Mr. VIGNOLES said, he did not think the Paper should be designated as treating on the German system of railways, though it contained an interesting description of various railway structures, and there were a number of points which, when studied in detail, would be useful and instructive. Nothing was related, however, of which there were not good examples, long previously existing in this country, and of a character which, if examined, would, he believed, be found more interesting to the engineer. Many of the works which had been described he knew perfectly well; and while he gave due credit to the engineers of Germany for what they had done, he was obliged, in his own mind, to compare them with similar works executed here and elsewhere. The German system of construction was, in general, no more than adopting, in a greater or less degree, the plans which had been found successful in this country, with such modifications as the circumstances required; but their works would not as a rule bear comparison with similar ones in the United Kingdom. For instance, the viaducts built from the designs of Mr. J. Miller (M. Inst. C.E.), upon the Glasgow and Dumfries Railway, were still unequalled in Europe, for boldness of conception and excellence of workmanship, and instead of following the old Roman fashion, of building tier upon tier of arches, as was the practice on the continent, there was only one tier of arches, each pier being carried up to its full height without lateral support. With regard to the Dirschau and the Marienberg Bridges, it was unnecessary to analyse the principles upon which they had been designed, because even from the descriptions given by the engineers of those bridges, and from the diagrams published with respect to those works, it might easily be shown that their mathematical construction was faulty, there being a want of due proportion between the several parts. He had watched the progress of these works during their construction, and had ascertained that their cost had certainly not been less than £45 per ton. It must be understood that this was not said by way of depreciation, because he thought, considering the struggles that had taken place in Germany, the results were most creditable.

He was exceedingly diffident in speaking on this subject, for he had so much to do in Germany many years ago, at the time of the introduction of railways, that it was impossible to allude to that period without saying more of himself than was becoming. When, thirty years ago, he laid out the railway from Brunswick to the foot of the Hartz Mountains, then almost the first after the Nuremberg and Fürth line, he introduced that particular form of rail, of which the Author had properly stated that seven-eighths of those in use on German lines consisted, which was known in this country as the contractor's rail, but was still better known in America and on the continent as the Vignoles' rail: it was a

system which he studied very much, before finally recommending and adopting it. It was properly called the contractor's rail, because the contractors were the first persons who had the courage to use it, in the face of authorities who would not at that period recognise it. At the same time he also strongly advocated the introduction, as many of his friends knew, of the system of fishing the joints of rails, which was first adopted in Germany.

The great principles, which he thought ought to have been insisted upon, as characterizing the German system of railways, were the simplification of the permanent way, and the perfection of their statistics. All the Companies were compelled, as in France, to give positive returns, under specific heads, of every detail of expenditure, and as these were published annually the Companies were brought into a wholesome competition, for the reduction of the working expenses to a minimum. Each Company was held up "in terrorem" to the others, so that all were interested in the reduction of their respective expenses. A recent inquiry showed, that the expenses per train mile on two-thirds of all the German railways were within a fraction of each other. But notwithstanding this, he believed it was capable of proof that the average expenses per train mile were less in the United Kingdom than in Germany. Still he thought it would be a wholesome regulation if Railway Companies in this country were compelled to give that information, in the same way as farmers were asked to contribute agricultural statistics. If those returns were furnished, it would be possible to trace every item of expenditure to its source, so that it would readily be seen where economy might be effected. It had been stated that the average cost of the German railways, one-fourth only having two lines of way, was £16,400 per mile; that would amount to about £14,000 per mile of single line. Now when the cost of land, the Parliamentary and legal expenses, and a vast number of other items which had unfortunately swelled the expenditure in this country were taken into account, he thought that the average cost of the lines in this country did not very much exceed that amount, particularly when of later date, those items of construction which did not fall upon the continental lines being of course eliminated.

The principle of railway legislation in Germany, as on the continent generally, was this:—The Government granted a concession for a railway from the town of A to the town of B, and sometimes provision was made, that it should run by way of the intermediate towns C and D, but all the details were left to be decided during the progress of the works. The evidence of individuals, in respect to the direction the line should go, was not taken, but the line being granted from point to point, the details were decided on the spot, where they could best be settled; and although it some-

times gave rise to considerable delay and annoyance, it saved vast sums of money. The same might be said as to the land. There was more trouble, perhaps, in getting land on the continent, but then it was obtained at the mere agricultural or mere town value.

There were a number of matters to be considered in making a comparison between the cost of lines in Great Britain and on the continent. As a rule, neither the engineers nor the labourers were so well paid on the continent, and there were various contingencies besides; so that he really thought —and it was a question he had studied for many years—when all these were taken into consideration, if the quantity of work done and its cost were contrasted, that the expenditure was not greater in Great Britain than it was, in the end, on the continent. And he would lay it down as a positive fact, that in no part of the world could work be done so cheaply as in the United Kingdom, whether measurement or weight of material were taken as the standard of comparison.

With respect to inclines, on the line between Nuremberg and Hof, on the route eastward to Leipsic, there were about 7 miles of 1 in 45, with curves of 400 yards radius, worked by locomotives. The last returns of the Semmering Railway in Austria showed that the working expenses exceeded the receipts; so great was the cost of working over 22 miles, with gradients of 1 in 40 and 1 in 45, and curves of 10 chains radius. The railway itself had been constructed at a cost of nearly £100,000 per mile, and he might mention that the bricks for the viaducts were brought from Vienna, so that the expense was enormous. However advantageous the line might be politically, and perhaps in other respects, to the Austrian Government, commercially the speculation was a most unprofitable one.

In mentioning the railway between Cologne and Liège, the Author had not noticed the way in which the passage had been effected between the two countries. The principal works were in Belgium between Liège and Verviers, and up to the Prussian frontier. They were constructed at an early period in the history of railways, and abounded in rapid curves, and comprised an extraordinary series of tunnels and viaducts; and altogether formed one of the most remarkable examples of engineering on the continent.

He had laid out the Würtemberg State Railways, and he knew they had been executed according to his recommendations; but most of the rolling stock was founded upon the American fashion, and he thought had not turned out satisfactorily. In determining the gauge for the railways in Würtemberg, Mr. Vignoles was called on to decide, whether the Bavarian gauge of 4 feet $8\frac{1}{2}$ inches English, or the Baden gauge of nearly 6 feet, should be adopted. Though himself a warm advocate for a wider gauge, he felt compelled, under the then existing circumstances, to declare

in favour of the narrow gauge. It was then too late to adopt the wider gauge; and the Baden Railways being isolated from the lines of Germany on the east, France on the west, and Switzerland on the south, were, as the Author had remarked, compelled to alter their gauge, and change the under-frames of their rolling stock.

The Taunus Railways had latterly been relaid, in consequence of the failure of the rails. These were originally double-headed, and when worn they were turned; but a few months afterwards they broke, as might have been expected, at a short distance from the point of support: and he saw hundreds of tons of those rails which had been broken, lying in stack. Since then a different kind of rail upon sleepers had been adopted.

Mr. T. E. HARRISON said, in his opinion the Paper contained much useful information, and although it was possible some of the Members might be acquainted with the railway system in Germany, yet the younger members, who had not had the same opportunities, could not fail to profit by it. It was stated that the average cost per mile of the whole of the railways in Germany amounted to £16,400. If this was contrasted with the cost of railways in England, undoubtedly it showed very favourably; but there were many causes which operated in favour of the German system, in respect of cost of construction. In the first place, they were exempt from Parliamentary expenses, which was a heavy item in this country; then, an exorbitant price was not paid for the land. Besides, the railways, when made, were not subject to the same competition as in England; and until lately,—for he believed a change had taken place in the views of Parliamentary Committees,—the whole basis on which railways seemed to be considered by those Committees was, that competition was a desirable thing. In Germany the lines, for many hundreds of miles in some districts, ran almost upon the surface,—while other portions were made through a country of the most difficult character,—yet on an average the cost per mile was low, and being without competition, he thought there could be no doubt that the railways there were destined to pay a remunerative interest to the shareholders. He observed also, that the Government had contributed aid, either directly or indirectly, to nearly two-thirds of the entire system. In England, that was a state of things with which they were totally unacquainted. True, in India the Government were contributing towards the completion of nearly the whole of the railways; but the lines in India would not be liable to the same competition as in England: because the Government being the guarantors, they would take care that competition should not exist. With regard to the Society formed in 1847, under the title of 'The Association of Government Railway Directions,' it appeared that part of its

duties was to lay down rules for the government both of the railways and of those who had the management of them. Thus, the radius of the curves, and the maximum gradients admissible under particular circumstances, were prescribed; but after all these rules resolved themselves into the simple question,—what was the best gradient, or curve, which, having reference to the nature of the country, could be obtained? A rigid rule providing against a steeper gradient or sharper curve than a particular amount was simply impossible, inasmuch as what might be good in one state of things, where there was a large amount of traffic, would possibly entail expenses which would not be justifiable, in a case of a small amount of traffic. The question of statistics was referred to, and it appeared to be considered by some engineers in this country, that it would be a wholesome regulation, if Railway Companies in Great Britain were compelled to give detailed information as to the cost of working the lines, and that such statistics would lead to a reduction of expenditure. Now Mr. Harrison held, as regarded the management of railways, that there was no point which was of more importance to the Companies than having perfect statistics of working cost. Having been much engaged in the practical working of railways, he had felt the general advantage of that plan; but when it was urged that it would be desirable if Railway Companies were compelled to make those returns—he presumed to Government—he believed the results would not be such as had been anticipated. In so far as the statistics prepared by the Railway Companies themselves were concerned, they were invaluable; because not only the officers of the Company but also the Directors were enabled to see from time to time what expenses were incurred; and by weekly or fortnightly returns being laid before the Board of Directors, which was the case with the Company with which he was connected, showing in a tabular form the cost of each individual part of the system for a series of years, any excess of expenditure in any department could be at once detected. But then there was this difficulty—the cost even of one large system of railway could not be compared with another, without these details being accompanied by a great number of facts which bore upon that cost. For instance, on portions of the system he was more immediately connected with, the cost of maintenance of way was, in some cases, four times as much as it was on others. The working expenditure per mile reached nearly 80 per cent. on some portions of the line, whilst on other portions the cost did not exceed a minimum of about 40 per cent. Therefore, for the North-Eastern Railway Company to compare its expenditure with that of the London and North-Western Railway Company, for instance, would be to contrast two things which were totally dissimilar; and unless all the circumstances involved in the expenditure were taken

into account, such a comparison would not only be useless, but would be calculated to mislead. He had seen statements, prepared with great ability, from figures exactly of the same data, of the results of the working of one Company as compared with another, the deductions from which were, to his own knowledge, exactly the reverse of the facts. He held that however valuable such statistics might be to the Companies themselves, the advantages were confined to their own particular system.

Allusion had been made, in the Paper, to the Semmering Railway. He had passed over that line, which was the work entirely of foreign engineers, and he would say that he knew no engineering work that would better repay the time and trouble of an inspection. It had been stated that, on the Southern State Railway of Bavaria, there was an embankment 172 feet in height, containing 3,000,000 cubic yards. The details of that embankment, as to the conditions under which it was carried out, were not furnished, but it was certain that in no part of England was there an embankment of that height. It appeared from the rules of the Association to which he had previously referred that the use of cast iron was completely ignored. Now he thought there were many cases in which cast iron was exceedingly useful for bridges; and though that material might be open to some objections, yet when employed in the form of segments, of which there were many admirable examples on railways in England, he could not agree in the conclusion which had been arrived at by the German engineers. The details had been given of a number of bridges of great spans, some exceeding 370 feet, which had been executed in Germany. He would suggest that it would be very useful if the Author would furnish some data from which an estimate could be formed of the cost of those bridges—either per ton of metal or per lineal foot; and in the case of tunnels the cost per yard; as it would be interesting to compare the cost of these large works with the cost of similar works in this country. The viaducts on the Semmering Railway were constructed with intermediate arches in their height. There were numberless examples of high viaducts throughout this kingdom—and those upon the Glasgow and Dumfries Railway had already been referred to; but in many parts of Lancashire, there were viaducts more than 100 feet in height, and he had built viaducts more than 150 feet in height, without a thought of introducing intermediate arches. Comparing the general designs of these viaducts, it appeared to him that those on the Semmering Railway contained more material than had been introduced into viaducts in England. Looking upon the Paper as a carefully prepared record of what had been done in a foreign country, entirely by foreign engineers, he regarded this communication as a valuable

one; and he repeated that any one who visited those works would be amply repaid for his trouble.

Captain MOORSOM remarked, with reference to the small cost of the German lines of railway, that it appeared they were laid down generally with the earthworks and bridges to receive double tracks eventually, but almost invariably waiting for the double track till the traffic should justify it. He thought a useful lesson might be taken in that respect in this country. He had only a few weeks ago perused a report from one of the Government Inspectors, in which it was noted as a matter of unfavourable character, that land had not been purchased sufficient to lay down a double track on a railway branch where only four trains each way were run during twenty-four hours. The fact was erroneously reported by the Inspector, but still it showed one of the impediments thrown in the way of economy in this country, as compared with the German system. He was at a loss to understand why 'The Association of Government Railway Directions' in Germany should limit the radius of curves to 3,600 feet on level ground, 2,000 feet for hilly country, and never less than 600 feet. He was prepared to say, that curves of 300 feet radius might in some instances be desirable. Not that in England such were frequently found, but he should not hesitate to adopt a curve of 300 feet radius, if necessitated by the circumstances under which he was obliged to lay out a railway, as he believed it would be possible to work round such a curve, to the satisfaction of the locomotive superintendent, at a speed of 20 miles or 30 miles an hour. Some years ago, he laid down a curve upon a radius of 7 chains, or between 400 and 500 feet, which remained to this day on one of the great lines of the kingdom. The trains were calculated to travel on that curve at 25 miles an hour; but when the line went out of his hands, the Directors issued instructions not to exceed 15 miles an hour round that curve, by which instructions of course all the calculations for 25 miles were falsified. With respect to the limitation of gradients to 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountain lines, he remarked that the character of gradients must be guided by what the country would admit, as some countries seemed to be laid out for a certain class of gradient. Thus, in the West of England, the land was laid out for 1 in 60, and if 1 in 70, or 1 in 80, were attempted, serious difficulties would be encountered. In other parts the ground was suitable for gradients of 1 in 100. Therefore, as the country seemed itself to design the gradient on which the railway should be laid out, to limit these gradients by the dictum of book, or tables, appeared exceedingly undesirable.

The speed of the trains on these German lines appeared to be lower than was necessary. On the Semmering Railway the speed

of the express trains was limited to 14 miles an hour in ascending, and to 16½ miles in descending, gradients of 1 in 40. He was satisfied that speed might be doubled with safety, from his experience in the working of the Lickey incline, of 1 in 37, on the Birmingham and Gloucester Railway, since the year 1839. The goods train at 9½ miles an hour might do very well, as high speeds were not required for goods, and it was expensive to have high speed for goods trains on heavy gradients. In descending such gradients, it was quite possible, with ordinary breaks, always to have the train under command, when travelling at a much higher speed; and the only limitation in descending upon heavy inclines was that which enabled the train to be held 'in hand.' When a train was obtaining the mastery, running ahead in fact, it was readily perceived, and there was a certain stage of progression which might be denominated the ultimate speed which a train attained, after the breaks had been got to a proper bearing; and this speed would not decrease, or increase, unless a greasy part of the line, or the falling of dews, intervened to give more sliding way. The late Mr. Robert Stephenson used always to complain of the cost of going up those heavy inclines; but Captain Moorsom believed, that the cost of working up the Lickey incline, at 28 miles an hour, was practically no more than going up at the rate of 15 miles. From the year 1840 to 1845 the speed on that incline was 15 miles an hour with passenger trains of seven or eight carriages, at a certain cost per train mile, which he did not remember, but it was per engine about £700 per annum. From 1845 to about 1855, a material improvement took place, as regarded the traffic, which increased so much as to require ten or twelve carriages, instead of an average of seven or eight, and heavier engines were used. The result was that, from 1845 to 1855, the trains of twelve carriages used to run up that incline at 28 miles or 30 miles an hour at no more practical cost than they ran in 1845 at the rate of 15 miles an hour. He referred to the accounts in verification of the correctness of this statement. He thought that embankments of 170 feet in height were dangerous to execute. He was laying out a line for the next session with 82 feet of cutting rather than have an embankment of 42 feet. The London clay or lias would slip at less heights than that, and he knew of no soil that could be trusted to the height of 172 feet. He had an embankment of 84 feet in the gritstone, but not higher than that. With respect to the bridge over the Rhine, at Cologne, to which allusion had been made, he thought it worthy of mention, that a member of this Institution furnished the design for which the Prussian Government gave the prize over sixty-one competitors of all nations. That design was for a lattice bridge of peculiar character, and very large spans. He was not certain whether the

design had been carried out in all its details, but he was told that a lattice bridge had been constructed there. He mentioned this circumstance, as reflecting credit upon the Institution, that one of its members should carry off the prize as to Engineering Construction thus largely competed for, while the prize for Architectural Design was awarded to an Architect of Berlin. He quite agreed that the general contour of the Paper was useful, and that they were indebted to the Author for the statistics he had given.

Mr. J. SCOTT RUSSELL said, it had happened that during the last fourteen years he had passed over many of the German railways, and he had been struck by several points which appeared to distinguish them from the railways of this country. In the first place it seemed to him that the Germans, almost first among the continental nations, set to work to ascertain what, in the British system, was best suited for their practice; and nothing surprised him more, than to see how rapidly anything successfully introduced into this country was, not copied there, but adapted to suit German circumstances and the peculiarities of the German mind. He had often asked himself the question, what could be the reason that the German engineers so quickly took to making railways, and he found but one cause, and that only accounted for it up to a certain point. He observed that, so far back as the year 1848, the German governments had taken to the belief, that a special education for engineers of all classes—mechanical and civil—was one of the first duties of a government. At that time, when young English engineers were picking up knowledge in the best way they could, there were regular colleges for the training of skilled workmen, and the education of civil engineers, in most of the great cities of Germany. By these means a set of thoroughly educated young men was prepared, ready to acquire practical knowledge, and to turn it to account in a short period of time. Many of these men were sent to England, to take advantage of the earlier practical experience in engineering works gained here, and they proved to be most apt pupils. One result of this was rather remarkable. Sooner, he thought, than any other country the Germans took to making locomotive engines. The English types were at first implicitly copied, but when once that was accomplished, and engines had been fairly constructed, the German engineers took to making designs for themselves, and departed more and more from the established patterns; so that now the engines on most of the principal lines were made exclusively in Germany, and in some cases at a less cost than in this country. It was still more remarkable that German engineers were now tendering against the British in many foreign markets; and it was even said, that one firm, that of Borsig, of Berlin, had recently successfully competed in England. From the manufactory he had named many beautiful and admirably

constructed locomotive engines were sent out, and they were far from being copies. In another case he knew that a German house had taken a large iron bridge contract from the best English houses.

Another circumstance which attracted his notice was, as it could not fail to do that of any engineer—the character of the earthworks. Immense trouble was evidently taken, the works were executed with great nicety and skill, and the result was, there were few slips. He believed that might be partly owing to the fact, that many of the early earthworks in Germany were designed by military engineers, who bestowed more care and attention upon earthworks than railway engineers. With regard to the gradients, he quite agreed in the view already expressed, that it was pure pedantry to attempt to dictate the gradients on any class of lines. The country and the circumstances must determine what these should be. Great mistakes had been made on some German railways from the adoption of theoretical gradients for a long line of country, where, in order to preserve—say a gradient of 1 in 200—many miles of moderate cutting had been incurred, which might readily have been avoided, if the contour of the ground had been more closely followed. It was true, the curves were generally of much longer radius than in this country, but that also was due to the character of ground passed over. Germany was, in general, well suited to the construction of railways, because there were long tracts of level land; and it was easy to concentrate the gradients upon that place where any auxiliary power that might be wanted could be obtained. Great judgment had been shown in the early adoption of a cheap permanent way, including the fish-joint, which, he might remark, it was somewhat astonishing was only first used on the great lines in this country, about ten or twelve years ago, after the Germans had adopted it almost throughout their entire railway system. The waggon-stock was peculiar. It consisted of long square boxes, or warehouses, placed upon two laurries, on four wheels; and was perfectly watertight, instead of being composed of open trucks, covered with tarpaulin. It was said that the goods were carried with great care, and were delivered in admirable condition.

In the first-class carriages, seats for four passengers abreast had been all along provided. Whether that was a convenience, or not, to individual passengers was a question; but the plan was coming into use in this country. In regard to the first cost of the German railways, he did not think there was much merit in that. The country itself was not of a nature to demand expensive works; and to compare the two countries—so different as the great level cornfields of Germany to the hilly undulating garden of England—would give no useful information. It was no doubt true, that

many expenses necessarily incurred here were not repeated there; but it was entirely a question of country; and he regretted that the papers had not entered more fully into details on this subject, because it would have been useful to know what the great bridges and the earthworks had cost in the two countries respectively. In regard to management and economy of working, he thought there was much to be explained. In the first place, on the German lines less accommodation was given than on the English. The trains were very heavy, but they were run seldom, and at slow speeds, comparatively, and in that respect offered little public convenience as compared with the metropolitan lines. Therefore their economy of making did not go for much. It must also be remembered that the stations were far apart, and therefore there was not the loss in stopping and in starting which was incurred on more frequented lines. Then again, in regard to the earnings of the lines, there was another element besides first cost. It was this—he did not remember to have heard it stated what the comparative fares were; but a friend of his, who had a large trade in minerals, had made inquiries in this country as to the cost of the carriage of goods, minerals, and heavy traffic, when he found that the current rates on German railways were two or three times greater than on railways in England. That was another cause why the earnings should be higher, without there being any superiority over English railways. If the accommodation was less, the speed slower, and a higher sum was charged for the transport of goods, it was plain these were elements which would cause larger dividends to be realised on comparatively smaller capital. These were a few of the main circumstances which he thought distinguished German railways, and he believed would go to show, that though German railways had great merit, yet it must not be considered that all these apparent advantages were really advantages to the country through which the railways passed, and whose interests those railways were intended to serve. The Institution was under great obligations to the Author of the Paper, and the young engineers of England could not do better, than ascertain what their professional brethren were doing in other countries; for, as far as he was able to judge, although English engineers were at present superior to the engineers of all the countries of Europe, he had the impression that the engineers of other countries, especially on the continent, were making more rapid progress.

Mr. MALLET said, he had had a good deal of experience, while a mechanical engineer and contractor, of the methods employed in this country and abroad in the construction of railways. Last year he had travelled over many German railways, and upon some lines not commonly visited by Englishmen. For his part he felt unbounded admiration of German engineers, and he was satisfied

that, as regarded sound technical education, the comparison between the English engineer and the German was much in favour of the latter, and increasingly so. Such an expression of opinion would probably be unpopular, but if true, it was nevertheless wholesome to be heard. As an illustration of the general truth of the opinion, as to the imperfect character of engineering education in England, he would ask any one who had visited the Western Annexe of the International Exhibition of 1862, which amongst the steam engines there shown displayed most mind and knowledge of principle, and the best advance towards theoretic perfection. Not certainly any of the English ones, but two of American origin, one improved and carried out by Germans. With respect to originality of construction manifested in the German railways, no doubt the earliest lines in that country were suggested by the successful creation of the railway system in England. They were, he believed, not designed by military engineers, but by officers from the Bergampt (School of Mines), the first ideas of railways being taken from those of their great projector, George Stephenson; but the works were carried out in their own way from the commencement, and with striking originality in structural detail. So far from having copied English engineers, the latter had in several respects copied them. The lattice bridge in iron was in fact introduced from Germany. One of the earliest German iron lattice bridges was that across the Elbe at Magdeburg, the wooden lattice having been long previously known and adopted in America. Sir John Macneill, who was the first to employ iron lattice bridges in this country, took his earliest examples, in Ireland, from this and other early German bridges. Mr. Mallet would venture to say that he believed, in the end, the lattice bridge, in iron, in one form or another, would supersede all others for railway uses.

He had recently been over a new line of German railway, the Deutz and Giessen, which ran along the valleys of the Lahn and Sieg, through, in great part, a very uneven country, one very unlike the level plain of Central Germany, so commonly supposed to form the basis of all German lines. This line comprised a vast amount of heavy earthworks, and over bridges, and extensive lattice viaducts repeatedly crossing the Lahn, a large navigable river, and it passed through a country more difficult than any he had seen in England. In one place, for 14 miles in length in one stretch, the gradient was 1 in 40, and nowhere less than 1 in 80; almost all this was in rock cutting and side embankment, and the line was obliged to take curves in the form, in some places, of the letter U. That line, he understood, had been made nevertheless at an expense of about £12,000 per mile. The bridges over the Lahn were on the lattice principle, and were beautiful examples of structural skill, and in some points novel. One cha-

racteristic of the German railways was well worthy of imitation; that was the care taken to prevent accidents, which seemed to be to a great extent neglected in this country. Some years ago a brother of their member Mr. Siemens, himself a German engineer by education, proposed a mode of telegraphing along all the lines, by which each train, as it started, telegraphed its approach to the station immediately in advance. That system was adopted on every line, he believed, and the result was an almost entire immunity from accidents on German lines. It was not correct to suppose, that the freedom from accidents on the German lines arose from their running few trains, or that these invariably travelled at a slow rate. In Westphalia, the grand centre of German industry, on the trunk lines, as many trains ran as on some of the English lines, and the speed of the express trains was 40 miles an hour, while the average speed of ordinary trains was 4 German, or nearly 21 English miles per hour. Repeated efforts had been made to get the same system introduced here, but the attempt had been nugatory except in one or two instances. This inertness to improve in England might be illustrated by a smaller matter. Nearly all the railways in Germany had their axles lubricated with liquid oil, instead of solid grease, the imperfect material in universal use here; one loth, or ounce of oil, serving to grease an ordinary axle for a month. About fifteen years ago, he introduced a mode of oiling the axles of railway wheels which, although independently invented by him, turned out afterwards to be identical with that in use in Germany on certain lines. He endeavoured to get the method tried on some English lines, but was met by the statement, that however good it might be, grease was so generally employed that no change would be made.[1] In Germany there was an admirable system at work for the technical education of engineers and others engaged in skilled and scientific employments with which there was nothing to compare in this country, and it would be well to study it and to adopt it as far as possible, otherwise this nation would, in this respect, assuredly fall into the rear.

In illustration of the rapid expansion of German industry, Mr. Mallet then directed attention to a map, annually produced by the 'Oberbergampt,' which exhibited, graphically, the progress and distribution, year by year, of the coal industry of Prussia. It showed the tons of coal raised, used and exported, from each of the great coal basins—the Westphalian, the Saarbrücken, the Silesian, &c.—and also the imports and distribution in Germany of coal from England. This was at once an indi-

[1] An attempt is now (September, 1865) being made to try oil as a lubricant on some passenger carriages on the London and North Western Railway.—R. M.

cation of the perfect way in which Germany treated every question, and an illustration of the enormous progress of German industry and railway traffic. The Westphalian basin alone contained more coal than the whole of Great Britain. A comparison of that map, over a few consecutive years, would show, how steadily British coal exports were decreasing all over the continent, and the product of German coal increasing. Germany had now got an abundance of coal, and everything needful for industrial success along with it. It was in itself the source to her of direct wealth, and the creator of every other form of riches. If then technical education in this country was not made to keep pace with that of Germany, the British would not long maintain that relative manufacturing pre-eminence which they had hitherto held amongst the nations of the earth. He regarded the growing prominence of Germany in the industrial arts as mainly owing to the more perfect education of all its technical classes. The great movement in education dated in Prussia from the year 1813, when Germany shook off the despotism of Napoleon. Education, in its primary rudiments, was compulsory on all; so that no one could stand between the child of Prussia, and that fundamental knowledge that should fit it, in whatsoever station, to become an honour, and not a disgrace, to the fatherland. Moreover, the gymnasia, and the universities were better fitted for technical education than in Great Britain, where, as an organized system, there did not exist, between the elementary schools (more particularly for the middle and wage classes) and the universities, any efficient system of technical education at all. There was thus a great gap, filled only by a few isolated institutions, such as the Museum of Practical Geology, &c. The superiority in result of the German system was not badly indicated, by comparing the 'Taschenbucher,' or pocket-books of data, in use in that country, with those found here. The German books were prepared by men of thorough and exact information, and were obviously addressed to persons who had already received the fundamentals of a sound general education, and hence were prepared to accept and apply scientific and technical data in an exact and technical form. Similar books in this country were addressed to men, who were yet supposed not to have the elementary knowledge of well-educated schoolboys; and as such books were in demand, it was plain that English artisans, &c., really had not on the whole that amount of preliminary knowledge.

Mr. SHEILDS said, that in the north and north-east of Germany, everything in the way of railway works was so plain and simple, and so like what it was in any easy district of country at home, that there was not much to remark upon. The expenditure upon the railways had been small from a variety of reasons, one

being that the population supplied an excellent industrious class of workmen, and the work did not appear to be hurried so much as was the case in this country. There was a less amount of work to be done, and being carried out more slowly, large bodies of workmen were not collected together, by which the price of labour was raised to an artificial height. The German navvy was paid about 1*s.* 6*d.* per day, and did a large amount of work, so that he believed throughout Prussia the cost of the earthwork did not exceed 8*d.* or 9*d.* per cubic yard. It was to be remarked, that but little contractors' plant was employed, the embankments being executed mostly from side cuttings, with barrow runs of much greater lengths than in this country, even up to 300 yards. This might account, in a great degree, for the excellence of the earthwork to which allusion had been made. The stations in Germany had been spoken of as being excellent; and he was surprised that the Author had not noticed especially the station at Breslau, which was perhaps one of the finest in Europe, as regarded architectural effect. In his opinion, the German lattice bridges should not be taken as models of the best design and construction. The lattices were composed of flat bars, which were inherently weak in themselves, and which, however they might be supported at intervals, by vertical bracings, to keep the top and bottom flanges apart, were imperfect constructions. It was, he thought, far better to give the lattice bars the necessary rigidity in themselves, than to make them inherently weak, and supply what was deficient in them by additional construction. He had made such girders some years ago, when it was the customary practice, but he found their deflection to be very great; in consequence, he had since adopted the system of employing angle irons for the lattice braces, whether in tension or compression, or of using plate girders, which undoubtedly formed a good strong bridge. The rolling stock was of excellent construction, and the passenger carriages most commodious; but the trains were few in number, and in most cases several hours apart. Under such circumstances, he did not think that so much credit as had been claimed for them was due for their freedom from accidents. In fact, no fair comparison could be made in this respect between the German and the English systems; and he believed that if the trains ran as frequently on German lines as on those in England, it would be found that as great, if not a greater number of accidents would take place on the former than on the latter.

Mr. COCKBURN CURTIS said, notwithstanding the remarks which had been made, he did not feel any apprehension, that English engineers would be surpassed in professional ability, or practical attainments by their German, or other continental brethren. Such a result certainly would not be owing to any fault in their pre-

sent mode of education; but if it ever unhappily did take place, he considered it would be more likely to be occasioned by the substitution of a theoretical system of training, for the practical apprenticeship, and the test of public confidence, in existing works, which had hitherto been the credentials of the English engineer. It must be remembered, that the qualifications required in an efficient engineer were more of a practical than of a theoretical character, and that the great object in educating a youth for the profession was to strengthen his thinking and working powers, by habits of self-reliance and by the acquisition of such an amount of scientific and practical knowledge as would be readily available in cases of emergency. He contended that no amount of theoretical knowledge, however easily it might be insinuated into the mind by treatises and compendiums, could compensate for the ready aptitude, and difficulty-overcoming power, which was attained by that continuous labour which simultaneously connected scientific knowledge with actual experience. Mr. Curtis had never been in Germany, but his personal experience in other continental countries, where similar institutions and systems had been adopted for the education of engineers, induced him to believe, that any advance that might have been made in the efficiency of the German engineers was rather to be attributed to the national development of a healthful spirit of speculation and enterprise, and the consequent necessity which had arisen for emerging from the previous state of crude and pedantic theory, of which instances had been given and commented upon in the course of the discussion; and upon the whole he considered that while the evils of the English system of engineering education were probably overrated, on the other hand, it would be impossible to overrate the evils that might arise from transplanting the German, or any other continental system of educating engineers into this country.

Mr. C. H. GREGORY said, he was afraid the effect of some of the observations which had been made might be of a depressing character, as regarded the capabilities and prospects of English engineers. He observed, however, that the map which Mr. Mallet had alluded to showed, that notwithstanding the great advantages arising from the Prussians having coal-mines close at hand, still English coal found its way into that market, and competed with the coal of the country, in spite of the expenses of transport. With regard to the alleged advantages of special education, without venturing to depreciate that which was a valuable aid to the labour of all classes, and very useful in assisting the engineer, and the practical man, to the best way of attaining his object, yet he submitted that undue importance should not be attached to theoretical education, to the neglect of that practical experience and training which the engineer should always bring to bear upon

his profession. The history of engineering in this country showed that the works which reflected the highest honour upon the profession had been carried out, to a great extent, by men who had not any large amount of special theoretical education, but who, being possessed of great natural powers, were enabled to take advantage of the national resources and peculiarities in such a way as to command for English engineers universal respect. He thought that this result would not have been attained, if they had relied upon a technical theoretical education, and systematized rules, cut and dried by others, instead of their own energy and originality of mind and action.

Mr. MALLET was far from wishing to disparage the achievements of those who had been the great fathers of English engineering; but he would ask, how much greater would those achievements have been if these undoubtedly great men, the Brindleys and the Stephensons of engineering history, in place of having to employ their grand intellects in hammering out imperfectly, and as best they could, the information they needed, had had that educational training that would have placed at their command, in orderly array, the accumulated stores of knowledge of all mankind in all time past, and the power that such confers?

Mr. CRAWFORD observed, through the Secretary, in reference to a remark that the works between Verviers and Liège, on the line from Cologne to the Prussian frontier, had not been described in the Paper, that that railway was in Belgium, and being beyond the Prussian frontier, was not within the limits treated of in the Paper. The principal works of interest on the railway from Cologne to the Prussian frontier, namely, the incline at Aix-la-Chapelle and the large tunnel, one of the first constructed in Germany, were alluded to.

November 18, 1862.

JOHN FOWLER, Vice-President,
in the Chair.

THE Discussion upon the Paper No. 1,071, on "The Railway System of Germany," by Mr. R. CRAWFORD, was continued throughout the evening to the exclusion of any other subject.
