THE HARBINGER.

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Internal Improvement.

DESCRIPTION OF THE LIVERPOOL AND MANCHESTER RAILWAY.

There is so little in scenery that is interesting on the turnpike road from Liverpool to Manchester, that a formal description of the way between the two towns may appear to be rather an unpromising undertaking. The traveller along the Railway, however, will speedily admit that there is little similitude between the two routes; the whole character, structure, and appearance of the Railway being altogether different from the general aspect of the turnpike road. Instead of a uniform, flat, and uninteresting country, the line of Railway is diversified continually by hill and dale, offered to the contemplation of the traveller in a sort of inverse presentment, the passenger by this new line of route having to traverse the deepest recesses, where the natural surface of the ground is the *highest*, and being mounted on the loftiest ridgest and highest embankments, riding above the tops of the trees, and overlooking the surrounding country, where the natural surface of the ground is the *lowest*,—this peculiarity and this variety being occasioned by that essential requisite in a well-constructed Railway—a levied line—imposing the necessity of cutting through the high lands and embanking across the low; thus, in effect, presenting to the traveller all the variety of mountain and ravine in pleasing succession, whilst in reality he is moving almost on a level plane, and while the natural face of the country scarcely exhibits even those slight undulations which are necessary to relieve it from tameness and insipidity.

To accomplish a complete survey of the Railway, we should commence our journey of observation at the Liverpool end, in the Company's yard, at Wapping. Here the lower entrance of the great Tunnel is accessible through an open cutting, 22 feet deep and 46 wide, being space for four lines of Railway, with pillars between the lines to support the beams and flooring of the Company's warehouses, which are thrown across this excavation, and under which the wagons pass to be loaded or discharged through hathchways or trap doors communicating with the stores above; wagons loaded with coal or lime passing underneath the warehouses to the open wharves at the Whapping end of the station.

Proceeding along the Tunnel, the line of Railway curves to the right, or south-east, till it reaches the bottom of the inclined plane which is a perfectly straight line, 1980 yards in length, with a uniform rise of three-quarters of an inch to a yard. The Railway from Wapping to the commencement of the inclined plane is level; the whole rise, therefore, from Wapping to the Tunnel mouth at Edge-hill, is 123 feet. The Tunnel is 22 feet wide and 16 feet high, the sides being perpendicular for five feet in height, surmounted by a semicircular arch of 11 feet radius: the total length is 2260 yards. It is cut through various strata of red rock, blue shale and clay, but principally through rock of every degree of hardness, from the softest sand-stone to the most compact free-stone, which the axe or the chisel will with difficulty penetrate. It frequently was found necessary, in the progress of the work, to make an artificial vault of masonry, which has been effected by brick arch-work in those places where the natural rock could not be trusted to support the superincumbent mass. The height from the open surface of the Tunnel upwards to the open surface of the ground, varies from 5 feet to 70, the greatest mass of superstratum being in the vicinity of Hope street and Crabtree lane. The whole length of this vast cavern is now furnished with gas-lights, and the sides and roof are *whitewashed*, to give better effect to the illumination. The different colours and peculiar appearance of the varying strata through which the Tunnel passes are thus hidden from view, and the attention is no longer attracted to those faults or slips in the solid rock which indicate that the whole mass has been rent asunder by one or more of those terrible convulsions of nature, of which the traces are so frequently visible, but of which no further record remains. The geologist will be disappointed, in traversing the subterraneau vault, to find the natural varieties converted by lime-water into one uniform and artificial appearance; but the principle of utility is paramount in a commercial undertaking.

At the upper or eastern end of the Tunnel, the traveller emerges into a spacious and noble area, 40 feet below the surface of the ground, cut out of the solid rock, and surmounted on every side by walls and battlements. From this area there returns a small tunnel, 290 yards in length, 15 feet wide, and 12 feet high, parallel with the large one, but inclining upwards in the opposite direction, and terminating in the Company's premises in Crown street, at the upper and eastern boundary of Liverpool; being the principal station for the Railway coaches, and the depot for coals for the supply of the higher districts of the town.

Proceeding eastward from the two Tunnels, the road passes through a Moorish archway, at present unfinished, which is to connect the two Engine-houses, and will form the grand entrance to the Liverpool station. The structure is from a spirited design of Mr. Foster's. The traveller now finds himself on the open road to Manchester, and has an opportunity of contemplating the peculiar features of a well-constructed Railway, the line in this place being perfectly level; the slight curve which was unavoidable, beautifully set out; the road-way clean, dry, and free from obstructions; and the rails firmly fixed on massive blocks of stone. Crossing Wavertree lane, the Railway descends for 5½ miles at the rate of four feet in the mile, a declivity so slight and uniform as not to be perceived by the eye, but still sufficient to give a mechanical advantage and facility of motion to a load passing in that direction. The road a little beyond Wavertree lane is carried through a deep marle cutting, under several massive stone archways, thrown across the excavation to form the requisite communications between the roads and farms on the opposite sides of the Railway. Beyond the marle cutting is the great rock excavation through Olive Mount, about half a mile to the north of the village of Wavertree. Here the traveller passes through a deep and narrow ravine, 70 feet below the surface of the ground, little more space being opened out than sufficient for two trains of carriages to pass each other; and the road winding gently round towards the south-east, the prospect is bounded by the perpendicular rock on either side, with the blue vault above, relieved at intervals by a bridge high over head, connecting the opposite precipices. The sides of the rock exhibit already the green surface of vegetation, and present altogether far more of the picturesque in their appearance than might be expected from so recent an excavation. At night, when the natural gloom of the place is farther deepened, the scene from the bridges above will readily be imagined to be novel and striking. The light of the moon illuminating about half the depth, and casting a darker shade on the area below—the general silence interrupted at intervals by a noise like distant thunder—presently a train of carriages led on by an Engine of fire and steam, with her lamps like two furnaces; throwing their light onward in dazzling signal of their approach—with the strength and speed of a war-horse the Engine moves forward with its glorious cavalcade of merchandise from all countries and passengers of all nations. But the spectacle is transient as striking; in a moment the pageant is gone—the meteor is passed, the flaring of the lamps is only seen in the distance, and the observer, looking down from the battlement above, perceives that all again is still, and dark, and solitary.

Emerging from the Olive Mount cutting, you approach the great Roby embankment, formed of the materials dug out of the excavation we have described. This embankment stretches across the valley for about two miles, varying in height from 15 to 45 feet, and in breadth at the base from 60 to 135 feet. Here the traveller finds himself affected by sensations the very reverse of what he felt a few minutes before. Mounted above the tops of the trees, he looks around him over a wide expanse of country, in the full enjoyment of the fresh breeze, from whatever quarter it may blow.

This vast embankment strikingly exhibits how much may be accomplished when our efforts are concentrated on one grand object. There is a feeling of satisfaction by no means common-place, in thus overcoming obstacles and surmounting difficulties, in making the high places low and the rough places plain, and advancing in one straight and direct course to the end in view; while the pleasure afforded by the contemplation of this great work is farther enhanced, when considered in contrast with ordinary and every-day impressions.

After passing the Roby embankment, you cross the Huyton turnpike road, leaving Huyton Church and village on the left hand, and proceed in a slightly curved direction to the bottom of the in line plane at Whiston, between seven and eight miles from the Company's station in Liverpool. This plane rises in the ratio of three-eighths of an inch in a yard, or 1 in 96. It is a mile and a half long in one straight line, and the inclination (being so slight) would scarcely attract observation, did not a decrease in the speed of the carriage indicate that an important change had taken place in the level of the way. At the top of the Whiston inclined plane there is a portion of the road (nearly two miles in length) on the exact level.—About half a mile from the top of the inclined plane, the turnpike road from Liverpool to Manchester crosses the line of the Railway at an acute angle of 34 degrees, and is carried over the Railway by a substantial stone bridge, of very curious and beautiful construction, being built on the diagonal or skew principle, each stone being cut to a particular angle to fit into a particular place, the span of the arch, measured at the face, being 54 feet, while the width of the Railway underneath, measured from wall to wall, is only 80 feet—each face of the arch extending diagonally 45 ft. beyond the square. Rainhill bridge is nine miles from the Company's yard in Wapping, and it was underneath and on each of this bridge that the experiments took place with the Locomotive Engines which contended for the premium of £500 in October 1829.

Passing over the summit level at Rainhill, we come to the Sutton inclined plane, which descends in the opposite direction, and is similar in extent and inclination to the Whiston plane, the top level being 82 feet above the base of each plane. Par Moss is the next object of attention, the road way across the principal part of it being formed by the deposite of heavy material (clay and stone) dug out of the Sutton inclined plane. This Moss is about 20 feet deep, and the material forming the Railway, as it was deposited, sank to the bottom, and now forms an embankment in reality 26 feet high, tho' only four or five feet appears above the surface of the Moss. The borders of this waste are in a state of increasing cultivation, and the carrying of the Railway across this Moss will hasten the enclosure of the whole area.

Leaving Par Moss, we soon approach the great valley of the Sankey (about half way between Liverpool and Manchester, with its Canal at the bottom, and its flats or barges in full sail passing to and fro, between the River Mersey, near Warrington, and the great Coal districts near St. Helen's.—Over this valley and Canal, and over the topmasts and high peaks of the barges, the Railway is carried along a magnificent viaduct of nine arches, each 50 feet span, built principally of brick, with stone facings, the height from the top of the parapets to the water in the Canal being 70 feet, and the width of the Railway between the parapets 25 feet. The approach to this great structure is along a stupendous embankment, formed principally of clay, dug out from the high lands on the borders of the valley. Looking over the battlements, there is a fine view down the valley to the south—Winwick spire rising in the distance, and below you, the little stream of the Sankey running parallel with the Canal; whilst the masts and sails of the vessels, seen at intervals in the landscape is no longer visible, present a vivid specimen of inland navigation. Immediately below you, the barges, as they approach the bridge, escape from view for a few minutes, till, having sailed under your feet, they become again visible on the opposite side of the viaduct.

On leaving the Sankey, we speedily approach the town of Newton, or rather the borough; for this ancient and loyal place sends two representatives to Parliament, under the auspices of Colonel Legh, M. P. A few hundred yards to the south of the town the Railway crosses a narrow valley by a short but lofty embankment, and a handsome bridge of four arches, each 40 feet span. Under the eastern arch of the turnpike road passes from Newton to Warrington, and beneath another arch flows a stream which turns an old corn mill, immediately below the bridge. Adjacent also, is situate one of those antique mansions, built in the ancient baronical styles, whose white exterior, with black oak crossings, and pointed gables, harmonizes well with the rude scenery around.

A few miles beyond Newton is the great Kenyon excavation, from which about 800,000 cubic yards of clay and sand have been dug out, part being carried to form the line of embankment to the east and west of the cutting, and the remainder, deposited as spoil banks, may be heaped up, like Pelion upon Ossa, towering over the adjacent land. Near the end of this cutting, the Kenyon and Leigh Junction Railway joins the Liverpool and Manchester line by two branches, pointing to the two respectively. This Railway joins the Bolton and Leigh line, and thus forms the connecting link between Bolton, Liverpool, and Manchester. From the Kenyon excavations the transition is easy to the Broseley embankment, formed of the material dug out of the cutting, as before described. Moving onward, we pass over Bury lane and the small River Gless, or Glazebrook, being arrived on the borders of the Chat-Moss. This barren waste comprises an area of about twelve square miles, varying in depth from 10 to 26 feet, the whole mass being of so spongy and soft a texture that cattle cannot walk over it. The bottom is composed of clay and sand, and it is not an uninteresting, if not a very profitable speculation, to carry our ideas back to that remote period when the sea flowed over the basin of this huge fungus. There are they who profess, by examining the vegetable fibre of the Moss, to calculate its age: as the fortune-teller will cast your nativity by the furrows in your hand. No doubt this vegetable matter is still increasing. The flower and the leaf of the heather still bud, grow to maturity, and fall; and the process of decomposition amalgamates the new and the old fibre; but what is thus deposited has been previously extracted from the Moss, save what has been supplied from the hydrogen and other gases absorbed and combined in this great laboratory. At a very moderate calculation Chat Moss comprises sixty millions of tons of vegetable matter; and we shall leave to philosophers to calculate in how many centuries this weight could be drawn from the clouds and the air.—Northward of the Moss, in the distance, is Tildsley Church, one of the modern Parliamentary edifices; and, as we approach the eastern boundary, conspicuous on a gentle eminence to the left, is Worsley Hall, the seat of R. H. Bradshaw, Esq. M. P. so well known as Trustee for the Duke of Bridgewater's Canal.

Beyond Chat Moss we traverse the Barton embankment, crossing the low lands for about a mile between the Moss and the Worsley Canal, over which the Railway is carried by a neat stone bridge. At this spot it is evident you are approaching a manufacturing district. On the banks of the Canal a great cotton factory rears its tall sides, with its hundred windows, and the fly-wheel of its steam engine pursuing its continuous and uniform revolutions, as if symbolical of that eternal round of labour and care, of abundant toil and scanty remuneration, of strained exertion and insufficient repose, which, through day and night, through seed time and harvest, through years of civilization and ages of barbarism, have been the condition and tenure on which the existence of so large a portion of mankind has depended.

From the Barton embankment we soon arrive at Eccles, four miles from Manchester, leaving to the right the vicarage and parish church of that village. Between this place and Manchester the Railway passes at no great distance from several country seats and villas, whose rich lawns and flourishing plantations afford an agreeable variety, after the great sand hills at Kenyon or the wide waste of Chat Moss.

The immediate approach to Manchester, by the Railway, is through a portion of Salford, as little interesting as can well be imagined. Over the River Irwell the Railway is carried by a very handsome stone bridge, and then over a series of arches, into the Company's station in Water street and Liverpool road, Manchester; from which the traveller whose object is pleasure rather than business, will probably make his way, without loss of time, to the more genial attractions of the Albion Hotel, or New Bridgewater Arms.—*Booth's R. R. Report.*

Mathematics.

FOR THE HARBINGER.

Solution to quest. XXXIII. by Ned Numscull. Let ABC represent the horizontal plane; B the point where the wheel touches it; DHB a diameter perpendicular to the plane, and EFH parallel to it. Let the radius GH be taken to express the weight of the barrow and the direction in which the arms are to be elevated, and resolve it into perpendicular forces GI, IH. Now GI is the only part of the force GH which is employed in pushing the barrow horizontally, and is the same as though it were collected at the point I and employed in turning the wheel round; but this effect is, by mechanics=GI.IH=a max. by hypothesis, ∴ it is well known that GI=IH and the angle of elevation=45 degrees.

W. W. R.

Solution to quest. XXXIV. by Moses Elbow. It is well known that if the two sides of a triangle represent the quantities and directions of two forces, the base will represent a force equivalent to both; therefore there are given two sides of a plane triangle and an angle opposite to one of them to determine the other side, a question which I would recommend to the notice of the Sophs.

W. W. R.

A general solution by Zero. Let P, S and Q represent the forces, A the angle which P make with S, and x the angle the same force makes with Q; then, art. 24, Venturoli's Mechanics, S squared=P squared+2P.Q. cos. x+Q squared, and

$$\sin A = \frac{Q}{S} \sin x;$$

hence S squared

$$= \frac{(Q \cos A)\ \text{squared} - (P \sin A)\ \text{squared}}{\sin A\ \text{squared}}$$

=P squared+2P. Q cos x+Q squared, from which by an obvious reduction cos x

$$= \frac{P}{Q} \sin A\ \text{squared} + \frac{\cos A}{Q} . \surd \{ Q\ \text{squared} - (P \sin A)\ \text{sq.} \}$$

COR. I. If P=Q; then cos x= −sin A squared+cos A squared=cos 2A; ∴ x=2A, and S=2P cos A.

II. If cos x=0; then Q cos A=P sin A.

Solution to quest. XXXVIII. by Diggory Sweepstakes. Since CT is parallel to HF<HFC=<FCT and arc HC=arc FT. Because AZ=ZB (4.1), ZN=ZC (24.4), <AZB is bisected (2cor. 4.3) ∴<NZH=HZC (13.1) and the arc NH=HC. Again, because the arc AF=arc FB (4.3), CF bisects the vertical angle ACB, but by construction CG=CB, ∴ CF is perpendicular to BG and <HFC=ABG, because each is the supplement of<CIB, ∴ arc HC=AM=NH=AF=FT. Q. E. D.

Solution to same by Uncle Ben. In the triangle AZB, since the diameter HF is drawn at right angles to AB, it bisects it (4.3) ∴ AZ=ZB and<AZE=<BZE. But NZ=ZC when AZ=ZB (24.4), hence NC is bisected at right angles, and NH=HC (4.3). Also the alternate angles FCT and CFH being equal the arcs which they subtend are equal (6. 3.) Again, the triangles MGA and BGC are similar (6.4) for the vertical angles MGA and BGC are equal, and the sides about the equal angles are proportional (24.4) ∴ MAG=MGA=CGB; but (2cor. 4.3) the angles at V are right angles as well as HCF (8.3) ∴ HC and MB are parallel (4.2) and CGB=CAM=ACH, consequently in the triangles ACM AHC, the side AC is common, <CAM=ACH, and CMA=AHC, they are therefore equilateral (7.2), ∴ HC=MA and the arcs which they subtend are equal (3.3). Q. E. D.

This is a very ingenious solution, and we hope our correspondent will try his skill on the subsequent propositions.

COR. I. by Zero. CD is perpendicular to HF.

II. The arc MH=CB. For AH=HB and AM=HC

III. The <ACH=half the supplement of the vertical angle ACB.

IV. If R be the centre of the circumscribing circle; then the angle CZB=CRB. For ZA=ZB, ∴ CZB=2ZAB (6.2)=CRB (5.3). Hence a circle will pass through the points C, Z, R, B, (cor. 6.3).

Quest. XLIX. A person rows from A to B 10 miles and back again from B to A in five hours, the tide flowing uniformly in the same direction the whole time; and he finds that he can row 8 miles with the tide in the same time that he can row 3 miles against it. Required the velocity of the tide supposing it to communicate or destroy a velocity equal to its own?

Quest. L. by Zero. The whole surface of a right cylinder is six times the area of the base. Required the ratio of the altitude to the diameter of the base.

Quest. LI. by Zero. Four agents A, B, C and D can jointly produce a given effect in 10 hours. A's agency alone would produce it in 26 hours, but with the assistance of E the difficulty can be surmounted in the same time that it would take B, C and D together; B can accomplish the same object as soon as C and D united, and A and D in the same time as B and E: How long will it take for their joint and separate production of this effect?

Quest LII. Prop. 7. The rectangle ED, EH is equal to the sum of the sides, OC.

We had prepared the above when we received a communication from Obadiah Gandershank containing solution to questions 38 and 39. They are concisely and perspicuously demonstrated and shall appear in our next.

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Continuation of our article on SOUND.

Let us now examine how the air is modified in different parts of the wave; and, for this purpose, let us imagine planes parallel to the piston, which divide the column of air into lamina, or thin slices, such as *abcd*, *cdef*, &c. having all the same thickness; it is probable that in each lamina all the molecules of air from the axis to the centre of the tube, undergo the same modifications, for all are similarly circumstanced. Therefore, to understand what has happened to the whole mass of air which composes the wave, it is sufficient to know what has happened to a molecule of each lamina. Now since the air which was included within Pp and *AA* has been compressed in its totality, and reduced so as to occupy only the space Ss*AA*, it necessarily follows that the molecules in each lamina have experienced two effects; 1st, they have become compressed; 2d, they have received a certain *impulsive* celerity, i. e. a celerity which removes them from the centre of the shock or of the piston which moved them.

It is evident that, in the whole length of the wave, the different laminæ cannot be in the same state: the last lamina, for example, that which touches *AA*, has only received a very small velocity and a very slight compression, because the motion has only just reached there; the first lamina, that which touched Ss, has already regained its state of rest, since we are considering the phenomena at the instant in which the piston was stopped; and as the lamina has no longer any velocity, it has for that reason no compression; it has already communicated all it possessed. On the contrary, the laminæ which are towards the middle of the wave have at the same time the greatest compression and the most celerity. There is therefore a certain order in the various modifications of the different laminæ, both as respects the velocity of the molecules of the air and their compression. This order depends on the increasing and decreasing velocities through which the piston passed in being transferred from Pp to Ss.

We can represent, by a figure which addresses the eye, all the motions which characterize a wave from its origin to its termination; for this purpose, it is sufficient to erect on the line SA, which expresses its length, perpendiculars which represent the degree of compression of the corresponding laminæ; the extremities of these perpendiculars will form a line whose curvature or sinuosities will accurately represent the order in which the compressions of the successive laminæ succeed one another. At S the height of the perpendicular will be nothing because the compression is nothing, it will be the same at A; at X the height of the perpendicular will be for example, X*X*, at Y it will be Y*Y*, at M it will be M*M*, &c. so that the curve of compressions S*MA* might be a semi-circumference of a circle. But we perceive that, on this length SA, we can trace a multitude of continuous curves passing through the points S and A, and even one of these curves being given, we can always give the piston such a motion in its passage from Pp to Ss that it may excite a wave whose successive compressions should be represented by this curve. When there are many sinuosities in the curve of compressions we say that the corresponding undulation is an *indented wave*.

After having analysed the various modifications which the piston may impress on the column of air whilst passing from Pp to Ss in the interval of one second, we may endeavor to ascertain what will take place in the succeeding intervals, the piston always continuing to stop at Ss. The air momently compressed from Ss to *AA* cannot remain in this state; for the tube being open at T, it follows that after a certain time, the excess of air must egress, and the whole column return to a state of rest. Now, it is demonstrated, in mechanics, that compression and velocity are communicated successively in the following manner: in the first instant of the second *second* the velocity passes to the right of *AA*, invades a first lamina, and at the same time the lamina which touches the piston returns to a state of rest; in the second instant a second lamina on the right of *AA* is invaded, and a second lamina in front of the piston sinks to a state of rest; in the third instant the motion reaches the 3d lamina in front of *AA*, and a state of rest reaches the third lamina in advance of the piston, &c; so that at the end of the second *second*, the air is in a state of rest from S to A, and is in a state of agitation from A to B; the length AB is equal to SA, and moreover the compressions and velocities from A to B are exactly what they were from S to A. Thus, the undulation advances and is conveyed, in some measure uniformly, by preserving its length and all its characters, at the end of the third *second* it would be at BC; at the end of the fourth, at CD, &c.

The wave which we have just described, in which all its laminæ are *compressed* and all the velocities *impulsive* is called a *condensed wave*, or sometimes *condensing wave*.

But it is easy to see that the inverse phenomena are developing at the left of the piston Pp when it is transferred to Ss. In fact, a greater space has been presented to the column of air, the first lamina rushes after the piston by *being rarified*, the second rushes after the first and takes its place, &c. &c; and after the first *second*, when the piston stops at Ss the rarefaction is perceived as far as *a*. The wave which results from it is called a *rarified wave*, or rather *rarifying wave*; its length is exactly the same as that of the condensed wave which is produced before the piston, the rarefactions are nothing at Ss and at *aa*, and, in all the laminæ, the velocities are *appulsive*, i. e. directed towards the centre of the shock.

The rarified wave is also propagated, successively through the whole extent of the column of air, preserving every where the same length and the same succession of velocities and rarefactions.

These considerations show us, now, the principles on which the phenomenon of hearing rests, for if we imagine