Correspondence.

Mr. A. S. E. Ackermann wished to endorse strongly the Author's view that there was great need for the study of American methods in many engineering matters; and he considered that it was a pity that there were so many persons, even among engineers, who would not realize that the commercial prospects of Great Britain were in danger owing to foreign, especially American, competition, and to the fact that in so many matters, especially mechanical, her methods were antiquated. That there were several first-class firms in Great Britain whose methods could not be improved upon in the present state of knowledge, and that there were a number of very out-of-date shops in America, every one would admit; but it was the general standing of engineering in the two countries that should be compared; and the result of such comparison, it seemed to him, could lead only to one conclusion, namely, that the position of this country relative to America was now greatly inferior to what it had been during the past century, and that this unsatisfactory state of affairs was becoming daily more exaggerated. That this was and would continue to be so seemed to be almost inevitable, largely on account of the difference in the natural resources of the two countries. The area of the United States was nearly thirty times that of Great Britain, while the population was rather more than double; consequently the average density of population was only one-fifteenth of what it was in this country. The natural resources of America were almost boundless, and practically untouched, whereas those of Great Britain were largely worked out; and he would extend the Author's statement that there was more science in the drawing-office by saying that the general standard of education, considered from the scientific and commercial standpoint, was much higher; and that the people in America who were not engineers by training and profession were half engineers by instinct. In a recent tour in the United States, which had extended over 5,000 miles, he had met with some startling indications of industrial activity. For example, the well-known Baldwin locomotive works at Philadelphia had turned out, in the year 1901, over 1,200 locomotives—a rate of nearly four per day. Again, McCormick's harvesting-machine factory turned out 1,200 harvesters per day of 10 working-hours, or 120 complete machines per hour; which was said to be equal to the total production of

Mr. Ackermann.

Mr. Ackermann. all the harvesting-machine manufacturers in Great Britain. In the harvesting-twine factory belonging to the same firm, 60 tons of twine were made per day; and the output would shortly be increased to 100 tons per day. At McCormick's factory he had seen six men in charge of sixty-five automatic machines. Turning to an entirely different industry, the total output of coal by America in the last 3 years had exceeded that of Great Britain, and the effect of the use of machinery in this industry was strongly marked. In 1900 the coal cut by machinery in Great Britain had been only 1·48 per cent. of the total, with the use of the total number of 311 machines; whereas in America 19·6 per cent. of the output had been so cut: or, if only bituminous coal were considered, then 25·15 per cent. of it had been cut by machinery, with the use of the total number of 3,907 machines, or nearly thirteen times the number at work in Great Britain: while the number of machines employed in America in 1900, as compared with 1899, had shown an increase of 782 machines. Considering the coal got per annum per person employed, the average in Great Britain for the 3 years, 1898–1900 inclusive, was 300 tons, while the corresponding figure for America was 537 tons; or if bituminous coal only were considered (anthracite not being cut by machines), then the figure for America was 622 tons, which was more than double the quantity got per person employed in Great Britain. On the other hand, the value of the coal at the pit's mouth in America was almost exactly one-half of its value in England; and this fact, he thought, largely accounted for the Americans being able to build bridges more cheaply, even in British colonies, though it was not mentioned in the Paper. That there was serious need for reform in Great Britain was strongly indicated by the large number of successful firms in this country which were to all intents and purposes American, such as the British Westinghouse Co., Messrs. Babcock and Wilcox, the Standard Oil Co., etc. He feared a corresponding list of British firms in America could not be made. To all engineers and others interested in this important question of American competition, he would strongly recommend the articles on "American Engineering Competition," which had appeared in the *Times*, a reprint of which had been published recently by Messrs. Harper Bros., of London.

Mr. Blair. Mr. MALCOLM BLAIR, of Garston, observed that, as long as railway companies and corporations fortunately excluded foreign iron and steel from their work, there would always be a certain amount of bridgework for English bridge-builders. He did not think the Author was entirely correct in his statement that the cheap-

ness of production was the sole reason why American bridge- Mr. Blair.
builders were under-quoting British builders for bridges to be delivered outside this country. He was afraid they were treating this work as surplus production, and were willing to sell at a loss to keep up their output; getting a high price in their own country, and thus obtaining on the whole output a fair average price. This was known to be the course pursued by German and Belgian competitors for rolled material, the average result being usually equal to the selling-price of British material. The prices for the large contract for girders for the Uganda Railway, placed with the American Bridge Company some months ago by the Crown Agents for the Colonies had been published,[1] the lowest price quoted by English makers having been £13 17*s.* 6*d.* per ton, and the American contract price £10 6*s.* per ton delivered f.o.b. in any port in this country. It was idle to suppose that, if this work had been carried out in strict accordance with the very severe specification of the Crown Agents' engineers, it could have been executed at a profit. British manufacturers were handicapped to a certain extent by the free advertisement given to their American competitors by the newspapers in this country; many of these advertisements were exaggerated, and some were untrue. For instance, in almost every newspaper in Great Britain, it had been stated that Lord Kitchener had been obliged to go to America for the Atbara Bridge, because he had been unable to get it erected in time by British bridge-builders; and in addition it had been stated that the country had saved a considerable amount in the cost. The facts were these:—Out of about thirty bridge-builders in this country, only five, he believed, had been asked to tender. Drawings and a specification had been put before these five builders, and tenders had been sent in, no invitation being given to submit alternative designs and specifications. The times offered for completion of the work had not been considered satisfactory, and the Americans had been invited to tender. They had at once declined to do so to the Government design and specification, but had submitted tenders for their own stock design of pin bridge, for which they had the templates and material in stock; and their tender had been accepted. Surely this was contrary to all British ideas of fair play; for many bridge-builders in this country could have done as well as the Americans, if the work had been given to them on the same lines. Such a bridge would not have been accepted by an English railway engineer. The Americans were not always successful

[1] *The Engineer*, vol. xci. p. 166.

Mr. Blair. in their competition for work in this country: for instance, the contract for the supply and erection of about 13,000 tons of heavy constructional steelwork for the British Westinghouse Company's new works at Old Trafford, near Manchester, had been secured by an English firm in severe competition with America; though the designs and specification had been made and the work had been supervised by American engineers. He quite agreed with the Author that at the present time, when there was such keen competition with the manufacturers on the Continent and in America, the conduct of the trades-unions in this country was a great menace to its prosperity in the future. These associations were generally supposed to be disciplinary bodies, whose aim was to ensure good and punctual workmen; but he knew of no body of men who lost more time than the members of the Boiler Makers' Society, who were the bridge-makers in this country. A number of them made a practice of losing the first quarter of a day on Monday, and one or two more quarters during the week; and it had now become a custom to convert every Bank Holiday into a three or four days' holiday. The loss entailed by this waste of time to a firm with a standing charge, before profit could be made, of £25,000, could easily be calculated. If complaint were made to the society, the men are supposed to be cautioned or fined, the severity of which measures was generally shown by their losing the first quarter, or perhaps the whole, of the following day. It might be asked: Why not do without these society men and employ non-union men? That had been tried; with the result that when, after much expense in loss of out-put, etc., a staff of non-union men had been obtained capable of turning out satisfactory work, it had been found one day that about three-fourths of the men, by special inducements as to compensation and superannuation, had been persuaded to join the society, which then requested that the remaining non-union men should be dismissed, as the shop had become a union shop. Again, many of the inspectors who examined the work were members of the trade society, and the work of non-union men would not be entirely satisfactory to them The trades-unions encouraged their members to limit their out-put in several ways, viz., by refusing to allow a man to work more than one machine, though in many cases several machines could be advantageously attended to by one man; by reprimanding and fining their members for doing too much; and by interfering in the contracts between employers and employees for piece-work. He quite appreciated the Author's recommendation as to labour-saving machines, and in many works in this country these were being

adopted more or less; but the drastic measures which the Author stated were taken in America with obsolete, or partially obsolete, works, were, he feared, impossible in Great Britain, where capital was not invested in so venturesome a manner as in America; and he could imagine the feelings and words of the shareholders of a large British engineering works, when told by the manager, through the directors, that their works and machinery were obsolete and must be pulled down, rebuilt and re-equipped. British shareholders were not of that nature. As far as he could see at the present time, all that could be hoped for was a better feeling and less jealousy between British bridge-builders, and coalition to put the trade societies in their proper place, and thus secure the abolition of the limitation of out-put and the exorbitant pay received by their members for an indifferent day's work. In conclusion, he would like to draw attention to the fact that the enormous output of the Pencoyd Works, described by the Author, seemed to show that a fair quantity of the steel constructional work turned out was punched, and not afterwards rimered. This appeared to indicate that American engineers were ignorant of, or ignored, the fact that punching steel—even steel of mild quality—reduced its tensile strength by about 9 tons or 10 tons per square inch, in comparison with steel drilled or punched and afterwards rimered to a diameter at least $\frac{1}{8}$ inch larger than that of the original punched hole. While congratulating the Author on the admirable way in which he had put forward his facts, and thanking him for pointing out so clearly to British bridge-builders what he considered to be their weakness, Mr. Blair felt bound to confess that all engineers were not so pessimistic as the Author appeared to be. He believed many thought that British builders would still be able to live for many years to come, even in competition with foreign capital and labour, as long as engineers required a first-class job, and were determined to see that they got it. Mr. Blair.

Mr. A. BUCHANAN considered that the whole Paper emphasized the great difference which existed between the requirements of the American and the British home markets. It could hardly be otherwise, when the vastness and roominess of the United States, with its great rivers and rectangularly-built cities and towns, was considered and contrasted with this crowded island and its cities and towns built, for the most part, on no plan whatever. These local conditions had necessarily controlled the development of constructive engineering in the two countries, and could not fail to continue to do so, to a greater or less degree. The American Mr. Buchanan.

Mr. Buchanan. engineer could make his site suit his bridge; the British engineer's site governed the form of his bridge. The compactness of the Pencoyd Works bore eloquent testimony to this difference of conditions. Were it necessary in America to erect complete, in the bridge-works, every bridge made, the Pencoyd Works with their large turnout would require almost indefinite enlargement. Again, the drawing-office arrangements would most likely be found to require much modification. Either the staff in those offices would have to be largely increased, or the number of template-makers, as in British shops, would have to bear a much larger ratio to the drawing-office staff. The absence from British home work of repetition of parts (a feature predominant in American work) rendered many of the admirable Pencoyd arrangements much less applicable in British shops. The small number of planing-machines at Pencoyd was very striking, and was, of course, due to the fact that, apparently, the American plate-mills rolled wide plates much as bars were rolled in Great Britain, so avoiding the necessity for any planing, except at the ends of plates. Lastly, with regard to the human element, it seemed clear that the determination of the American workman to consult his own interests and to earn all he possibly could, more than equalized the higher rate of wages paid in America; and it was much to be desired that the same spirit should prevail in this country. He thought it was possible, however, to adopt, with great advantage, many of the American methods of saving labour; most of all, perhaps, in the handling of the work by electric overhead and other cranes, thereby reducing unskilled labour and securing rapidity of motion. Many older works might also be re-arranged so as to secure continuity in the various workshop-processes; and British bridge-builders would be blind to the signs of the times if they failed to do this. In all probability, however, these changes would be more effectively made now than they would have been some years ago. The danger to British trade for work other than home work would, he feared, remain, unless American methods of designing such work could be adopted. The American bridge-builder was largely the designer as well as the builder, and naturally he standardized his work, thus securing repetition of parts, and leading up to arrangement and adaptation of machinery so as to produce the work most economically. In this, he believed, lay the secret very largely of the success of the Americans as against British manufacturers in foreign and colonial fields.

Mr. Graham. Mr. J. GRAHAM remarked that a perusal of the Paper could not fail to impress the fact that, whatever the American bridge-

manufacturer found to do, he did with all his might. The methods of his British competitor might not at first sight show up well in comparison, and possibly there was a little Eastern apathy on the British side when compared with the energy of the West; but in many respects Great Britain was not far behind, and one thing was certain, viz., that the splendid quality of some of the modern British bridgework erected in various parts of the world could never have been attained by the methods and practice put forward in the Paper. So long as the respective spheres of influence did not clash, it was of little importance that Great Britain preferred to go along in the same old ruts; while nothing but new and go-ahead methods satisfied the feverish haste to comply with American demands. The opinion that in the near future the effect of this greater energy might be felt made the information contained in the Paper of great value, as indicating the direction in which improvements to facilitate rapidity of manufacture should tend. One thing which had seriously handicapped advance in British practice was the fact that there had never been any competition in bridge-design, and consequently the manufacturer had never had any stimulus to develop the simplest and most economical form; while the uncontrolled powers of the designing engineer had enabled him to perpetuate only his individual and often ancient ideas, good, bad or indifferent. Since the introduction of the Warren girder little had been done in British practice to improve ordinary bridge-design, unless it were the insistence on riveted joints in lieu of pin-connections; and it was satisfactory to know that good American practice was tending to confirm this preference. The chief complaint about British bridges was that they were too heavy and in too many parts. It must not be overlooked, however, that the country had been sending bridgework abroad for upwards of 50 years, whereas its competitors had been making for home consumption only; and experience had indicated that short stiff bridge-members were by far the most suitable for the rough handling they had to undergo during export. The modern tendency to send out long, slender, fragile bridge-members often resulted in many of them arriving at the site broken and bent, in consequence of heavy weights having been piled on them in ships' holds. Quite recently painters had called his attention to two of the angle-bars in the bottom boom of a large girder just erected; on examination, apparently slight cracks had turned out to be complete fractures, vastly reducing the strength of the whole bridge. It was apparent, therefore, that light, slender bridges had not

Mr. Graham.

Mr. Graham. everything in their favour, though it must candidly be admitted that their simplicity was very attractive. In the past year, in his experience in India, the parts of a 170-foot span, as delivered from England on the river-banks, had been erected 50 feet from the ground in four days. Within that time a turned service-bolt had been in every drilled hole, and the span had been ready to carry a train if necessary. This had been done without special effort, by native workpeople only; and the result was entirely due to the small number of parts, the simplicity of the connections and the perfection of the workmanship. In the foregoing remarks only the best practice was referred to; there was not the slightest doubt that British bridge-manufacturers were often hampered considerably in having to build bridges to unpractical and amateur designs; and there was yet much to be done before they would be generally employed only on the simplest and best designs, though undoubtedly the tendency was in the right direction. Capricious, arbitrary and useless conditions of manufacture were often imposed unnecessarily; in fact, to undertake some work was almost to court ruin when the low price paid and all the pains and penalties were considered. Manufacturers had only themselves to blame for accepting contracts with absurd and conflicting conditions, but no matter how stringent the conditions might be some one was always found foolish enough to take the work at a low price. A good common-sense bridgework-specification for one and all was extremely desirable, and a conference of engineers and manufacturers would be well employed in drawing up and promulgating such. Assuming that designs were in every way satisfactory, possibly the condition in bridgework-specifications—"all parts of a span to be assembled in position at the makers' works, and all rivet-holes to be filled abroad rimered out *in situ*"—was the one most opposed to American practice. In a recent article [1] he had dealt at some length with this subject, and the conclusion come to had been that the British practice secured the most satisfactory work, and that the holes need not be more than $\frac{1}{32}$ inch larger in diameter than the rivet. At the same time, the American practice was permissible, and the holes might be allowed to be a full $\frac{1}{16}$ inch larger than the rivets, if the shearing-area of the rivets in a connection was 75 per cent. more than the area of the tension member it connected, or the compression member, not including allowance for flexure. However, after designs, conditions and

[1] *The Engineer*, vol. xcii. p. 135.

methods had all been made simple and straightforward, the most vital question was, whether the British workman would approve and help to develop all the contrivances for doing in five minutes work on which he had possibly in the past been paid for one hour's time. One striking passage in the Paper was the statement that an American workman never seemed to want another man to help him to do what he was able to perform himself. This seemed to be the finality of Western advancement, and was the antithesis of Eastern practice. One thing, however, should be impressed on the British workman, and that was that the cheapest and best in every way was now demanded, and that the Empire's requirements should be provided for within the Empire. So far as bridgework was concerned, several years' intimate association with the Indian mechanic had satisfied Mr. Graham that repetition-work, such as the preparation of bridge-parts from templates, was work for which the native was eminently qualified. India was one of the largest consumers of bridgework, and labour being 50 per cent. to 60 per cent. cheaper than British labour, there was not a doubt that, given a yard laid out on American lines, it should never be necessary to go to America for bridgework, if Great Britain was incompetent to provide it at market rates. Nor must it be overlooked that all the objections to the shipment of fragile parts would be overcome if the material arrived in India only as plates and bars instead of as built-up members. Mr. Graham.

Mr. J. J. ROBINS remarked that for many years the Phœnix Foundry Company, of Derby, had been quick to design specially adapted tools for any multiple work placed in their hands; but, as was well known, British requirements had been so varied in design, that it had been next to impossible to adopt labour-saving appliances unless under exceptional circumstances. A few of these might be enumerated. On the Battersea bridge over the Thames (1889–90) there had been one hundred and eighty-five cast-iron girders to deal with, each girder being in five segments; all these girders had been faced at angles, and finished with the utmost accuracy, by a machine similar to that shown in *Fig. 11*, which was substantially a copy of the Company's design. On the same bed and at the same setting, six holes, 2 inches in diameter, through 3-inch metal, had been drilled simultaneously at each end of the segments, in 30 minutes. This machine had since been used for many purposes, especially for butt-joints of floor-plates for the firm's bridge-building yard. On the Liverpool Overhead Railway, in 1890, the Company had had nearly 11,000 tons of Hobson flooring to deal with, under Sir Douglas Fox and the late Mr. J. H. Greathead. Mr. Robins.

Mr. Robins. For this work a multiple drill of one hundred spindles had been designed and made, which had drilled each side of the flooring at one setting, completing two hundred $\frac{3}{4}$-inch holes in 15 minutes, or eight thousand holes per day of 10 hours; and this machine, before the completion of the work, had drilled upwards of five million holes. With other special tools then in use, it had been closely scrutinized by American experts who had frequently visited the works. Another tool used had been a special bar attached to an ordinary De Bergue punching-press, for punching the T-bars for the flooring. This tool had enabled four thousand $\frac{3}{4}$-inch holes to be punched per day, one man and a boy working it. On the pontoons for the Liverpool landing-stage they had been able to adopt these spaced bars for punching the plates and angles. Goose-necks, such as were represented in *Fig. 7*, had then been in use by them.

Mr. Roechling. Mr. H. A. ROECHLING remarked that the Author had dealt with a somewhat thorny subject entirely from an engineering point of view. Incidentally he had referred to questions of much wider range, belonging to the domain of national and political economy and social politics, the consideration of which was beyond the scope of the Institution discussions. The question of method was put forward very prominently in the Paper, and he could not help thinking that it was, to some extent, at the root of a few of the difficulties in this country; for there could be no doubt that what was conceived in a perfectly methodical way must, in the end, conquer that which was based on chance and carried out in a disjointed manner, one part of the work not bearing its due relation to others. Political speakers had frequently dwelt upon the absence of proper method in this country, and he thought there was a good deal of truth in the complaint; and while it was not necessary to imitate others who had learned from this country, he thought that, as a matter of sound common sense, there should be no reluctance to profit from the experience of foreign competitors. The Author had very properly placed the labour question in the forefront, for with a limitation of the output and the restriction of the working-hours, British manufacturers were placed at a considerable disadvantage as compared with their competitors who were not hampered in this way. However, he was glad to notice that especially in the engineering trades, the representatives of the labour interest seemed to have become aware of this at last; and he sincerely hoped that before long the strife between capital and labour would cease, and that the workman would realize the disadvantage accruing to him from the restrictions put upon the

manufacturer. The pendulum seemed to have swung too far one way, and it was time it assumed its normal position. The question of free trade was a very large one, but it must suffice to say that signs were not wanting to indicate that the wind was veering round and commencing to blow in the direction of protection. The apostles of free trade would, no doubt, stoutly combat any such tendency; but he felt satisfied that the conditions of the world's markets existing at the time when free trade had been established existed no longer, and, with protection all around, some form of reciprocal dealing with other countries was the only logical sequence. Mr. Roechling.

Mr. S. F. STAPLES thought a few observations on the subject of riveting, as carried out in American works, would be of interest in connection with the Paper. The floating dock which had just been completed for the American Navy Department from the designs of Messrs. Clark and Standfield, by the Maryland Steel Works, and which was the largest floating dock in the world, had been riveted entirely by percussion riveters. The most serious problem which had faced the constructors in the carrying out of this work had been the question of riveting. It had been solved completely by the utilization of unskilled black labourers and pneumatic riveters. The diameter of the rivets varied between $\frac{3}{4}$ inch and 1 inch, and the work had been carried out under most rigid Government inspection. On testing the quality of the riveting it had been found throughout to be most satisfactory, and the dock as a whole has just been tested by easily and successfully lifting with it the largest battleship in the United States Navy. There were upwards of one-and-a-quarter million rivets in this dock, and he believed he was literally correct in stating that not a single rivet in the whole structure has been put in by hand. Almost every type of percussion riveter had been used in carrying out the work. For riveting up frames which were attached to the skin, ordinary yoke machines had been used; for riveting the skin-plating, pneumatic and lever-bar holders-up had been used, and for driving the 1-inch rivets which were to attach the joint-plates connecting the different parts of the dock together to the body of the dock, special heavy dollies had been used. Upon the strength and water-tightness of these latter connections the safety of the whole dock depended, but there had not been the slightest difficulty in getting perfectly sound riveting. On straightforward work as many as 1,460 rivets had been put in by one gang in 1 day of 10 hours, the rate of payment for this class of work being 75 cents for one hundred rivets. From experience gained in his own works upon the same Mr. Staples.

Mr. Staples. class of construction, he knew that it would have cost about two and a half times as much, and the amount of work turned out would not have been anything like as large, thanks to trades-union restrictions. This, surely, was a striking example of what would have to be done in this country if British manufacturers were not to be left behind by their competitors. Some years back he had had to make about ¼ mile of large wrought-iron water-pipes, and these he had had entirely machine-riveted by unskilled labour, very successfully. At the end of the time he had been found out by the union, and had been informed that if he attempted to repeat the performance all the union men in the shop would be called out, notwithstanding the fact that he had practically demonstrated that the work could just as well be done by labourers as by members of the union who were skilled riveters. He thought many engineers would agree that the time was not very far off when there would be another big fight with the unions, in which the central question would be whether machine-riveting should or should not be done by any man who had sufficient intelligence to handle a machine, whether he had been regularly apprenticed or not, whether he belonged to a union, or whether he preferred to be a free man, paid according to his own energy, skill and intelligence.

Mr. Thorpe. Mr. W. H. THORPE considered that the particulars supplied with reference to the drawing-office output were of interest, but thought such figures were of little value unless a distinct knowledge existed of the way in which the total tonnage was made up, whether the bulk was special or "repeat" work. He thought it might be of service to give some results of his own experience relating to bridges of which in each case one only had been made, and detailed in the manner usually considered complete in this country (with quantities), including a swing-bridge, a swing-aqueduct, three N-truss bridges of 102 feet, 150 feet, and 219 feet span, and a plate-girder bridge; making a total of 1,800 tons, which worked out at 1,100 tons per year of 49 weeks, having 40 hours each. There was, however, no true comparison to be made between the output of works drawing-offices, in which much incidental work was done apart from that strictly relating to the final product, and the work of an engineer's office dealing only with design. With respect to works cost, it certainly appeared from the particulars given that this must be materially less than for English bridge-yards, and it would be of value if some further details were given: failing that, perhaps the Author would state whether 25*s.* to 30*s.* per ton was about the figure, as would seem to be the case. Low

shop-cost was greatly favoured by the large use made by American bridge-engineers of channel and H sections. He thought it inexplicable that in England engineers should still use channel sections built up of a plate and two angle-bars, when the solid bar of equal weight was stronger, cheaper, and neater. Much of the time lost in completing contracts was due to waiting for steel from the mills, a difficulty which was accentuated by the fact that quite commonly four to six makers supplied steel for the same job. This necessitated visiting each steelmaker's works for the purpose of testing; by the time an inspector (not being resident) reached some of these, it became quite a business to find the plates or bars he had to deal with, which might be covered by many tons of later-rolled material, also awaiting an inspector. To accept the test-pieces preserved by the maker for his own use, reduced the whole process to a farce, as it would clearly be quite as reasonable, and more economical, to accept the maker's own tests. He was disposed to think it would be of advantage to all concerned if official inspectors were appointed by, say, the Board of Trade, to be stationed at the mills in order to test all material as rolled, and to be prepared on the results of such tests, to issue certificates at a scale of fees to be decided. He thought this might be done, still retaining the engineer's right to make his own tests, if he preferred to do so. Much time would be saved, as the material, having been tested on leaving the mill, would be loaded up without unnecessary delay, if the certificate showed compliance with the specification. While it was evident that much might be learned from American experience, it need not be forgotten that this was not in all respects enviable, and that it would be well to avoid such a straining after economy as to favour results in any degree similar to those culled from the pages of the *Railway Review* (Chicago) for the years indicated below, which, though possibly not complete, sufficiently justified the warning. It might be admitted that the cases cited were, to a large extent, irrelevant to the discussion, relating as many did to timber bridges; but only those distinctly

Mr. Thorpe.

	Total Failures and Washaways.	Metal Bridges.
1896	93	6
1897	27	3
1898	3	0
1899	5	1
1900	76	2
1901	34	10
	238	22

Mr. Thorpe. stated to be metal had been placed in that category. The majority had been washed away by floods; bridges destroyed by fire, or by loads extending beyond the gauge, had not been counted. From the total number of bridge-accidents, forty-three fatalities in all had resulted. Of the failures of metal bridges about half a dozen were "collapses."

Mr. Wilson. Mr. JOSEPH M. WILSON remarked that the subject of the Paper was naturally of greater interest to the British than to the American manufacturer, in that its object was to suggest to the former how he might recover lost ground over his rival in the business in question. The Author appeared to state the situation very clearly, and his selection of Pencoyd as an example of a modern American bridge-plant was a happy one, as that was probably the largest and best example at the present time in the United States, and was the principal shop of the lately organized American Bridge Company. He could add little or nothing to the Author's excellent description, although he was more or less familiar with the plant, and had known for years most of those who operated it, having had a large amount of work done there. The pith of the whole matter lay in a thorough system and organization down to every detail, from the inception of the work in the drawing-office to its complete erection in the field; with competent, energetic men in every department, thoroughly familiar with their duties, full of vim, with eyes open to the adoption of every expedient to facilitate the work, either in time or economy of cost, and having a thorough personal interest in its success. The Author's reference to the maintenance of the full efficiency of the shop by the replacement of machinery, when it became in the least obsolete, with new, up-to-date machines, was one of moment. The use of standard types of bridges exactly suited to the operations of the works, or rather, the adoption of standard types and the adaptation of the works to their construction, was very important. Standard designs and specifications were used, as well as standards for details, standard rules for making shop-drawings, points to be observed in order to facilitate erection, etc.; and these were printed in book form for bridges, office-buildings, warehouses and factories, and were distributed gratuitously to engineers and architects, so that all designs for work might be adapted to the special machinery and operations of the Company's plant, thereby facilitating in every way the economical construction and rapid completion of any order. The standardization of shapes was in direct line with the development of the system of interchangeable parts and the use of tolerance gauges, which demanded that these

parts should be made by machinery and not by hand, and which had done so much in America for its machine manufacture and in one sense was now doing it on a large scale for its bridgework. While this idea had originated in France nearly 100 years ago, it had soon been abandoned from not having been started in the right direction. The United States had been the first nation to originate the proper method of doing such work, and it had carried out the system for 50 years before any other country had followed its example. Mr. Wilson.

The AUTHOR, in reply to the Correspondence, remarked that, with regard to the drawing-office arrangements referred to by Mr. Buchanan, it appeared to him that the work of drawing out the details of a complicated joint or ascertaining the exact length of a bridge-member should be done in the drawing-office, where the draughtsman has his drawing-board and instruments, works of reference, and a comparatively quiet and clean place to work in, rather than (as was frequently the case) in the template-shop, with a steel rule, a square of uncertain accuracy, a pair of templater's compasses, a chalked board, and a carpenter's pencil; among all the noise, dirt, and interruption of a template-shop. In other words, it paid to have draughtsmen's work done in the drawing-office, and not in the template-shop. He did not quite agree with Mr. Graham that American methods were incompatible with good quality in the work, his own experience leading him to believe that good work could be done just as cheaply and as quickly as bad work, and that rapid progress could be made only when the work was good. The delays and alterations necessary when work fitted badly, more than compensated for any apparent cheapness in bad work. He could fully endorse Mr. Graham's remarks regarding the facility with which first-class British work could be erected. During the Afghan War, 20 years ago, the Government of India had been so desirous to get the Sohan Bridge, near Rawal Pindi, completed, that they had issued instructions to him to the effect that they were willing to risk the loss of a span rather than delay the work. Floods had been of almost daily occurrence, and the staging, which had been over 100 feet in height, had already been washed away once; but the last span of 120-foot close-latticed girders had been made self-supporting in 26 hours, the bottom boom being fully riveted up and the rest of the span bolted. The labour had been entirely native labour, under European supervision. He could also fully corroborate Mr. Graham's observations in regard to the Indian mechanic. Excellent girders of The Author.

The Author. considerable span had been built both in Bombay and Calcutta, and about 14 years ago he had attempted, in vain, to obtain permission for a large firm in Bombay to tender for steelwork for the State railways, to be constructed in Bombay with material imported from England. Had this permission been obtained there would have been a large development of steel construction in India. He regretted that he was unable to furnish the information asked for by Mr. Thorpe as to works cost per ton. With regard to the "collapses" of metal bridges, many of the earlier bridges in the United States were, to use the mildest term, "peculiar," both in design and workmanship. Wheel-loads had largely increased since the time of their construction, and the wonder was that there had not been more collapses. Modern bridges in the United States were no more likely to collapse than were those in Great Britain.

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21 January, 1902.

CHARLES HAWKSLEY, President,

in the Chair.

The discussion upon the Paper by Mr. H. B. Molesworth, on "American Workshop Methods in Steel Construction," occupied the evening.
