One side being finished throughout its entire length, the trains were turned upon the up-line, and the same mode of proceeding followed with the other side. A series of bearers, 6 feet apart, were then placed over head, and a close flooring laid so as to serve for scaffolding for the workmen, and to prevent the building materials from falling upon the rails. A pair of ribs were then raised upon each bearer, and keyed with a strut, 7 inches below the crown of the arch; the supporting stays were fixed, the laggans laid upon the ribs, and the brickwork of the arch was constructed in English bond throughout the whole length, and on both sides of the tunnel, simultaneously, to within 2 feet of the crown; a moveable centre, 2 feet 3 inches long, was then introduced, and the arch was closed in with two half brick rings.

The whole of the work was done with blue hard burnt Staffordshire bricks, laid in cement and sand, in equal proportions, for the side walls; for the arch, up to within 15 inches of each side of the crown, two-thirds of cement, and one-third of sand; the two rings for keying up the centre or crown were laid entirely in cement, without any mixture of sand. Materials employed.

Previous to commencing the new work, a series of chases were made in the old wall, which, when closed in front by the lining arch, formed drains, $4\frac{1}{2}$ inches square, terminating in the culvert beneath the centre of the railway, and conveying thither all the water, which would otherwise have separated the new from the old brickwork. Drainage.

This work was finished, and the scaffolding removed, within the short space of forty days, by Messrs. Grissell and Peto, under the direction of Mr. Robert Stephenson, and the immediate superintendence of Mr. Dockray. Duration of the repairs.

This communication was accompanied by a drawing, showing the details of the scaffolding, and the mode of construction.

“On the formation of Embankments and the filling-in behind retaining Walls.” By John B. Hartley, M. Inst. C. E.

The numerous failures of the embankments in the construction of railways, and the constant occurrence of defects in retaining walls, induced the author to offer some remarks upon the subject. The formation of embankments.

He first examines the ordinary mode of commencing the embankment at the contemplated finished level, and proceeding with the work at that height throughout, leaving the material to find its own Mode of filling.

inclination; forming the required slopes on the sides when the filling is completed. This he contends (although without doubt the most rapid mode of proceeding) is defective in principle, for the material as it is deposited forms layers or strata at such an inclination as its nature permits, and always has a tendency to slide in the direction of the slope. In such cases, as the centre sinks, the sides slide away, and having nothing at the feet to resist such a tendency, they are carried out to a dangerous extent. This is particularly the case with clay embankments, for the material is generally brought from the cuttings in large lumps, which cannot be consolidated as they are deposited: the water lodges in the interstices, keeping the bottom soft; and when it begins to subside it slides away, until it has formed itself into a slope, at which it can resist the pressure.

Footings. To prevent this sliding, the author recommends proper footings being prepared for the sides of the embankments by cutting trenches, about 4 feet 6 inches deep, along the bottom line of each slope, and forming a 'cop' of sods or of stones, placed at right angles to the line of the slopes. These footings must be of a strength proportioned to the height of the embankment, and the whole length should be completed before the filling is commenced, that they may become solid, and the sods have grown together, before the weight is brought upon them.

**Proposed
mode of
filling.**

He advises, also, that instead of carrying on the filling in one lift, two embankments should be made, varying in height from 15 feet to 20 feet, according to the nature of the material, wide enough for two earth waggons on the top; one of them running along each side of the site of the contemplated embankment: a valley would thus be left in the centre at the junction of the two inner slopes. When they have been carried along the whole length, or to such a distance as would insure their being considerably in advance, the second or the final lift may follow. With clay or soft materials, four low lifts following each other would be advisable; with these precautions slips of the embankments would be of rare occurrence. The bottom would become solid by the passing of the weight over it, and the succeeding lift being thrown into the centre valley, must settle vertically. The subsidence, which is always in the line of inclination, would be concentrated and thrown inwards; by these means the width of the slopes would be restricted, and the work would be constructed much cheaper, there being a saving of both land and labour. Land springs, which are usually only discovered by the pressure of the weight above, would be more easily reached with the low lifts than when covered by the heavy ones.

This mode of construction has been practised by Mr. Jesse Hartley,

on the Manchester and Bolton Railway, where the embankments were very heavy, and the material of the worst description: yet the work was executed in a most satisfactory manner, and the cost of the maintenance of way upon that line is quoted as being less in proportion than on any other railway in the kingdom.

This method may require more time, and be a little more expensive, but the author is of opinion that the trifling difference in time and cost would be amply repaid by the freedom from expense when the road was opened.

The author then examines the subject of retaining walls. He considers the method of filling towards the wall from the natural bank behind to be highly objectionable; the material lies in strata at the angle at which the deposit is made; as the quantity increases, the subsidence commences, and the earth slides downwards, throwing its whole weight against the back of the wall. The tendency to slide is frequently accelerated by the natural form of the ground upon which the earth is thrown, as it not unfrequently inclines towards the wall, in which case the pressure will necessarily be in proportion to the inclination of the slope, and the nature of the material of which the filling is composed. The wall at Hunt's Bank, on the river Irwell, is instanced as a failure of this description. The wall, about 100 feet in length, and 20 feet in height, 5 feet thick at the bottom and 3 feet 6 inches at the top, built of ashlar masonry strengthened by counterforts, was forced into the stream by the pressure of the earth behind it.

With proper attention to the manner of filling the different materials, a comparatively slight wall may be constructed to sustain a considerable weight of backing. The author lays down as a rule that, wherever it is practicable, all filling behind walls should be commenced at the wall, and be proceeded with from thence towards the solid ground, by which means the strata would be inclined in a similar direction: ledges or benches, either level or inclined in an opposite direction to that of the bank, should be cut in the solid ground to receive the filling, and counteract its tendency to slide. The weight should not be laid too quickly upon a new wall, and if with these precautions care be taken that the counterforts are constructed simultaneously with, and well tied into, the wall, a comparatively weak structure will bear a heavy mass of filling.

The author gives as an example the retaining wall constructed on the west side of Jackson's dam, near the Brunswick Graving Docks, Liverpool. This wall, although built of slight dimensions, and filled behind with material of the worst description, resisted perfectly all strain; this could only be attributed to the filling having been

gradually done in the manner which the author's practice leads him so strongly to recommend.

This communication was accompanied by diagrams descriptive of the mode of constructing embankments.

May 25, 1841.

HENRY ROBINSON PALMER, V. P., in the Chair.

"A Tabular Statement of the Dimensions and Proportions of Forty Iron Vessels." By Lieut. E. N. Kendall, R. N., Assoc. Inst. C. E.

Iron
vessels.

The vessels, the dimensions and proportions of which are given in this communication, were all built by Mr. John Laird of Liverpool: they are adapted to a variety of purposes, so that they present but little uniformity.

The "Rainbow" and the "Glowworm" are celebrated for their speed; their proportions of beam to length are above one to six, and more than 3 tons to each horse power, which is generally assumed to be the proper ratio for sea-going steamers.

The tabular statement gives the dimensions and tonnage of the vessels, the power of the engines, the proportion of beam to length, and of tons to each horse power, the names of the owners, and the stations where the vessels are plying.

"On the Stationary Engines at the new Tunnel on the Liverpool and Manchester Railway." By John Grantham, Assoc. Inst. C. E.

Stationary
engines on
the Liver-
pool and
Manches-
ter Rail-
way.
Dimen-
sions.

This communication gives a description of two pair of stationary non-condensing engines, which were constructed by Messrs. Mather, Dixon, and Co., of Liverpool, from the designs and under the superintendence of the author.

The steam cylinders are 25 inches diameter, with a length of stroke of 6 feet; they have side levers like marine engines, but the connecting rods are reversed, and convey the power downwards to the machinery, which is placed in vaults cut out of the sandstone rock: upon which the beam pedestals are fixed without any framing. Cast-iron slides are used instead of the usual parallel motion, and