling plates in America which it took three to five men to handle here. He did not know whether he was right in supposing that the handling was done on the goose-necks, or whether there was any overhead gear. If there was any overhead gear it was not represented in the diagram. He would like to know whether compressed air or any other overhead gear was used for dealing with plates, angles, or heavy pieces in the immediate neighbourhood of machines. With regard to oil-furnaces, the Author might say something about their efficiency. The pneumatic riveter had been referred to, and he would be glad to know if the Author had seen it applied to boilers. His own experience was that the work was not anything like close enough, even with the heaviest pneumatic tools, to make good boiler-work. There were many cutting tools used in the works, and he also wished to know whether the practice of the shop was that those tools were dealt with by the workmen themselves, or whether they were taken from store and returned when they required to be sharpened or touched up.

Mr. C. F. DIXON remarked that one point which had occurred Mr. Dixon. to him was the fact that for many years, up to within the past four or five years, bridgework in this country had been hardly remunerative. No protective system existed to enable a high price to be charged in this country, so that work could be sent abroad at low prices. In order to tempt capitalists to put their money into bridge-works, as had been suggested, it was necessary to show a good return; he did not see how a capitalist was to be induced to put his money into an industry unless he could expect a profit. That bridgework was not remunerative was shown by the fact that, until the boom had started some five or six years back, bridge-works had begun to show signs of closing. If it was possible to get such a price as would leave the manufacturer a fair margin of profit, there was no doubt manufacturers would go ahead and put down machinery; but how were they to put down machinery if they made no profit? One of the surprising things in American competition was the price at which the Uganda bridgework had been taken. If he remembered rightly, the price had been £10 or £10 5s. per ton, delivered in Africa from America. At the time the price of bridge-materials in England had been about £8 10s. per ton. At the lowest estimate

Mr. Dixon, freight would be £1 per ton, which left 10s. per ton for making the work and for profit. He had tendered for the work; but, of course, unsuccessfully. He agreed with those speakers who considered British workmen second to none. A large number of the successful workmen in America had gone out from England. The labour difficulty in England would be overcome before very long. Personally, if he could see his way to put down works on the American system, and could get the men to adopt the idea of each man doing his best and working modern machinery to the best advantage, getting paid accordingly, he would be able to compete successfully with America for colonial work. As a matter of fact, in bridgework the idea of making all union men work on one level was not rigidly carried out now; the best men actually did draw higher wages, and the practice was winked at. One of the things which troubled him very much as a manufacturer was the fact that a yard like that described in the Paper, which was very little, if at all, larger in area than the yard he himself worked, and which certainly had not double the machinery, should turn out very nearly ten times as much work as he turned out in the year. It was true the works were run day and night, while his works were only run in the daytime; but, taking it on the basis of daytime only, that would make the Pencoyd output, roughly, five times as large as his. Probably that was due to duplication and to not having to put anything together. He understood the work was made and sent away without being put together; but when a bridge was made in this country it was put together in the yard, taking up room and time, before it was sent away, and probably that made a difference of a good many tons on the yearly output.

Mr. Matheson. Mr. EDWARD E. MATHESON observed that the Paper had considerable interest for him, as about two years ago Messrs. A. Handyside and Company, had sent him to investigate the methods of American bridge-builders, and he had had the privilege of being twice at Pencoyd, and also of visiting the Phoenix works and several others. According to what he had seen and heard, the Pencoyd works were supposed to be the best in the whole of the United States for the class of work for which they were laid out. The first question to consider was the attitude of the builder to the trade, and generally it might be stated that in America the bridge-builders were masters of the situation. They practically all made their own steel and their own designs, and specified to suit their shops, their machines, and their men. They did not erect their work; in regard to painting, they simply covered it with black varnish; and they had a supply of fresh men as fast as others

were used up. In Great Britain the makers were the servants; Mr. Matheson. and there was only one works, or perhaps two, which made their own steel. To put the thing in a nutshell, English manufacturers worked to everybody's specification; they had to erect and to paint to the colour and taste of every individual engineer; they had no fresh supply of men, and they had the trades-unions to fight. With regard to design, it was interesting to watch the progress of American engineers. They were always improving, and, as a rule, in their designs arranged for as few sections as possible, which could be readily obtained and which admitted of simple connection and accessibility for riveting. It was interesting also to see how Americans were borrowing from British practice more and more every year; and now they had discarded the pin type of structure for spans up to at least 130 feet, and the tendency was to continue in this direction. In the colonial designs sent to this country there was considerable room for improvement. Sections would be chosen which did not exist, or which were very difficult to get, or which were made by only one maker; and in regard to forgings, the question of standardizing, of material, and of difficulties of manufacture often seemed to be ignored entirely. With regard to advertising, he was rather inclined to disagree with the last speaker, as he believed the splendid work of the Gokteik and Atbara bridges had been taken at a deliberate loss to get into the market. The Americans were masters of advertisement, and would deliberately, with speculative audacity, tender for a work they knew they were going to lose upon, in order to get into the market and to be advertised gratuitously all over the world by the Press. With regard to overtime, for work that had not to be erected, English shops worked double shift, and his firm had been working double shifts until quite recently for about three years. In England only the best of American works were heard of. There was a large number of second-rate, third-rate and fourth-rate works also. It was dangerous to state, on the one hand, that there was nothing to be gained through American practice, and equally unwise to say that American practice should be copied *in toto*. It ought to be recognised at once that only a compromise was possible. It should be remembered that American manufacturers started in a new field, and could avoid their predecessors' mistakes. It must also be realized that the requirements in America approached more nearly to the requirements in, say, Uganda. There must be a definite and distinct policy recognizing that English main-line finish was wasted in Africa and other similar situations. American prairie land corresponded to the plains of Uganda, but a

Mr. Matheson. skew bridge, appropriate to London, was out of place on the Zambesi. The point to be urged with consulting engineers was that a different policy was required to meet the different conditions, and British specifications required editing to suit circumstances which closely approximated to American conditions. It was the same in every trade in England. Englishmen had had their way so often that they forgot that new conditions were arising. The Americans, when working to British designs, did not hesitate to simplify the designs to suit their shops, machines and men, in order to facilitate delivery or to cheapen the work. He was certain that the Gokteik and Atbara bridges had not been made to the original specification, and it devolved on consulting engineers to help the British manufacturer to strike out a new policy, and to omit the unnecessary finish. Out of ten points, perhaps there might be two where perfect finish was required, but that was quite unnecessary on the other eight on the Zambesi. Apart from organization, what British manufacturers had to learn, and what was so difficult to learn in a small and old country, was the American methods not only of getting but of keeping business.

Mr. Chatwood. Mr. A. B. CHATWOOD remarked that the advice had been given in the discussion to lay down new plant. That was no doubt a good thing, but in a great many works he had been in there was something more important, and that was to lay down new brains. There were hundreds of works in this country which had grown from small shops, employing five or six men, whose principal went out to get orders and came home to execute them. Those works had grown to formidable proportions nowadays, perhaps employing five hundred to one thousand men; but the methods which had been suitable, and, in fact, the only methods possible, with a little shop of twenty to thirty men were not the methods by which work could be turned out on a large scale. He was acquainted with works which had started in that way and which were now employing two hundred or three hundred men; when the shop had grown big enough to afford to pay a foreman, say, 30s. per week, the best man in the shop had been made foreman, and when it had grown larger he had been made the works-manager. It could not be expected that such a man should get the best results from his men or his machines, or do what a works-manager should do, for instance, with regard to driving-power. That foreman could not reasonably be expected to make a suggestion to his Board that, say, it was worth their while to consider the adoption of electric driving. What was required was some really good works-management. It had

been suggested that English managers should go to America Mr. Chatwood. for it, but he did not think that was necessary; there were plenty of men to be had who could manage works satisfactorily and get the best work out of the men, and do it with a great deal of good feeling. But such men required to be paid, and it was not to be expected that a man such as he had in his mind, who devoted the whole of his energy to his profession, and had to work hard in the works, should spend all his spare time in thinking out matters connected with his work, or in reading up what was being done elsewhere, in order to keep ahead, for £3 per week. He had been called to some works a short time ago to examine a planing-machine which had gone wrong. He might mention that the works-manager in that case was in receipt of £700 or £800 per annum. The machine was specially built to plane steel plates, up to 12 feet in length and 4 feet or 5 feet in width, square. The cheeks were separate castings bolted to the bed, and, the machine had a cross slide on it, with the tool-box travelling across. He had examined the machine thoroughly and had found that the cross motion was $\frac{3}{16}$ inch in 4 feet out of square. Needless to say it had now been put right; but it had been in that state for 10 years, and every plate planed on the machine had been planed down the two sides with two tools, and then re-set to an 8-inch square, and as the square belonged to a workman it was not particularly accurate.

The AUTHOR, in reply, referring to Mr. Robertson's remarks with The Author. regard to waiting on the rolling-mill being a disadvantage from which the British bridge-builder suffered, and to the influence of railway charges, observed that at Pencoyd only sectional material was rolled, the plates coming from Pittsburg, Harrisburg or Coatsville, so that railway freights did have some influence on the cost. Sir Douglas Fox's remarks as to the difficulties of designing work in England stated the case so completely on that point that the Author did not think he need say anything further on the subject. Mr. Rigby had observed that many of the operations described in the Paper were now, and had been for the past 40 years, carried out in this country; but the Author claimed no novelty for them; he had simply described them as he had found them; and although they might not be novel, they were not in general use in this country, and he disagreed with the statement that many of them had been tried and discarded as "unworkable." They could hardly be "unworkable," because they were in steady use in America, and were doing very good work. Mr. Rigby had also mentioned multiple drilling; but there was not a multiple

The Author. drill in the Pencoyd shop as far as the Author knew. The only machines that could be classed as multiple drills were the gantry-drills, which were separate radial drills mounted on a frame moving over the work, each drill being attended to by a separate man. With regard to the output of the Pencoyd Works, the quantity mentioned in the Paper was 3,605 tons to 6,151 tons per month, not 6,000 to 10,000 tons as stated by Mr. Rigby; and, as to joist-manipulating, there was a certain amount of joist-work at Pencoyd, but not a much greater percentage than in any ordinary English bridge-yard—certainly not enough to affect the question. Mr. Rigby's calculation, that if two thousand rivets were put in by one machine per day and 40,000 tons of bridge-work was turned out per year, it meant thirty riveting-machines working night and day, could only be correct on the supposition that 4 cwt. of rivets were put into each ton of steelwork, which of course was absurd; but, as for the Pencoyd Works not having "a tithe of that number," there were at least thirty riveters there, which disposed of the question whether there were enough. That gentleman's remarks also threw a light on the subject of drawing-office methods, and the saving that could be effected by them. He did not think this had been done intentionally, but with regard to Mr. Rigby's description of the drawings for the Uganda viaducts prepared by Sir Alexander Rendel as so plain that no working-drawings were required, and that 5,000 tons of work might be ordered from such designs in one morning, he might mention that when those very drawings had been received at the Pencoyd works the managers had first had made about 200 sheets of detailed working-drawings, and had then ordered the steel, the consequence being that every man had known exactly what he had to do. That was one of the reasons why in America they were able to turn out the work so quickly. As a matter of fact, they had turned out 2,000 tons of steelwork under his inspection in 6 weeks, and fully as much other work in the same time. There had been no pressure about it because the abutments had not been ready. Before the steel had been ordered they had arranged for the ships. They had known exactly when they could do the work and have it ready, and they had absolutely refused to start on it until they had made all their arrangements for shipping, saying that they would not have it lumbering the yard. As to the butt joint in plate girders, Mr. Rigby's information was correct, but his inference from it was not quite fair. Engineers in America did not specify that the web-plates were to be planed and fitted exactly, they relied upon the web-covers to take the stress;

but where they had a joint in direct compression they were just as particular about its being planed to a true fit as were engineers in England. It was a question of difference of practice, and he did not think it was possible to take it as a case bearing on the point of excellence or otherwise of manufacture. It was not required by the engineers, and consequently was not done. With regard to the amount of work that the American Bridge Company could turn out, he had had a communication from America in which it was stated that the present capacity of the rolling-mill was 200,000 tons per annum, and of the bridge-shop 80,000 tons; so that apparently they had increased their output since his visit. Mr. Rigby had indicated a preference for assembling work under single radial drills and drilling through twelve or fourteen plates at a time; and thought that, if it was possible to drill thus fourteen plates in 45 seconds, that plan was not much behind American practice. He presumed they would be $\frac{1}{2}$ -inch plates at least, which made 7 inches of solid steel; and he certainly thought that if Mr. Rigby could drill through 7 inches of solid steel in 45 seconds he was not much behind American practice. At all events, nothing mentioned in the Paper could compare with this performance. Mr. Ewing Matheson had observed that the labour in American workshops was "mostly English;" if he substituted the words "partly cosmopolitan," he would be more correct. Although there was a fair sprinkling of Europeans, the Author was of opinion that the bulk of the workmen were American. As to all the energy being worked out of the men by the time they were forty-five, and there being a constant stream of fresh labour to replace them, he disagreed with Mr. Matheson *in toto*. The American workman was abstemious, and his home life was much more comfortable and refined than that of the average English workman. Mr. Matheson appeared to question the experience of the Author in recent English practice. He had been for more than five years manager of a large bridge-building works in Manchester, with an output of about 5,000 tons of bridge-work per annum; he had left these works in 1900. Most of the work had been done for English railways. On his leaving the works, some of the workmen had come to him and had offered to put in all their savings, if he would start new works and undertake the management of them. With regard to the clips for lifting joists and channels, it was quite true that similar clips were used for stone in quarries, but their use for the purpose described in the Paper was certainly not common in this country. He had described them because they saved a great deal of labour in slinging. It would never have occurred to him to institute a

The Author.

The Author: comparison between the American eye-bar and the links on the Charing Cross bridge, and he did not consider that the American class of eye-bar could be rolled. Quite an ordinary size for an eye-bar in the United States was 8 inches by $1\frac{1}{8}$ inch in section and as much as 40 feet long, with a head $18\frac{1}{2}$ inches in diameter and a $7\frac{1}{2}$ -inch bored hole at each end. He did not see how bars of these dimensions could be rolled, and he did not agree with Mr. Matheson that the fibre of the steel was in any way injured by the upsetting; in fact, the tests which were regularly made on eye-bars showed that there was no injury to the steel in process of manufacture. Makers in the States guaranteed their eye-bars to develop the full strength of the bar, when a full-sized bar was tested to destruction. He had had considerable experience with pin-connected bridges in India, and also considerable trouble with them. He had had surplus pin-connected bridges supplied to him from the Bombay and Baroda Railway, both on the Northern Bengal Railway and on the Punjab Northern Railway, and had been obliged actually to insert wedges between the links in order to secure even approximately equal tension on them; otherwise many of the links which should have been in tension were actually in compression. He would never have instanced these pin-connected bridges as examples of good workmanship, and they had been condemned wholesale. With regard to percussion riveters, at the Maryland Steel Works he had seen a pontoon dock, probably the largest in the world, for New Orleans, built to the inspection of the United States Government from the designs of Messrs. Clark and Standfield, of Westminster, wherein about 1,500,000 rivets $\frac{3}{4}$ inch to 1 inch in diameter had all been put in by percussion riveters and the riveting had been perfectly satisfactory. Probably the objection to percussion riveters arose from the fact of light riveters being used for heavy work. Mr. Ewing Matheson was hardly correct in stating that plate girders of 70 feet or 80 feet span were not thought of in America. As Mr. Edward Matheson had mentioned, Americans had discarded the pin type of structure up to at least 130 feet span, and were still discarding it; and a large portion of the output of the Pencoyd Works consisted of large plate-girders which were usually shipped whole. In reply to Mr. Donaldson, there was no overhead gear, the plates resting either on rollers or on goose-necks. The oil-furnaces were the ordinary furnaces burning oil, sprayed with a compressed-air jet. He had not seen the pneumatic percussion riveter used on boiler-work. The sharpening and repair of tools was not done by the workmen; the tools were returned to be repaired and sharpened.