Clarence Foundry, Liverpool,
DEAR SIR, *August 30th*, 1847.

AT the request of Mr. Turner, I have examined the plans and specification of his proposed roof, for the Lime-street station, and must observe, that it appears to me to be a grand design, and one which will be most convenient for a railway station. The strength in the specification appears to me to be sufficiently strong in all parts, except the tension rods, which in place of a section of $5\frac{1}{4}$ square inches, should not be less than $6\frac{1}{2}$ square inches,—even though the $5\frac{1}{4}$ square inches, may be able to support the heaviest load of snow which may ever come upon the roof; the sections at all the joinings being rather more than the general section of the bars.

I would also recommend, that when two of the principals are constructed, and properly stayed, in the manner they will be when completed, they should be loaded to at least three times the greatest weight, that may be supposed ever to come upon the roof, as a test.

This would give perfect confidence to the Directors, that the whole of the roof was sufficiently strong and safe.

I am, dear Sir, yours truly,
JAMES KENNEDY.

H. Booth, Esq., Secretary,
London and North-Western Railway, Lime Street.

Mr. TURNER said, he must express the obligation he was under to Mr. Locke, for the valuable advice and instruction afforded by him, throughout the progress of the work, which in the first instance was considered perfectly visionary and chimerical. When the design for the roof was laid before Mr. Booth, the Secretary of the London and North-Western Railway Company, he considered, with his usual judgment in mechanical subjects, that it possessed sufficiently the elements of stability to entitle it to be tried, but before giving any decided opinion, he desired to refer the matter to Mr. Locke, who, after inspecting the model, thought it was well adapted for the situation. The favourable opinions of Mr. W. Fairbairn, of Manchester, and of Mr. Kennedy, of Liverpool, strengthened these views, which were further confirmed by the experience afforded by a somewhat similar construction, in the Royal Botanic Gardens, at Kew, where the roof over the Palm House, of 65 feet span, erected from the design of Mr. Decimus Burton, for Her Majesty's Commissioners of Woods and Forests, had proved very satisfactory; it was therefore determined, that the system should be tried.

It was originally intended that the area at the Lime-street station, should have been covered by two spans, with a row of columns in the centre; but as Mr. Turner considered the grand desideratum would be the omission of all obstructions, where the traffic was to be carried on, he suggested to Mr. Booth, the idea of having a roof of one span of 153 feet, offering at the same time,

as he had not hitherto executed a work of similar magnitude, to erect at his own risk a portion of the roof, which should be subjected to any test, that might be required by the engineer of the Company. The details of these experiments, and of the satisfactory results obtained, were given in the Paper and Appendix, but certainly, Mr. Turner was not prepared for the exhibition of such a surplus amount of strength, as had been proved to exist, under the peculiar mode of testing to which it had been subjected.

After Mr. Locke had satisfied himself as to the general stability of the roof, and had made such observations as were necessary, to establish his views of the mode of strengthening certain parts, he proceeded to make further experiments, for the puposes of scientific research, and the result was the production of a roof, which Mr. Turner believed was hitherto unequalled for stability and strength, and he was so confident of the correctness of the principle, that with his present practical experience, he should not hesitate to undertake the construction of roofs of almost any extent, within the limits of the strength of the material employed, particularly if he had the advantage of the advice and supervision of Mr. Locke.

In answer to a question from Captain Moorsom, Mr. Turner said, the total cost of the roof fixed and finished, including the cast-iron columns, and the wrought-iron box-beam, was about £15,000, or nearly £20 per square of 100 feet.

Mr. Locke, M.P., *V.P.*, said, that when he was instructed by the railway company to consider the applicability of the plan for the Lime-street station, it became his duty, before giving an opinion, to examine its construction very carefully, and to ascertain the positive strength of the structure. For this purpose he had recommended, that a portion of the proposed roof should be erected and be subjected to certain trials; accordingly three principals, composing two bays, were constructed by Mr. Turner, at his workshops, in Dublin, when the middle principal was subjected to a test of 40 lbs. per superficial foot of the span, or opening of the roof, the two outside principals being left perfectly free. Mr. Locke then and still considered this test necessary, to enable an accurate opinion to be formed of the merits of the construction, though Mr. Turner protested against it, as an extreme test for such a structure. However, as the roofs erected for the Admiralty were subjected to a similar test, the trials were made, and with the success which had been described in the Paper.

Before commencing the experiments, a horizontal line was drawn from side to side, and on applying 5 tons to the first suspended cradle, the deflection was noted at each cradle: this

operation was repeated on the application of every additional weight of 2½ tons on that and every other cradle, until the load amounted to 10 tons on each. When one side of the roof had been tested in this manner, Mr. Turner said he ought to be satisfied, but he thought differently, and therefore proceeded to apply the testing-weights to the cradles on the other side; eventually, and before the maximum weight had been laid on, the principal, or rib, gave way, and bent laterally. The vertical strength of the beam was sufficient, but it evidently required lateral support; he therefore recommended the introduction of additional knee-bracings, and although this might have caused it to be stronger than necessary, he thought it prudent to insist upon it.

The general question of the roofing of railway stations, in one span, was a matter of considerable importance to engineers. At the Euston-square station, some of the carriages of a long train had recently run off the rails, and had been driven with such force against the columns, as to knock down one of them, which of course, brought down a portion of the roof, and might have caused serious injury. It would be extremely advantageous if columns could be dispensed with altogether in stations, and he believed, that the description of the roof over the Lime-street station, which was really an admirable structure, would be instrumental to the adoption of larger spans, and a more convenient system of building, than had hitherto been used, and he was much pleased that it had been brought before the Institution.

Mr. PYM said, that as he was present at the experiments referred to, he wished to add his testimony to the patient anxiety shown by Mr. Locke, to contrive the means of testing the roof, and his recording every fact, which could elicit the peculiarities of the structure. There was scarcely any railway engineer, who, in making arrangements for sidings, or for the reception of increased traffic, had not found a range of columns in a station, to interfere materially in the carrying out of his plans, and it would be admitted to be a grand desideratum, to obtain a free area for the construction, and the working of the line.

Mr. DOCKRAY said he had seen the roof at Liverpool, and thought it, in all respects, a beautiful structure, and well adapted for the position. It would be a great advantage to get rid of the columns at the Euston-square station, as they were exceedingly inconvenient, and frequently prevented crossings being made, which would facilitate the traffic of the station.

Mr. ERRINGTON said, with regard to the strength of the roof in question, and its resistance to the weather, Mr. Daglish had ex-

amined it the day after the recent storm in Liverpool, and had not found a single bolt sprung.

Mr. LOCKE, M.P., *V.P.* thought the correct estimate of the cost of the roof under discussion would be about £2 per superficial yard. The cost had been probably augmented by the heavy cast-iron columns on the one side, and the wrought-iron box-beam, on the other. The length of the shed was about 120 yards, by 50 yards in breadth, giving about 6,000 superficial yards.

February 26, 1850.

WILLIAM CUBITT, President, in the Chair.

No. 825. "Observations on the Street Paving of the Metropolis; with an account of a peculiar system adopted at the London and North-Western Railway Station, Euston-square." By William Taylor, Assoc. Inst. C.E.*

The paving of the streets is next in importance to the sewage of the Metropolis, and it is only by a good combination of the two, that true sanitary measures can be rendered complete and permanent. The immense sums of money annually expended in repairing paving, prove that the subject has hitherto been much neglected; and the following observations, giving (it is true) only the practical results of hitherto limited operations, are made with the view of directing attention to the subject, and in the hope that the discussion may induce a more extended application of the system, if it be approved, and lend assistance to the consideration of a subject of such increasing magnitude.

The street paving of the Metropolis has been for many years carried on under one general system. The method is to employ granite, in blocks of from 8 inches to 14 inches long, 6 inches to 9 inches wide, and 9 inches deep; these are merely laid in rows upon the subsoil (Fig. 1), and after the usual process of grouting and ramming, the street is thrown open for the traffic which is expected

Fig. 1.

ORDINARY LONDON PAVEMENT.

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* The discussion upon this subject was extended over a portion of two evenings, but an abstract of the whole is given consecutively.