into the cistern, the carriage is lowered on to the rails; it is then pushed back, and the apparatus is rolled over, ready for re-commencing the operation, the whole transit not having occupied more than a minute and a half.

The communication is accompanied by three drawings (Nos. 3365 to 3367), giving a general view of the traversing frame, with the attached pumps, details of the construction of the pumps, with their framework, and a view of the machine raising a first-class carriage.

Mr. Dodson stated, in answer to questions from the President, that Mr. Dodson's hydraulic traversing frame had cost about £220; that it was the ^{son} only one of the kind at present in use on the Great Western Railway, but that in consequence of its action being so much approved, several others were expected to be erected.

Mr. Brunel said, that the machine in question was made by Mr. A. Napier;* it was extremely well constructed, and he intended using others of the same kind. He expected they would be less expensive than the one described, which was the first that had been made. Mr. I. K. Brunel.

No. 641. "Account of the land-slip in Ashley Cutting, on the line of the Great Western Railway." By John Geale Thomson, Grad. Inst. C. E.

The object of the author of this paper is to show, that the land-slip which he describes, had its origin in a peculiarity of the geological position, and not in the nature of the ground in which it occurred. Land-slip in Ashley Cutting.

To explain this view, the formation of the oolitic district, so far as it relates to engineering purposes, is described generally, and a more particular account is given of the valley of the Box brook, in which this slip took place.

The Ashley cutting is situated about 5 miles on the London side of Bath, at the base of Kingsdown hill, the level of the rails being about 23 feet above the level of the Box brook.

In Mr. Lonsdale's account of the oolitic district of Bath,† the valley of the Box brook is styled, a denuded valley of the lias, or in other words, that the action of denudation has ploughed into, but not through, the lias, whereas it has completely eroded the superjacent strata. The valley is one of the two plains, which separate the

* Mr. A. Napier, York Road, Lambeth.

† Vide Trans. Geol. Soc., vol. iii., part 2.

parallel ridge of the great or upper oolite, which occupies, with few exceptions, the summits of the hills in that part of the country. The extreme height of the range of hills at Lansdown, its western extremity, is about 813 feet above the level of the sea. The summit of Kingsdown hill, behind the cutting, is rather higher than Box-hill, over the tunnel; and from the several heights given by the author, it appears, that the country slopes gradually from Kingsdown hill to the railway, at the rate of 1 in 11, exposing a slope of 4000 feet in length, to the decomposing action of the atmosphere, and to the collection of water. From the appearances of this locality and other observations, the author contends, that a considerable accumulation of drift from the high lands behind the cutting, had, in the course of time, settled at the base of the hill, whereby the original contour of the valley of denudation had been altered; that this had been caused by the unremitting action of water and the atmosphere, smoothing down the projections, and filling up the cavities, which the unequal effect of water upon strata of different degrees of hardness, had left upon the slope; and that the mass of loose stuff, through which the cutting was partly carried, was formed from the slope behind it, in the manner described, and was not part of the original stratification.

On the north side of the valley, the upper oolite was generally wanting, having been carried away, except from the tops of isolated hills, such as Banner Down and Lansdown, which lie between the sea and the southern and more continuous range. Owing to the slightness of the strike of the country towards Bradford, it is contended, that all the surface-water found its way down the slope of the hill, or the line of steeper descent, little or none being absorbed into the body of the hill; that as even in winter very few streams were visible, the vast quantity of water discovered in the cutting, must have entered the surface above, and percolated the ground for a considerable distance, and at last found its way into the Box brook, whence it carried considerable quantities of sand and silt, causing the subsidences at the surface which were everywhere visible. In excavating the eastern part of the cutting, holes of 12 inches to 18 inches diameter were found in the loose ground; these had been evidently formed by the action of water, which flowed from them in clear uninterrupted streams. That great changes of the surface had occurred, was further evident, from the circumstance of finding at a depth of nearly 10 feet, two human skeletons, whose bones were scattered and rubbed, as if they had been carried thither by the settling of a semifluid mass.

The wood-cut (Fig. 1.) shows a cross section, giving the form of the

NORTH.

Fig. 1.

SOUTH.

Cross section of Box Valley, in the line of the slip, showing the alteration in the contour of the valley by the accumulation of the drift.

original valley, the strike of the strata, the position of the cutting, the drift as supposed by the author, and the joints which traverse generally the secondary stratification. The position of the cutting with regard to these is shown as being partly in the lias marl, and partly in the drift. The author ascribes the movement of the ground, entirely to the weight of the saturated drift, either forming a joint in the marl, its tendency being down the slope AB, after the removal of the ground for the purposes of the railway, had destroyed its equilibrium, or acting upon a joint already in existence, so as to detach the mass, and force it towards the brook.

In Fig. 2 is seen a section of the valley at right angles to Fig. 1,

WEST.

Fig. 2.

EAST.

with the dip of the same strata, and the direction of the valley towards the sea. From a joint consideration of these two sections, it will be seen, that the drift in which the cutting is situated, is based upon the slopes AB Fig. 1, and CD Fig. 2. It was in a direction, compounded of these two, that the ground was observed to move, and it was accordingly attributed to a sliding motion of the drift, upon the surface of the marl, which idea appeared the more feasible, as the first indication of the movement, was the separation of an immense unbroken mass from the side of the hill, and not of a gradual

breaking back of the ground, as generally happens, where the slip is attributable to a want of consistency in the stuff itself. Subsequent examination and experience, however, satisfied the author that the origin of the movement was seated deeper, and that a mass of the lias had separated from the hill, somewhat in the form of the curve XYZ, in Fig. 1; and this idea was subsequently verified, by the rising of the ground on the north side of the railway (where it is supposed the curve came out) at X. The drift is stated to be in a highly saturated condition, owing to the great extent of its surface, its peculiar property of holding a considerable quantity of water, without falling to pieces, and to its being seated upon the lias marl, which is impervious. Hence it is contended, that the surface of the marl is the floor of the water-seam, and the point to which drainage must be applied to be effective; and it is stated, that the weight of the drift was considerably reduced, by the means which were adopted to drain the eastern or upper half of the cutting, to which, in the author's opinion, must be attributed the non-extension of the slip, beyond the part primarily affected.

The author then proceeds to describe the means adopted with regard to the moving ground, as well as the precautions taken afterwards, to prevent a similar disaster taking place, where the ground was still firm. He states that the removal of the broken ground, to a slope of $4\frac{1}{2}$ to 1, was finally had recourse to, laying bare the slope AB, Figs. 1 and 3, for a considerable distance, and that all efforts to draw off the water from the drift, after it had broken up, proved totally useless. Drains filled with rubble stone or faggots, were used; but in most cases, without effect, as they soon became choked by the movement of the ground; the further causes of their failure are commented upon in detail, as well as the benefit derived from the experience which they afforded, in pointing out the proper mode of treatment to be pursued in future. The mode of proceeding which was at last adopted, and which is stated to have been perfectly successful, is shown in Fig. 3.

It consisted, first, in removing a considerable portion of the drift, from the area occupied by the cross section of the cutting, before the marl at its bottom was touched; and secondly, in driving headings from the valley into the hill, and connecting them by shafts, sunk to meet them, from the high ground south of the line of railway, which in their progress downwards, necessarily pierced the water-bearing strata. These shafts and headings were afterwards connected, by headings driven on the surface of the marl, parallel to the railway, and thus the water was by degrees drawn off from the drift, and its quantity sensibly decreased. Upon the eastern part of the cutting, three benchings were cut, so as to bring the general line of the slope of the cutting, within the point B on the ridge, which is formed by the valley slope and the strata, and hereby, it was thought, a firmer base would be obtained.

Upwards of 1,500 yards of shafts and headings were driven, at an average cost of about thirty shillings per yard forward. The drift is stated to stand at present at a slope of 2 to 1, which is assumed by the author as a confirmation of his opinion, that the ground was radically favourable for railway operations, but that it was affected by local peculiarities, which it was originally impossible to have foreseen.

The necessity of attending to geology, as connected with engineering, is insisted upon, as the author contends, that in almost all instances, the actual surface of the country forms but a poor criterion, for judging of its original formation. The paper concludes, with an examination into the effects of water upon clay, when in the ground and under pressure, and when exposed to the action of the atmosphere. The author attributes the disintegration of the clay by water, in the latter case, solely to the degree of pressure it is subject to, and cites some instances which came under his observation, in support of this opinion.

The account embraces a record of the work, extending over a space of more than two years, so that it is impracticable within the limits of an abstract to give more than an outline of it.

The paper is illustrated by a drawing (No. 3482), showing the plan and numerous sections of the cutting, in all stages of the progress of the slip and of the works.

Mr. Lowe remarked, that the paper which had been read, showed Mr. Lowe. how intimately the science of geology was connected with that of civil engineering, and of what essential assistance its study was. This could not be too strongly insisted upon, and it was very desirable, that resident engineers on railways, should communicate to the Institution, plain but detailed accounts of the events which occurred daily