metals, and second, the iron plus the concrete, had been supported in great part by the grip of the clay all round the cylinders, and not merely by the bottom. Then, when the flood had come, the water had passed down the sides under the pressure, and had thus lubricated the iron and diminished the grip. He had immediately gone to work to get on the three remaining lengths of the cylinders, had filled them with concrete, and had gradually piled on each pair 220 tons of permanent rails. The effect had been to push down those on the right bank something over 1 foot, and those on the left bank nearly 2 feet. The load had then been about 7 tons per square foot. Under that load the clay could not be further compressed. Making up pieces had then been cast and put on, the concrete and heavy girder-bed stones fixed, and the building of the bridge had proceeded. At the official inspection, Colonel Yolland had gone down on his knees to see if the cylinders budged when his two locomotives were run over the bridge, but on this story being told him, he had desisted. This recalled another little incident that had occurred on this inspection. Mr. Mansergh had left the centre bay of the timber staging, upon which the bridge had been built, to facilitate testing the deflection under load, by means of a piece of wood sliding tightly in a dovetailed groove. This timber had been right under a cross girder, with about 9 inches or 10 inches clearance, and after testing the main girders Colonel Yolland had wished to try if there was any additional deflection under the middle of the cross girder, and had asked Mr. Mansergh (then young and slim) to squeeze in, if possible, with the slide. It had been a case of lying full length, and a very tight fit, and when the locomotives had been run over, each pair of wheels had made it tighter by about $\frac{5}{8}$ inch, but no harm had been done and the Colonel had gone away happy. Mr. Mansergh.

Correspondence.

Mr. A. W. MANTON wished to ask the Authors what had been the size, and the method and dimensions of the general timbering, of the very long temporary heading referred to on p. 88; whether the invert had been kept from rising by the timbering, and whether the pressure exhibited had been thought to be due to the expansion of the clay immediately outside the timber (through contact with the air), or whether there had been actual general settlement or movement, as seemed to have been the case, in connection with the tunnel. Also, whether such movement, if Mr. Manton.

Mr. Manton. any, had shown itself continually during the subsequent cut-and-cover and break-up operations, imposing greater stresses on the timbering than might have occurred with no previous disturbance. He asked these questions because, in smaller headings exposed to the air for even a week, he had noticed general distress of the timber, even where the side-trees had had ample foot-blocks. He would like to know whether close planking, pugging-up and grouting solid between the timber and the ground had been tried in this heading? Referring to the general covered way, it would be interesting to know why the side walls had not been excavated for, and put in, first, as it had been suggested, in previous Metropolitan cut-and-cover work carried out principally in clay, that smaller timbering might be used, that greater expedition would be possible, and that there would be less risk of movement during construction and afterwards. He thought it was a pity that the very handsome frontage and approach to the passenger station had not been carried out to the Marylebone Road. With regard to the roof, he thought many members of the Institution would be glad to know the approximate cost, say, per square foot of horizontal area, of the Marylebone roof and of circular or segmental roofs of large span, such as New Street, Birmingham, and St. Pancras. Apparently the roof described in the Paper, between 37 feet and 40 feet high to the apex and between 40 feet and 50 feet in span, should be cheaper in first cost (allowing for extra cost of heavier side-walls, etc., for large spans) and in maintenance. The disadvantage of columns on platforms, in the 6-foot way, or in the cabway, if they were carefully arranged, would appear to be small in most cases like the one described. The roof in question was handsome in design, and he thought it should not be compared with small-span transverse ridge-and-furrow roofing which covered even large areas at many English stations. By reason of height, beauty of detail and span, the Marylebone roof should at least be admitted to be of an intermediate and desirable type; and that being so, the relative costs of roofs of different type would be all the more interesting.

Mr. Twinberrow. Mr. J. D. TWINBERROW considered that the most interesting features in the description of the terminus of the Great Central Railway were those which were calculated to enable the railway to deal with traffic at less cost than its competitors. He had been struck by the fact that no less than 50 wagon-turntables were indicated upon the ground-plan alone; he considered that wagon-turntables were an incubus which European railways owed to lack of foresight on the part of a bygone generation, as they were

costly to instal and to maintain, a source of delay in handling traffic, and an obstruction to the employment of a more economical type of vehicle. In laying out the mineral yard the engineers appeared to have been bound by "the present practice of London coal-dealers," and to have decided that "no mechanical or labour-saving appliances were needed." Established custom invariably presented obstacles to the introduction of labour-saving appliances, but in view of the large expenditure involved in weighing and bagging by hand the contents of 440 coal-wagons in 24 hours, he thought that some attempt to economise would have a good prospect of securing the eventual approval of the London coal-trade. He presumed that the greater part of the tonnage was drawn from the district north of Annesley, and the movement of that number of wagons would in consequence necessitate the working of about 3,300 train-miles daily; the cost of locomotive-power, traffic, maintenance of way, and wagon-repairs for this volume of traffic would amount to about £412 per day; if, however, the same net tonnage were handled in wagons of great capacity, the train-mileage might be reduced by between 15 per cent. and 20 per cent., and the consequent net saving would be, say, £75 per diem, or £23,250 in a year of 310 working-days. But the possible saving due to improved equipment was not limited to this amount, for if arrangements were made to work the mineral traffic in trains of 1,200 tons gross weight (and it should be borne in mind that mineral trains weighing 2,000 tons were now quite usual in certain countries) a further saving of about £45 daily could be effected in locomotive-power alone. The saving in cost of transportation would thus amount to at least 7*d.* per ton; the employment of self-discharging wagons and mechanical means for handling at the terminus might be expected to increase the net saving to 1*s.* per ton; the division of this amount between the carriers and the coal-trade would probably lead to a rapid growth of traffic. He was therefore of opinion that the Great Central Company might find it advisable to remodel their terminal coal-yard and to arrive at some arrangement with private wagon-owners, whereby the existing stock of engines and wagons should be gradually replaced by units of greater earning-capacity.

Mr. Twin-berrow.

Mr. JOHN J. WEBSTER observed that the Paper raised the important question of the relative advantages of large and small spans for the covering of railway stations; and, although it was not possible to generalise upon the subject, there were one or two vital points, or rather conditions, which should definitely determine the plan to be adopted. The two things which required first consideration were the comfort of the passengers and the

Mr. Webster.

Mr. Webster. facilities and accommodation for dealing with passengers' and other luggage; to obtain these satisfactorily it was necessary to have wide platforms without the obstruction of columns, for although the actual sectional area of the columns might be small, they were fixtures, and could not respond to the familiar "By your leave." Absence of columns on the platforms meant of course moderate span for the roof; and when the comfort of the many existing stations in this country and on the Continent, having broad unencumbered platforms, was compared with the discomfort of the narrow platforms of other stations, the result was strongly in favour of the roof of large or moderate span. Again, it would be difficult to imagine any stationmaster or traffic manager advocating small spans and consequently obstructed platforms; and when large platforms had been obstructed by offices and other things—as might be seen occasionally—it was most probable that the man who had the regulation of the platform traffic had not been consulted in the matter, and that the obstructions had been erected by another department. The atmosphere of any station with low short-span roofs was never as clear as in those with roofs of large or moderate spans, the foul gases, etc., not having the same facilities for escaping; this point was surely worth consideration. The cost, per square yard covered, of large or moderate spans was no doubt greater than that of smaller spans; but with a well-designed roof of large span this additional cost was not as great as might be imagined. The cost of a roof was affected considerably by the amount of skilled labour required in its construction in the contractor's yard; in small spans the joints and connections formed a far greater portion of the total weight of the truss or rib than in large spans; and consequently the actual cost per ton for construction was greater in small spans than in well-designed large spans. The cost of erection might, however, be greater in the large spans, unless there was considerable repetition; when, with proper erecting plant, the cost per ton could be considerably reduced, and would compare favourably with the smaller spans. Another strong point in favour of the large spans lay in the fact that practical considerations quite prevented the sectional areas of many members of the small-span roofs being made proportional to the ascertained stresses; as a consequence, many of the members had a far greater sectional area than was actually required, and no matter how well the roof might be designed—and great credit was due to the designer of the Great Central roof, for the skilful manner in which all the details had been worked out—it was impossible to avoid this excess of metal in some of the members of a small roof. With

a well-designed large span this excess of material was not necessary; and an engineer could look with more satisfaction upon his work when he knew that he had been able to take full advantage of the properties of a splendid material. There appeared therefore to be practically only one advantage in the adoption of small spans, and that was in cost; but when this probable advantage was weighed against the other undoubted disadvantages, and when it was remembered that the public naturally expected to see a structure for the terminus of a great trunk line constructed upon a somewhat different scale from that of an enlarged roadside station, it would appear that the evidence was strongly in favour of large or moderate spans. That this was the opinion of Continental as well as of many English engineers was shown by the fact that the two comparatively recent stations at Frankfort and at Cologne had roofs of moderate spans, with large unencumbered platforms; and they formed two fine examples of good design and construction. Mr. Webster.

The AUTHORS, in reply to the Correspondence, stated that the size of the timber used in the frames of the heading had been 12 inches square, and that the frames had been fixed about 5 feet apart from centre to centre. There had been no sign of the sills rising. Some of the upper cross-timbers had been broken and also some of the sheeting timbers behind the frames at the sides. Where this had occurred additional frames had been fixed between the original ones. It was only in the tunnel that this difficulty had happened; no movement of any kind had been seen in the cut-and-cover work. The excavation had been made in the manner described in order that the invert might be built at the same time as the walls. It had been considered safer to do this than to build the walls in trenches, and then, after the removal of the dumpling, to excavate for the invert, leaving the walls (not designed as retaining-walls) to retain the clay without the assistance of the invert; and the result had been most satisfactory. The Authors.

No comparison of the cost of the station-roof with those of Birmingham, St. Pancras, etc., would be of any practical use unless the circumstances and conditions, prices of materials and labour, etc., were known in each case, as they were, without doubt, materially different. Sufficient drawings and information as to quantities were given in the Paper to enable experienced men to form an approximate estimate of the cost.

As regards the coal-yard and the use of turn-tables, the plan adopted was highly approved by the coal-merchants. Owing to the low level of the rails and the shape of the land it was far more convenient than a yard without turn-tables would be. The turn-

The Authors. tables were substantial, self-contained, and laid on good foundations, and were therefore easily worked and maintained. Each merchant had his own siding and his own roadway. Loaded trucks could be placed on his siding, and empties could be removed, by means of the up and down lines, without interfering with the traffic of another merchant, which could not have been done if the alternative scheme of long lines of sidings extending from Grove Road to Carlisle Street had been adopted. Whilst admitting the desirability of larger carrying units, in addition to the cost of hauling, the questions of shunting, carting, etc., at the terminus, must be taken into consideration in handling coal. The problem was further complicated by the number of merchants engaged in the trade and the many varieties in quality of the fuel. Coal was sold and distributed to London houses in small quantities and not in bulk. It would not bear unloading by means of self-discharging trucks; it was too much broken up, and merchants alleged that its value was thereby depreciated to the extent of one shilling per ton. Anthracite coal, as dealt with in that manner in America, was a different matter. If, however, a mechanical apparatus were forthcoming, which would transfer the coal from the trucks into bags, weigh it, and place it in the dealers' carts more satisfactorily and cheaply than by hand, there would appear to be nothing to prevent its adoption.

Few persons would agree with the opinion that the frontage and approach to the passenger station should have been carried out to Marylebone Road. The scheme adopted was much appreciated by travellers on the railway and visitors to the hotel. A better station and a better hotel were provided by separating than by amalgamating them. The arrangement, convenience and comfort to be found in the hotel were unsurpassed in this country. With regard to the station roof it was claimed to be appropriate to the scheme generally. It was hardly fair to compare the national undertakings of Frankfort and Cologne with that of a commercial enterprise.

---

20 November, 1900.

JAMES MANSERGH, President,
in the Chair.

The Discussion on the Paper by Messrs. Hobson and Wragge on "The Metropolitan Terminus of the Great Central Railway" occupied the evening.