Discussion.

The President. The PRESIDENT, in moving a vote of thanks to the Authors for their Papers, which brought before the Institution a large amount of valuable information, said it was an interesting fact, to which his attention had been drawn by Mr. Charles Hawksley, that these communications, indicating remarkable advances in railway transport, should be read on what was practically the centenary of the trial by which Trevithick demonstrated conclusively that traction on smooth rails could be successfully carried out. He did not desire that evening to offer any eulogy of Trevithick, but the fact was certainly notable that on the 21st February, 1804, Trevithick gave a demonstration of his invention on a railway near Merthyr-Tydvil, when his engine, coupled to five wagons loaded with 10 tons of iron, and seventy men, accomplished a journey of nearly 10 miles, there and back, in 4 hours and 5 minutes. The locomotive went at 5 miles per hour, but had to be stopped frequently in order that trees might be cut down and rocks removed which blocked the way. Coming to an incline of 1 in 18, the engine hauled up its load at 4 miles per hour. That now seemed ancient history, although it happened only 100 years ago. What had impressed him from the reading of the Papers was that the lesson learned many years ago in marine transport seemed at last to be applied to land transport. It had been clearly pointed out long ago that increase in size must lead to increase in relative carrying-power. That, as he had recently explained, was the secret of the great economy of oversea transport at the present day; and there was no doubt that it must be true also of railway transport. It was a notable thing, as Mr. Jepson said, that by increasing the size and improving the structural arrangements, instead of being 62·5 per cent. of the load carried, and sometimes more, the tare had been brought down to 34·6 per cent. of the load carried, or 25·7 per cent. of the total load hauled. Although there might not be the same freedom of movement in that direction on land that there was in marine transport, and although it was obvious that many interests besides those of economy in transport had to be considered, still there could be no doubt that there must be possibilities of improvement whose range was hardly realized.

Sir John Wolfe Barry. Sir JOHN WOLFE BARRY, K.C.B., Past-President, thought it could not be denied that the subject was one of vast importance, requiring

Sir John Wolfe Barry.

the most careful study, and deliberate and calm judgment. Considerable reduction in the tare of a wagon was in itself undoubtedly desirable; and the shortening of trains, which it rendered possible, of course tended to convenience and to diminution of the cost of sidings, as well as to economy in many other matters depending upon the length of the train: but at the same time there were many other things to be considered—at all events in England. His own experience lay more in the direction of shipping coal and minerals than in the handling of general goods-traffic, and he wished to confine his remarks mainly to the shipping of coal. It was quite clear that at the present time no satisfactory means existed of dealing with a high-capacity wagon of coal at any important English shipping ports. If real advantage could be shown to result from the use of these large wagons, the wise course would be to remodel the appliances for shipping coal; but that advantage must be shown to exist in a very conspicuous way. If the ratio of the tare to the paying load could be equally reduced by using short trucks, the difficulty of remodelling the shipping-machinery, which would press upon all coal-shipping ports, would be avoided. It was very desirable to have a type of truck which could easily be discharged at once into a ship, and which would not necessitate intermediate handling in smaller units of load. That mode of shipping had been adopted in some cases, 30-ton or 40-ton trucks being first unloaded into hoppers, and the coal then transferred from the hoppers into trolleys or boxes, and shipped by large cranes. He had studied the question closely, in connection with both Indian and Scotch railways, and he thought the Table appended to Mr. Shackleford's Paper (p. 124), giving the ratio of tare to the paying load, was very instructive. It showed that the smaller wagon ran the larger hard. For example, on the Bengal-Nagpur Railway a ratio of 70 to 72 per cent. between the paying load and the gross load was now being realized. It was true that there were advantages in India due to a broader gauge, and to less restriction in the height of the wagon; but in the Table given by Mr. Shackleford were indicated results not very dissimilar to those attained by the 40-ton trucks. For example, there was a North British Railway coal-truck, the paying load of which was 16 tons, and the tare 6 tons 14 cwt., giving a ratio of 70 per cent.; and some of the new Caledonian Railway trucks were quite as advantageous. There was undoubtedly a great advantage in getting rid of the bogie, because if a reasonable wheel-base could be obtained the wagon was more easily controlled in shipping. It could also, of course, go on to a turn-table with

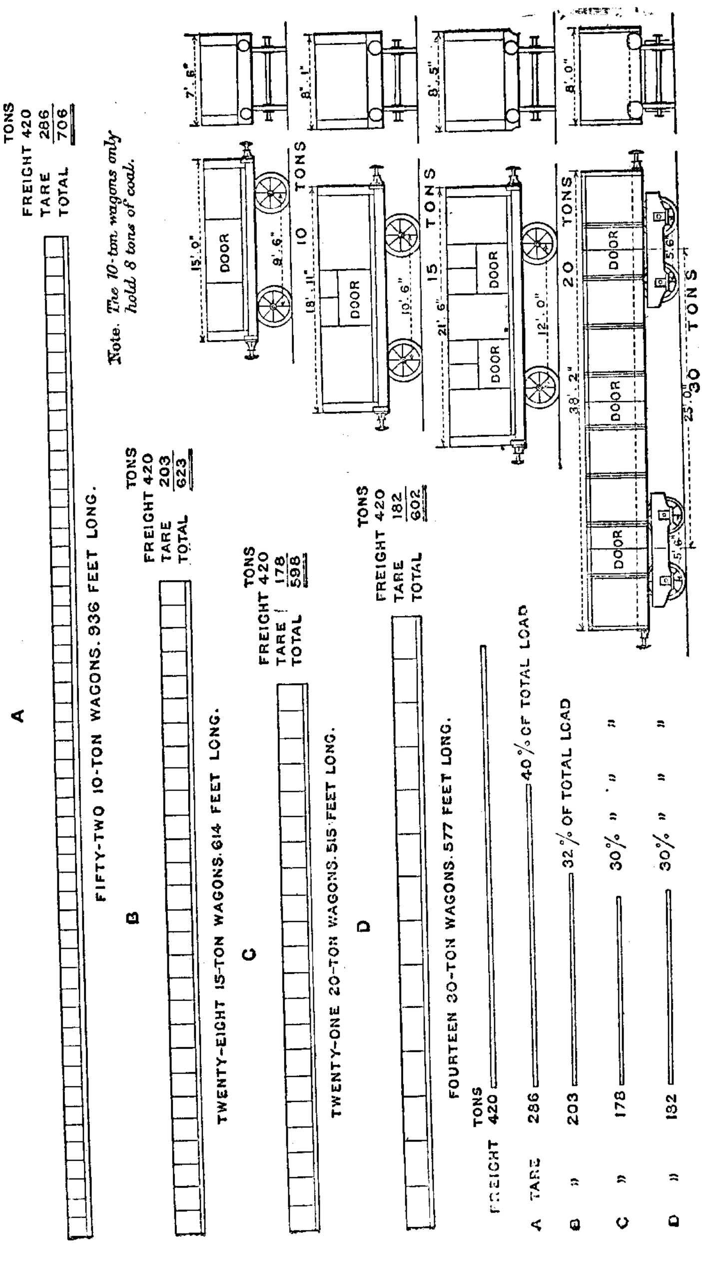
Sir John Wolfe Barry. greater convenience. Turning to the question of the discharge of coal, his own conviction was that no method of discharging was so cheap as through end doors. Hoppers were advantageous where they were suited to the mode of dealing with the coal—which was not often the case at English shipping-ports; but they had the disadvantage that they entailed a loss of capacity in the trucks, due to the shelving sides which were required for proper discharge of the contents. Many kinds of English coal had a tendency to cake, and did not run readily through a hopper; and certainly, in the Welsh ports, the coal was so large that hopper discharge would not be satisfactory. Some of the wagons illustrated in the Papers had a high ratio of paying load to tare, and the mode of discharging their contents was assumed to be equally satisfactory. But this was not in all cases the fact; for instance, the wagon shown in Fig. 2, Plate 3, had only one door on each side; and, while it was clear there could be no waste of space in that case, that wagon was certainly not suitable for the cheap discharge of minerals. The whole question of the capacity of wagons was so important that it required a great deal of weighing before any definite conclusion could be arrived at. Obviously, tare was not everything. It was necessary to have convenient ways of dealing with the contents of the wagon; and, again, the size of the unit in itself, if large, led to several drawbacks. For general goods-traffic it probably involved a great deal of transhipping, and that meant delay. One of the things of which Englishmen might be proud was the rapidity with which goods were at present conveyed from place to place; and any large amount of transhipping must militate against that speed. The expeditious transfer of goods was a question of high importance to the whole trade of the country, and it behoved the railway-managers to give it very careful attention. The general opinion of British railway-managers seemed to be that, however seductive might be the idea of large trucks of 30, 40, and even 50 tons burden, the balance of advantage lay with wagons of more moderate size, which could be designed with as low a relative tare as the larger wagons. Those who considered the question should not come to any hasty conclusion merely upon low tare, but should carefully weigh every other matter which tended to the success and expedition of railway traffic.

Mr. Bury. Mr. Oliver Bury remarked that the subject was of great interest not only to all engineers, but also especially to railway-managers, who had to deal almost entirely with its commercial side. Two of the Authors devoted their attention almost exclusively to coal for export, which was far easier to handle in bulk than the general goods-traffic of England. Before taking up the position of General Manager of the Great Northern Railway, he had been manager of one of the largest railways in South America, where most of the traffic consisted in the transport of wheat, maize, linseed, all kinds of grain, and hides, to the ports of the country, for shipment. The wagons were generally of the bogie type, and the maximum load in his time had been 35 tons, although 40-ton wagons were now being used. The consignments were all very large, and it was a simple matter to load these large wagons to their full capacity. He had come to the Great Northern Railway with almost a prejudice in favour of such large wagons, and shortly afterwards he had begun to make searching inquiry as to where and how they could be used on that line. A beginning had then been made with some 30-ton wagons which were used for the railway's own locomotive-coal. They were also used for the transport of bricks when they could be obtained in large consignments, and for removing the spoil from the underground lines now being constructed in the neighbourhood of the railway. In some cases they were used for iron ore: but for the general coal-traffic of London they were not suitable. On an ordinary day in one of the London coal-depots eighty-three small wagons of coal had been received, of which thirty-two had been single trucks from different collieries, eleven consignments of two trucks, four of three trucks, three of four trucks, and only one consignment requiring five trucks. For only eight consignments, therefore, out of a total of fifty-one, would it have been possible to use 30-ton wagons; and he had been told, on the best authority, that on the London and North-Western Railway 80 per cent. of the coal was carried in consignments of less than 20 tons. It was difficult, therefore, to see how such large wagons could be used to any extent for the ordinary London coal-traffic. With regard to the traffic for which they were used, it was necessary to have at least three doors on each side of the wagon, and those doors had to be made so that they opened right up to the top of the side; otherwise the wagon could not be used for general purposes, such as merchandise or bricks, as a man could not wheel the goods or bricks into or out of it. As was well known, the bulk of the coal was carried in private-owners' wagons; and though it might be possible to coax the traders, they could not be forced to build their wagons of large size, nor could they be forced to use large wagons belonging to the railway. The next trial had been made with 20-ton wagons, of which thirty had been built for trial. It had been found that in order to hold Mr. Bury.

Mr. Bury. 20 tons of coal, the wagons had to be made 9 feet 2 inches high. About one hundred and forty collieries were served by the Great Northern Railway, and at only twenty of these would the wagons pass under the screens, which were too low. As it was not possible to insist that the colliery-owners should raise the screens or lower the tracks to allow the 20-ton wagons to be used, the use of those wagons was considerably limited. In order to prevent undue overhang, the wheel-base had had to be made so long that in almost every case near London these wagons would not turn on the small turn-tables. It was therefore unlikely that 20-ton wagons would come into use for ordinary goods or London coal, though they were in daily use for locomotive-coal. He had then set to work to find some wagon which would serve for general goods and for London coal, and which would still be more economical than the ordinary 10-ton truck which had been in use up to that time. In the result a 15-ton wagon (*Fig. 1*) had been designed which had double the cubic capacity of the ordinary 10-ton wagon, with an increase of only 32 per cent. in weight. It was low enough to pass under the screens of all the collieries served by the Great Northern Railway; it would turn on the turn-tables, with one or two exceptions which would be enlarged; and for some goods-traffic, its larger capacity was a great advantage. By taking careful note of the work of a goods-depot in the city, it had been found that on a particular day the total number of consignments was 985, consisting of 4,427 packages, weighing 123 tons; the average weight per consignment was thus $2\frac{1}{2}$ cwt., and the average weight per package 62 lbs. For these goods seventy-two trucks were used; the whole of the packages were despatched to fifty-three different destinations, the average load per truck being 34 cwts. When 123 tons of goods had to be sent to fifty-three destinations, it was difficult to see, under the present conditions of English railway work and trade, how 20-ton or 30-ton wagons were to be used for general goods. The average load for goods-traffic throughout the country was approximately $2\frac{1}{2}$ tons. On one of the South American railways with which he had been connected, large wagons only, of the bogie type, were used. They were very economical and useful for export traffic, or for goods in large consignments; but on every railway there was a large quantity of traffic which must necessarily be dealt with in very small consignments, and the result was that big wagons had to be used to carry 1 ton, and frequently $\frac{1}{2}$ ton only. At the top of *Fig. 1* was represented a train of fifty-two ordinary Great Northern four-wheeled wagons, which would

Mr. Bury.

Fig. 1.


A
FIFTY-TWO 10-TON WAGONS. 936 FEET LONG.
TONS
FREIGHT 420
TARE 286
TOTAL 706
B
TWENTY-EIGHT 15-TON WAGONS. 614 FEET LONG.
TONS
FREIGHT 420
TARE 203
TOTAL 623
C
TWENTY-ONE 20-TON WAGONS. 515 FEET LONG.
TONS
FREIGHT 420
TARE 178
TOTAL 598
D
FOURTEEN 30-TON WAGONS. 577 FEET LONG.
TONS
FREIGHT 420
TARE 182
TOTAL 602
Note. The 10-ton wagons only hold 8 tons of coal.
10 TONS
15' 0"
9' 6"
7' 6"
15 TONS
18' 11"
10' 6"
8' 1"
20 TONS
21' 6"
12' 0"
8' 5"
30 TONS
38' 2"
25' 0"
5' 6"
8' 0"
DOOR
TONS
FREIGHT 420
A TARE 286 40% OF TOTAL LOAD
B " 203 32% OF TOTAL LOAD
C " 178 30% " "
D " 132 30% " "

Mr. Bury. each hold 8 tons of coal. That train, loaded with 420 tons of coal, occupied 936 feet of siding, as against 614 feet with a train of 15-ton wagons, 515 feet with a train of 20-ton wagons, and 577 feet with a train of 30-ton wagons. Railway-managers were continually being asked to extend their siding-accommodation in and around London and other large towns, where a heavy price had to be paid for land; and it was highly desirable to find some more economical means of carrying coal and other goods than in the small 10-ton wagons. It behoved engineers, when laying out new works, to allow a little more width for wagons in yards, sheds, and other depots; for while on the Great Northern Railway, as on other lines, it was possible to use passenger-coaches 9 feet wide—the Scotch trains and the suburban trains, for example—it was not possible in the ordinary way to use goods-wagons more than 8 feet 1 inch wide. Wider wagons could go all over the running-lines, but not into the sidings and depots. It was fairly obvious that it was more economical to increase the capacity of a wagon by adding slightly to the width than it was to continue adding to the length. With regard to steel versus timber wagons, experience tended to show that for four-wheeled wagons, the well-seasoned timber wagon was hard to beat; at all events, that was the result of experience on the Great Northern Railway. Steel wagons were found to be completely worn out after 12 to 15 years' work. It might be said that they had not been properly looked after and scraped or painted; but as a matter of practical railway-working, it did not do to have a wagon which often required to go to the shops to be painted. What was needed was a wagon which would not suffer from a little neglect; and in that respect timber wagons with four wheels were hard to beat. It was highly desirable gradually to get rid of the grease-box on English wagons as far as possible, because it was undoubtedly possible to haul an appreciably heavier load if the wagons were constructed with oil-boxes. Referring again to *Fig. 1*, it would be noticed that in transporting a given load of 420 tons of coal, the tare for the 10-ton wagons was 40 per cent. of the total load; for the 15-ton wagons it was 32 per cent.; and for the 20-ton and 30-ton wagons it was 30 per cent. As the weight and speed of goods-trains increased, so would the necessity for the use of continuous brakes, and it was highly desirable to have some uniformity in the matter of brakes. Two types of brake were now in general use, and a large portion of the stock had to be fitted with both, which was not an economical way of working. Engineers would have to settle this difficulty very soon.

Mr. F. R. Upcott mentioned that in India there were certain conditions which were peculiar to that country. There were about 29,000 miles of railways, and, unfortunately, four gauges. There were about 15,000 miles of 5-foot 6-inch gauge, about 12,000 miles of metre gauge, and 2,000 miles of narrower gauges, namely, 2 feet and 2 feet 6 inches. Leaving out of account the lines of small gauge, the more important lines, of different gauges, crossed at many places, where transhipment had to take place; and it was one of the conditions always to be borne in mind in designing, that wagons intended for goods which had to be transferred from one system of railway to another must be so constructed that the material might be taken from one wagon to another, and be easily handled across a narrow platform where the transhipment took place. The heaviest and longest through traffic consisted chiefly of export grain from the northern marts of India to the three large ports of Karachi, Bombay, and Calcutta. The length of lead might be taken as about 900 miles. The gauge of the line running into Karachi was 5 feet 6 inches, but this line was fed by lines of both 5-foot 6-inch and metre gauge. Bombay was similarly served. Consequently, the transhipment question was by no means a small one. The lead of most of the export coal-traffic in India was not more than 200 to 300 miles, of 5-foot 6-inch gauge, and for that purpose a uniform wagon would be very advantageous if it was possible to decide upon the most economical form. Another point—perhaps also peculiar to India—was that under the orders of Government a certain portion of the railway stock, both for the 5-foot 6-inch and for the metre gauge, had to be adapted for military purposes; that was to say, the wagons had to be so designed as to be able to carry horses, guns, and military equipment generally. As far as he remembered, it had been found most convenient to arrange for entraining and detraining artillery end on, and the wagons were all made with doors at the two ends. These doors lay down flat when opened, thus forming a long train on which the horses and guns could be drawn forward. Sometimes they had to be detrained on the top of a high bank, where it was obviously impossible to take them out at the sides of the wagons. He quite agreed with Sir John Wolfe Barry that a ratio of paying load to total load of about 70 per cent., as obtained in Indian wagons, was very good. Whether that could be increased he was not quite sure, because, as Sir John had rightly said, although low tare was very important, other conditions were quite as important, if not more so; and certainly for India the military side of the question of design was of quite as much weight as the commercial.

Mr. Upcott.

Mr. Cuningham. Mr. G. C. CUNINGHAM had recently designed six steel passenger-carriages, which had been constructed for the Central London Railway; and many of the problems referred to in the Papers had necessarily arisen in the course of the construction of those carriages. One feature he had secured in them which could not well exist in wagons was that the side of the carriage was one continuous trussed girder. The uprights of the girder, which were necessarily marked out by the window-spaces, were 2 feet 5 inches apart; and by making the cross bracings span two spaces between the uprights, he had obtained a trussed girder, 3 feet deep below the window-sill, extending the full length of the carriage. As there were no side doors in the Central London carriages, that arrangement could easily be carried out. One immediate advantage was that a very stiff carriage was obtained, without any truss-rods underneath. The girder itself, although light, was stiff, and strong enough to enable truss-rods to be dispensed with; and on such a line as the Central London Railway, where the carriages were low, and where it was of advantage to have as much room as possible beneath the coaches, the avoidance of truss-rods was an important matter. The whole of the carriage was constructed of steel; the roof was steel sheeting, lined on the inside with asbestos mill-board, which had been used in order to obviate risk of fire. In one of the carriages he had tried "uralite" panelling on the inside of the body. Painted to imitate wood, this would deceive even an engineer, and readily be taken for wood at a short distance. Another advantage of the steel was that the walls of the carriage being so much thinner, an additional space of 4½ to 5 inches was obtained inside the carriage, with the same outside dimensions as before. That 5 inches of additional space was of great value in carriages like those on the Central London Railway, because it admitted of the central passage between the transverse seats being made correspondingly wider, and allowed freer circulation of passengers. The steel carriages were only about 5 cwt. heavier than the wooden carriages, in a total weight of about 14 tons; and even that difference might easily be avoided in future construction. From his point of view, the chief advantage of the steel carriages was the avoidance of fire-risk, and the additional width obtained inside the carriages.

Mr. Phipps. Mr. C. E. PHIPPS considered that, as Sir John Wolfe Barry had already pointed out, tare and capacity were not by any means the only things to be kept in view. It was, of course, important to reduce the dead weight of the wagons to the utmost; no one was more anxious to do that than himself, and he had always

Mr. Phipps.

had that object in view in designing wagons. But there were many other conditions which wagons had to fulfil, and those conditions must not be lost sight of. Like everything else on a railway, a wagon was simply a tool, and whether the tool should be small or large, or of any particular shape, were purely traffic questions. What wagon-builders had to bear in mind was that the wagons must be built to suit the requirements of the line on which they were to be used. Hopper coal-wagons were very convenient for carrying large quantities of coal from point to point, where facilities for discharging existed; but, as Sir John Wolfe Barry had remarked, at ports where such facilities were wanting, the cost of discharging was really higher than it would be with smaller wagons, which could be lifted in the hoists and tipped right into the ship. The hopper-wagons had to be discharged through the bottom into a smaller wagon, which could be lifted by a hoist, and tipped into the ship; and that intermediate operation added to the cost of shipping. Although, by cutting down the tare and building large wagons, such as those described in the Papers, it might be possible to effect a saving in the actual cost of carriage and haulage, yet if the result were that additional expense was incurred in unloading first into another wagon and then into the ship, there would be no saving in the general cost of carriage, and the object for which the wagon had been built would be defeated. On the Madras Railway, with which he had been connected for 30 years, the traffic was of a very miscellaneous character—much the same as had been referred to as existing on the Great Northern Railway. There was a certain amount of coal carried—though not so much as formerly, because a great deal that formerly went from the coast to the Kolar gold-fields had been stopped, owing to the introduction of electrical power on the gold-fields—and recently the question had arisen of building wagons for the carriage of coal. A special record had therefore been kept of the loads passing through a terminal station at Madras, through which the bulk of the coal had to pass; and of 340 wagons noted on one day, 229 had contained consignments under 6 tons in weight, and only 33 had loads of over 11 tons, although most of them were capable of carrying 16 tons; while 228 wagons were loaded with miscellaneous goods in small consignments going short distances, some of them under 50 miles, as on the Great Northern Railway. The bulk of the traffic throughout the line was in small consignments, and that was so far recognized that special rates were quoted, in competition with a canal, for a consignment

Mr. Phipps. weighing 1 garce (1,600 lbs.), in order to get the merchants to send goods in large quantities. Even with that special rate it was difficult to compete with the canal. Some heavy wagons of 16 to 17 tons had been built, and put on the line for general traffic. The traffic-department had soon complained that those wagons were too big for general use. Not only could they not be filled, but often when they were cut off at a small station, the station-staff of three or four men were unable to push them from the siding into the goods-shed afterwards, and had to call in help from all over the village. That had formed a serious objection to their use; and finally, in procuring wagons for an extension of the line, although it had been quite recognized that larger wagons would probably be advantageous for certain traffic, the traffic-manager and the manager of the line had decided in favour of smaller wagons, and wagons carrying 12 tons, instead of 16 to 17 tons, had been obtained. Nearly all the wagons described in the Papers were open wagons. For Indian traffic, as Mr. Upcott had pointed out, military requirements had to be borne in mind, and consequently the wagons in general use were covered. The open wagon necessitated the use of sheets, which caused trouble by needing to be invoiced specially; but the covered wagons were water-tight, and to a certain extent thief-proof, and for those reasons nearly all the wagons used in India were covered. He was glad to hear corroboration of an opinion which he had always held, namely, that the timber wagon was very hard to beat. On the Madras Railway wooden wagons which had been in use for 25 years had been practically in good running order when broken up. Steel wagons after 8 years' work had had to have their plates renewed, owing to the rust. Mr. Shackleford said that could be avoided by painting; but Mr. Phipps had never yet found a paint that would stand an Indian monsoon or hot weather. Even if it did, a railway company could not afford to bring wagons into the shops at short intervals. Timber wagons would run for years without attention. They were supposed to be painted, and, if they were, so much the better; but if they were not, they did not suffer much. Many of the old wagons broken up had had practically no paint upon them, but the timber had been sound. If a wagon would last for 25 years he thought it had paid for itself, and that there was not much cause for complaint. The large wagons that had lately come into vogue were the result of a considerable amount of thought on the part of the builder. Each detail had been thoroughly well worked out. With smaller wagons that had not

Mr. Phipps. been done; and in many cases small wagons had been built exactly to an old pattern, with the result that they were much heavier than they need be. His experience was that, when a little care was taken, it was quite possible to design a wagon of small capacity with as favourable a tare as a big wagon. One feature noticeable in Plate 3 was the retention of diagonals and of laminated springs for buffers; and there were various other details which had really survived from the old wagon. In building a steel underframe it was not necessary to use diagonals or laminated springs at all. If wagons were designed so as to make the best use of the material, it was possible to have a much lighter and stronger vehicle. Recently he had designed, for the Madras Railway, standard open all-timber wagons with a tare of 5 tons 10 cwt., and carrying a load of 12 tons. That gave a ratio between paying load and total load of 68·58 per cent., which, compared with the figures given in Appendix II. of Mr. Shackleford's Paper, was very favourable. A larger wagon lately built for carrying coal, with a steel underframe and timber body and sides, had a tare of 6 tons 15 cwt., and carried 17 tons; the ratio of paying load to gross load being 71·58 per cent. That was quite as good as any of the figures given for large wagons. With regard to covered goods-wagons, those which had been adopted as the standard had a tare of 6 tons 14 cwt.; and an iron wagon similar in size was about 1 cwt. heavier. Each carried 12 tons, giving a ratio of 64 per cent. Some larger wagons had recently been sent out, of which he had not the details. Their gross weight would be 28 tons, the tare being about 8 tons, and the net load about 20 tons, the ratio being in this case about 71 per cent. The traffic-department liked the 17-ton wagons for coal and heavy consignments, but they still liked the lighter wagons for general work. It was mentioned in Mr. Shackleford's Paper as a matter of course that continuous draw-bars must be used; but in Mr. Phipps's opinion the continuous draw-bar was not in all respects satisfactory. He had had wagons built with continuous draw-bars, and in many cases the rear headstock had been broken. The reason was that with a continuous draw-bar a train resembled a number of reels of cotton threaded on a string, with a knot behind each, which pushed the reel in front of it when the string was pulled. The result was that when the train was jerked the draw-bar at the rear end of the wagon was pulled into the headstock, and broke the framing as well as the headstock. That had occurred repeatedly, and had become so troublesome that he had

Mr. Phipps. decided to discontinue the use of a long draw-bar, and to build wagons with short draw-bars, the draw-spring being brought close up inside the headstock, and the stress transmitted through the middle longitudinals to the opposite end. Of course the strain of the whole train was then transmitted through the framing; but he saw no objection to that, provided the framing was stiff enough and sufficiently well secured to the cross-bars and the headstocks at the ends of the vehicle. At all events, experience showed those wagons to be much better than wagons with continuous draw-bars. So long as timber frames were used, it was no doubt of the greatest importance to relieve the timbers of tensile stress, because these strains occurred at the fastenings, which were all more or less weak. Another point against the long draw-bar was that, each vehicle being pushed by its rear headstock, when this condition existed in a long 60-foot carriage, a serious cross strain was thrown upon the bogie and bogie-pin, and the tendency was to cause bad running. Instead of the vehicle being pulled, and so kept straight with the road, it was pushed from the rear, and the tendency was to make the bogie wabble. Mr. Twinberrow showed a very ingenious arrangement of bogie-lead. No doubt pulling a bogie by the centre-pin was not a good mechanical arrangement. With some device whereby the bogie could be pulled from its leading end instead of from the centre-pin, better running would result; and he was satisfied that that was the proper thing to do.

Mr. Darley. Mr. CECIL W. DARLEY observed that the Papers dealt largely with the construction of wagons for the carriage of coal, and he had had many years' experience of coal-traffic in New South Wales, at the port of Newcastle, where he had acted as Resident Engineer for 17 years, and had constructed all the coal-shipping appliances. At that port the staithe system was not now in use, so that large wagons such as were described in Mr. Jepson's Paper would not be suitable for shipping coal there. The whole of the coal was carried to the port in 9-ton or 10-ton hopper-wagons, the hoppers were lifted off the frames by hydraulic cranes, and their contents were discharged through large bottom doors. Few of the wagons illustrated would suit the coal-traffic of New South Wales on account of the large size of the coal. About 34 years ago he had constructed some shoots at Newcastle (N.S.W.), with openings 3 feet wide, whereas on the Tyne they were only 2 feet or 2 feet 6 inches. It had been found that coal could not be got through the 3-foot openings, the blocks being so large that they stuck, and the men had had to use bars to get them through.

Consequently the openings had had to be enlarged to 4 feet. All the old-fashioned fixed wooden hoppers had been discarded, and the trucks now in use had mostly iron frames and lifting hoppers. With these appliances it was possible to ship coal into large ocean-going vessels—the ordinary small collier seen round the coast of England was not to be found in New South Wales—as fast as, or even faster than, it could be trimmed. Cranes were found to be the best appliances, and such staithes as had been erected had ultimately been removed and replaced by cranes. For the larger ships coal had to be delivered at a height of as much as 50 feet above the wharf-level in order to get it into the bunkers, some of which had their openings on the upper bridge; and it would not be possible to get staithes to that height. Some of the large steamers which visited Newcastle could not be got under any of the staithes he had seen in England. He did not think high-capacity trucks would be of any use at all. Some were being tried for carrying ballast, but he had not heard the result. Mr. Darley

Mr. F. E. Robertson remembered well that, when home on furlough from India, he had often been struck forcibly by the disreputable and inefficient state of the goods-stock on British railways, compared with the stock on Indian lines. It did not seem right that the parent country should not be as well off. There had been a considerable awakening within the last few years, but still things were not as they should be. Recently he had seen some trucks on a train with a tare of 6 tons 6 cwt., to carry 8 tons, and, alongside, others with a tare of 6 tons 15 cwt., to carry 16 tons. That was not a question of a big truck versus a little truck, but merely of putting a little brains into the design of the trucks. The trucks he referred to were practically of the same type, yet one would carry double the load of the other. For the last 20 years the Indian goods-stock had been fairly efficient; on the average the paying load was about 70 per cent. of the total. The present rule was 12 tons per axle, the gross load of the larger portion of the stock being 24 tons. Lately, four-wheeled wagons had been built with 16 tons per axle. Some Indian engineers seemed to be suffering from an attack of megalomania; they were calling for ultra-American trucks and engines, regardless of the possible effects upon the road or the bridges. They said the road was made for the traffic, and not the traffic for the road. Of course, that was right to a certain extent; but it seemed to him that the principal interest of the subject of the Papers lay in the broad consideration of that point rather than in the details of construction. With Mr. Robertson.

Mr. Robertson. regard to such details, he might remark that Mr. Twinberrow omitted to give the tare of any of the wagons he described. Tare was not everything, but it was a very important point in a wagon, and he trusted Mr. Twinberrow would give the figures in his reply. Mr. Shackleford said: "It will be seen that a high ratio of paying load to tare is largely dependent on the weight permitted to be carried on one axle; and if this is allowed to rise to 16 tons per axle as in rolling-stock for India, or to 17½ tons per axle as in America, it will be possible to build a four-wheeled wagon which will give as good results as a large bogie-wagon." He thought that went considerably beyond the truth, even as stated in Mr. Shackleford's own Appendix II (p. 124). He could not see, from that or from what he knew, that either the 16-ton four-wheeled wagon or the huge bogie-wagon gave any better tare than the ordinary Indian wagon: they were all the same—namely, about 70 per cent. That led to what he thought were important issues arising out of the Papers. Up to what axle-load did the tare diminish? If the tare was not diminished, what other advantages were obtained? What did these advantages cost, and what did they earn? It must be remembered that the Indian wagon had 43-inch wheels, which were heavier than the wheels of the other wagons, and that just when the load was being increased was not the time to diminish the size of the wheels. Incidentally it might be suggested that Clearing House tires might give trouble under engine axle-loads on much smaller wheels. What was required was a few facts about the increase in hauling-power with the increase in the gross axle-load. They could easily be obtained by some gravity experiments on wagons such as the late Mr. A. M. Wellington had conducted. Then, with some correct data for the units, it would be possible to consider the question of the whole train and the engine which hauled it. The present standard six-coupled goods-engine in India hauled a 1,000-ton train, and on the East Indian Railway they now ran 1,100 tons, which was as heavy a train as could be worked. The trouble was not that the engine could not pull the train, but that it could not stop it; and he regarded automatic brakes to all goods-stock as a condition precedent to any substantial increase in the power of the engines, and consequently in the weight of the trains. He was not opposed to progress in axle-loads and large-engined trains where necessary, or where it could be shown that they would pay; but he did think that those who called for them should justify their need in their own particular circumstances, and also show that they were doing the utmost possible with the stock at their disposal. It was no use saying that because America or some other country had 16-ton or 17-ton axle-loads and 3,000-ton trains, those things suited every line. That point had already been ably dealt with by Sir John Wolfe Barry. Too large a unit was wasteful. If it could not be filled it meant hauling so much more dead load. Looking at the statistics of American railways, he could not see that those lines which had adopted excessively large trains and rolling stock had thereby diminished their ton-mile cost; it seemed rather to have risen: and it had to be remembered that an increase in the gross ton-mileage tended to reduce the cost per ton-mile, quite apart from the details of the methods by which goods were carried. It did not do to say that because the cost per ton-mile had fallen, the reduction was due to the big trucks. Mr. Robertson

Mr. J. MITCHELL could not help thinking that the traffic-departments should now be asked to substantiate their position. If they said that they could only put ½ ton into 10-ton, 15-ton or 20-ton wagons, they should be asked why they could not devise some system whereby they could send a larger load in the larger wagon. Surely there might be found some plan of marshalling trains outside a city, if not inside, which would enable this to be done. Mr. Mitchell.

Mr. TWINBERROW, in reply, remarked that one idea had pervaded the remarks of several of the speakers, namely, that if large wagons were to be used at all they must necessarily be for general purposes, and to be put at the disposal of the traffic-department to use as best they might. That had never been the view he had taken in connection with the matter. He was no believer in having a universal wagon. He thought that the railway which tried to make one type of wagon-stock suit all purposes, would not be working its traffic to the best advantage. But it was possible to divide the traffic so that certain sections of it would be worked with maximum efficiency. He had never advocated that large bogie-wagons should be put down in all the goods-depots to be loaded under the present system. Again, why it should be considered necessary to assume that the railways existed for the traffic-department, and not the traffic-department for the railways he did not know. It was possible that the methods of handling and dealing with the traffic were capable of improvement and reform, *pari passu* with the mechanical appliances provided by the engineering staff of the railway for dealing with that traffic. He had found in the traffic-departments of certain railways every readiness to meet that view, and to accept modifi- Mr. Twinberrow.

Mr. Twinberrow. cations. Many of the arguments advanced were ancient history, because the self-same view had been taken when the chaldron wagons were superseded on the North Eastern Railway in 1873. Doubtless every one supplying freight to or dealing with the railway would look at the matter from the point of view of his own interests, and the collieries were not wishful to spend money in making alterations, when they did not see their way to obtain any benefit from them. He had been told that when the Pennsylvania Railroad Company decided that wagons of 100,000 lbs. capacity should be the standard, and found the colliery-proprietors objected to loading the wagons, they set a large staff of men to do what was necessary, because they could see it was vital to their interests that the larger wagon should be introduced for coal-traffic. With respect to the provision of side doors for long bogie-wagons, he thought it was highly desirable that the doors near the end should open to the top. It was necessary to have frequent doors when dealing with freight in bulk, which had to be worked out by means of a shovel, because an extra yard or two of throwing with a shovel at once added to the cost; but in running bags, etc., into the wagons by means of barrows and the like, an extra yard or two of wheeling did not matter at all. The London house-coal trade was surrounded by peculiar difficulties, but the ton-mileage involved was so considerable that it would appear desirable to make a special effort to effect an improvement. It was futile to expect 30-ton or 40-ton wagons to find their way into the service under existing conditions of supply and distribution. Some lessons might, however, be learned from a study of the seaborne coal-trade: it did not appear to be vital to restrict the carrying-capacity of the steamers to 10 tons; the boats employed were, in fact, of considerable size, and probably averaged double the capacity of those in use 25 years ago. Sir John Wolfe Barry's remarks conveyed the impression that there was no important shipping-port on the north-east coast, or, in the alternative, that the means there employed for dealing with wagons of high capacity were not satisfactory. Mr. Twinberrow did not think that experience with 40-ton cars in the district referred to supported this view, because no alteration had been necessitated in the shipping-appliances, and the larger cars were preferred on account of the marked saving in coal-breakage effected by their use, as well as on account of other more obvious advantages. When the Hancock self-acting "anti-breaker" was used at the end of the spout, it was possible to maintain an unbroken stream of coal from the top of the wagon to the hold of the vessel, with an entire absence of concussion. It was of course immaterial whether the

Mr. Twinberrow.

wagon was raised to the necessary height for commanding the hatchways by a vertical lift or by an inclined approach. Turntables were not a necessary adjunct for rapid despatch; it would not be expected that they should find a place in designs for new installations, as distinct from mere additions to existing plant. There were three operations to be considered in connection with the shipment of minerals, namely, the loading, the transport, and the delivery on board. When the coal-field was contiguous to the port, the shipment might be effected directly from the mining-tubs or corves, were it not for the necessity of screening and picking the coal; but when the coal-field was a few miles distant from the port, necessitating train-working, the question of transport assumed a leading position. The shorter the haul, the greater was the cost per train-mile, though the total train-miles were proportional to the length of lead, the train-load being assumed constant. Hence, when the cost of working the traffic was not negligible, it was not rational to assume that the shortness of the haul was a reason for effecting no improvement in the yield per train-mile. The end slopes of hopper-wagons were advantageous for obviating breakage in loading coal, and this type of vehicle enabled many users of minerals to save labour in unloading, without installing any machinery for the purpose. The cost of two wagons, each with two axles, was, at present, rather lower than that of a single wagon equal to their combined capacity, and provided with a pair of bogies; but the saving in capital cost should be considered in relation to increased wear of rails, tires and bearings, and to the longer radius which it was necessary to adopt for curves with the four-wheeled type. The four-wheeled wagons were also more subject to derailment, and, with modern axle-loads, they would not be an unmixed blessing to the owners of private sidings. With respect to the military aspect of the question, he thought it was well to bear in mind that high capacity gave increased carrying power to the line, and would reduce the congestion which might be expected to follow the sudden increase of traffic due to warlike operations. The transhipment of bulk freight between lines of different gauge might be facilitated by an arrangement of sidings crossing each other at different levels, permitting a wagon on the overhead line to discharge directly into another placed beneath it. Several years ago he and his partner had designed passenger-coaches built wholly in steel, but they had not found an opportunity to put the designs into practice. He was acquainted with the designs of steel panel girders which were used in several European countries, and had noted dining-cars of

Mr. Twinberrow. this construction, the tare of which was about 25 per cent. lower than that of recent examples of British design. He also noted that some steel cars had already been built for the underground electric lines of New York. He gathered from Mr. Cuningham's description of the cars for the Central London line that the girders had diagonal bracing in addition to web-plates; and he thought the double system was unnecessary. He agreed with Mr. Phipps that a good case could be made out for wood as a constructional material for small cars, but he did not regard the efficient maintenance of steel cars as impracticable in any climate. He knew that the wooden wagons of some British railways averaged only 10 months' service between shop-repairs, and thought it would prove better policy to spend less on repairs and more on paint. Reducing the size of the wagons seemed to be an unusual method of meeting competition; he had not heard of any canal successfully meeting the competition of a railway by reducing the size of its boats. It was the cost of train-miles, not wagon-miles, that made up the total of working-expenses. Railway-traffic was frequently subject to seasonal fluctuations, and though small wagons might save shillings when working light loads in the dull season, they would involve the expenditure of pounds in extra train-mileage when a rush of traffic occurred. Mr. Robertson's remarks were gratifying because they corroborated Mr. Twinberrow's impressions of 18 years ago, when he found examples of British wagons constructed with a tare of 7 tons 8 cwt. for a load of 8 tons. He had worked more or less continuously at the subject since that date, and might claim to have given it broad consideration in all its bearings—not omitting a study of Indian conditions as closely as circumstances would allow—and had examined the limitations imposed by the rules and regulations and by the standard loadings for girder bridges. But his Paper was not intended to be a treatise on the whole subject, and he had endeavoured to keep within the limits of his title. He had therefore refrained from touching on the use and working of steel or other wagons of high capacity. The following Table summarized the fluctuations of capital, interest, receipts, expenses, goods ton-mileage, goods train-mileage, and rates on American railways; it was a comparison of the returns for 1902 with those for 1892. The tares corresponding to the figures illustrated in his Paper were:—Plate 1, Fig. 1, 8·25 tons; Fig. 2, 13·5 tons; Fig. 3, 11·75 tons; Fig. 4, 15·25 tons; Fig. 5, 14·8 tons: Plate 2, Fig. 7, 16·3 tons; Fig. 8, 15·8 tons. The bogie-wagons were all fitted with bearing-springs in superimposed series, and the weight

Mr. Twinberrow.

Description.	Increase or Decrease.	Per Cent.
Capital	Increase	19·0
Interest	,,	19·6
Receipts	,,	47·2
Expenses	,,	42·2
Train-miles	,,	3·0
Ton-miles	,,	85·5
Rate	Decrease	18·8

of the continuous brake-gear was included where shown; in some cases friction draft-gear was fitted. He agreed with Mr. Phipps that laminated buffing-springs possessed many undesirable features, but private owners of rolling stock had no option but to use them, as they were the standard form specified by the Clearing House. Mr. Bury had referred to the difficulty of compelling traders to build their wagons to the larger sizes now specified by that authority. Mr. Twinberrow would commend to Mr. Bury's consideration the fact that the existing regulations would not allow private owners to use any of the designs illustrated in these Papers other than the example of 10 tons capacity; he ventured to suggest that the rigid standardization which had been attempted might be relaxed, in order to allow British traders to take advantage of recent developments in the design of rolling stock. In conclusion, he would like to express his indebtedness to the officers of the North Eastern Railway, and to acknowledge the valuable services of Mr. G. T. Glover, Assoc. M. Inst. C.E., Manager of the Carriage and Wagon Works of the Northern Division, to whom credit was due for the manner in which he had overcome the initial difficulties surrounding the introduction of wagons of four times the capacity of those formerly used.

Mr. Jepson. Mr. Jepson, in reply, pointed out that the wagons described by him had been designed for special purposes, generally for minerals. In the wagons shown in Figs. 3, 5 and 10, Plates 5 and 6, the doors were 4 feet wide, each opening being 4 feet by 2 feet, and he did not know that any difficulty had been experienced in discharging. One very large colliery-company, who were using the 40-ton wagons, had written to him thus :—

"We have now regularly used the large mineral wagons for nearly 12 months, and our experience with regard to the 40-ton self-discharging wagons is certainly a favourable one on the whole. They are somewhat difficult to move from a dead weight, but once this difficulty is got over, either by means of winches, electric capstans, or other appliances, they run very well, and, in our opinion, are certainly preferable to the 10-ton wagons. The 40-ton wagons are well hoppered, which causes the coal to slide fairly gently to the bottom of the truck, and avoids undue breakage. They are easily loaded, and in discharging, instead of

Mr. Jepson. necessitating the opening of 16 bottom boards with a perpendicular drop of about 3 feet above the height of the rails, as in the case of four 10-ton wagons, there are only four doors from which the coal slides at a distance of only about 18 inches above the rails. A few slight modifications are necessary at the usual coal-shipping spouts, but these are easily effected. In addition to the above, the large wagons only require half the siding accommodation as compared with an equal capacity of 10-ton wagons. These points, of course, are all from the standpoint of the user of the wagons, not the owner. We cannot say anything, for instance, as to the effect of wear and tear and general durability as compared with the 10-ton type, but simply as comparing the use of one wagon with the other we are very much in favour of the large wagons."

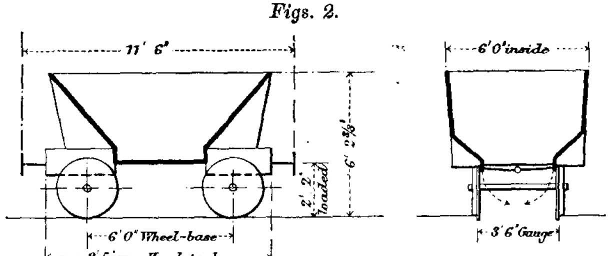
So that, apparently, colliery-proprietors were not likely to be averse to the use of the big wagons. At the same time he quite recognized the fact mentioned by several speakers that the large wagon was not suitable for the bulk of the general merchandise traffic of the country, owing to the number of small consignments. There was, however, a considerable portion of the mineral-traffic—which formed 70 per cent. of the whole goods-traffic—that could be carried with advantage in the 40-ton bogie-wagon, or in the 20-ton four-wheeled wagon, and he advocated them for this traffic, owing to the great reduction in tare and train-length which would be brought about by their adoption. Whether the bogie- or the four-wheeled wagon was adopted did not signify much. For special point-to-point traffic, where no turn-tables occurred, the former would undoubtedly be the better, even for short hauls; but when wagons were not intended for point-to-point traffic, and might have to pass over turn-tables, etc., the latter would be necessary. This, however, was a matter for the traffic-department to settle. One wagon could be constructed with as favourable a tare as the other, the only difference was that a train of four-wheeled wagons would be about 8 per cent. longer than a train of bogie-wagons, on account of the additional coupling-spaces, and there would be double the number of units to deal with. In order to involve the least possible alteration to existing plant, the wheel-base of the four-wheeled wagon should be made so that it could be turned on existing turn-tables, as in Fig. 10, Plate 6. To get the best result in the ratio of tare to load, and to reduce the length of mineral-trains on British railways, it was necessary to increase the load per lineal foot of train. This could be doubled by increasing the height of the wagons to 10 feet from the rails, and building to the width allowed by the Clearing-House regulations, as the North Eastern Railway Company were doing; and if it were made clear to colliery-owners and colliery-engineers that, by raising the screens at the pit-heads to allow of wagons 10 feet high passing under, they would be able to get double the quantity of coal in the same length of siding, they would soon raise the screens when more siding-accommodation was required, as this would be much cheaper than obtaining land and laying down new sidings. They would then gradually obtain wagons 10 feet high and make the best use of their sidings and wagon-stock, as the 20-ton wagon would certainly be much cheaper than the two 10-ton wagons. As the foregoing letter showed, one large colliery-company had already done this, with benefit, and they were now advocates of the 40-ton self-discharging bogie-wagon. In the case of new collieries, such as were being opened up in South Yorkshire, if it were pointed out to the proprietors that, by setting the screens high and obtaining higher wagons, only about half as much siding-accommodation would be required, this would undoubtedly be done. Both colliery-owners and railway-companies would benefit, and other collieries in the district would soon follow their example. It would also be an advantage, as pointed out by Mr. Oliver Bury, if English wagon-stock could be built of the same width as the carriage-stock, namely, 9 feet. The alterations generally necessary for this increased width were, however, a much more serious matter than for the increased height; and increasing the width of the wagon did not give anything like the additional capacity that was obtainable by increasing the height, which latter added least to the tare and cost of the wagon. The Caledonian Railway Company, however, had made a good move in this direction by having their 30-ton bogie-wagons built 8 feet 6 inches wide, which was 6 inches more than was allowed by the Clearing-House regulations for private-owners' wagons. Even for coal-traffic, one type of wagon could not possibly be made to meet all requirements. The hopper-wagon was necessary on the north-east coast and at some of the Humber ports where coal was shipped from staithes, and the 40-ton self-discharging wagon was doing excellent work there on a very short haul. The hopper-wagon was undoubtedly the best for gasworks and other traffic where the coal was discharged into bunkers below the rails, and this was the cheapest and quickest method of unloading, as one man could discharge the wagons at the rate of 1 ton per second. As shown by his Paper, wagons of this type, both four-wheeled and bogie, had been constructed, including either-side door-gear and brake, with a tare of 28·5 per cent. of the gross load on the rails, thus having an efficiency of 71·5 per cent. Consequently there should be no difficulty in building any of the other well-known and simpler forms of wagons with an equal, if not better, ratio of tare to load than was shown by these self-discharging wagons, for the Mr. Jepson.

Mr. Jepson. latter were by far the most complicated. For locomotive coal-traffic, the 40-ton flat-bottomed bogie-wagon described in his Paper should be very suitable; this wagon had a tare of 25·7 per cent. of the gross load on rails, and the load-efficiency was 74·3 per cent. It would be difficult to obtain a higher efficiency than this and at the same time allow a net capacity of 40 cubic feet per ton. The net capacity per ton should always be taken into consideration when making a comparison between the efficiencies of various wagons, and it would be found by reference to Appendix II. of Mr. Shackleford's Paper, that some of the wagons which showed a high efficiency when comparing the paying load with the gross load on the rails, had only a small capacity per ton: this occurred in examples 4, 10, 12, 16, 21, 22 and 24. With reference to the break of gauge on the Indian railways referred to by Mr. Upcott, in the case of a purely mineral line acting as a feeder to a line of 5 foot 6-inch gauge, the quickest mode of transhipment would be to have self-discharging wagons on the feeder-line and run them on to a simple form of staging constructed over the 5-foot 6-inch line at the transhipping station. As the narrow-gauge wagons passed over the stage, their contents could be discharged direct into the broad-gauge wagons standing below. An arrangement of this kind would not be very costly, and there would be no hand-labour required nor delays to the wagon-stock.

Correspondence.

Mr. Angus. Mr. J. Angus forwarded a sketch of a mineral wagon (*Figs.* 2), of which more than 1,000 were in use on the Rio Tinto Company's railway in Spain. These wagons weighed $3\frac{1}{2}$ tons and

Figs. 2.



carried $9\frac{1}{2}$ tons. They had been designed by the late Mr. Duff Bruce, M. Inst. C.E., and himself.