

*Extract from the:*

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*[From the London Mechanics' Magazine.]*

## *The Undulating Railway—Mr. Badnall in Explanation.*

**D**ear Sir: Your readers might naturally expect that I should have taken a much earlier opportunity, either of publishing the particulars of those experiments to which I so urgently invited their attention some time ago, or that I should have given some satisfactory explanation of my motive for withholding them. I am not, however, without a hope that this letter will prove a sufficient vindication of my conduct against any charge of neglect or wilful delay.

In my letter of the 20th August last (1834,) I stated that the Whiston Branch Railway was completed, but that our experiments were unavoidably delayed by the refusal of the Directors of the Liverpool and Manchester Railway to accommodate us by the loan of a suitable locomotive engine. At the same time, I intimated that, under such circumstances, I had no other resource than to endeavor to obtain an engine elsewhere, either on loan or hire.

With this view I made every necessary inquiry; but the only engine which I could hear of as being disengaged was the Manchester, which was built by Messrs. Galloway, Bowman and Glasgow; and though capable of dragging a considerable load, she was, from her particular construction, by no means adapted to the safe attainment of that velocity which could alone determine, on the Whiston line, the comparative superiority of an undulating or horizontal railway. I say upon the Whiston line, because the dip of the undulation was greater than I should ever recommend in practice; which may be judged of from the fact, that a loaded waggon, descending from the colliery by gravity alone, attained, after traversing about 500 yards, a velocity of upwards of 30 miles per hour.

Perceiving, however, that I had little, if any other, chance of trying immediate experiments, I consulted my partner, Mr. R. Stephenson, sen., on the subject, who, from being well acquainted with the capabilities of the engine, strongly objected to her being employed for the purpose in question, it being his opinion that, although a very powerful engine, when in good repair, the Manchester could not be trusted at those velocities which, upon the Whiston undulation, it would be necessary to attain. Mr. George Stephenson was also of a similar opinion.

Thus situated, I resolved on making a second application to the Directors of the Liverpool and Manchester Railway, offering, at the same time, a guarantee for payment of any damage which the engine might sustain, and explaining the difficulty

in which I was placed, by having publicly announced the trial of my experiments; which announcement I was induced to make in consequence of a verbal communication which I previously had with Mr. Booth, and from which I had formed, it appears, erroneously, an opinion that, if a *guarantee were* given, there would be no longer an objection to the loan of an engine being granted me. To this second application I received the following reply :

*Railroad Office, Oct. 13, 1834.*

*"Dear Sir: I submitted to the Board your renewed application for the loan of a locomotive engine, for your proposed experiments on the Whiston Branch Railway, and am required to inform you that the Directors regret they cannot comply with your request. They gave the matter due consideration previous to their former decision, and they do not see reason to alter the determination they then came to. I am, dear Sir, yours most obediently,*

*H. T. BOOTH.*

Under these circumstances, and finding how impossible it was for me to obtain a suitable engine, and feeling how deeply I had committed myself in your pages, by a declaration that the period was arrived when the whole question should be determined without further delay, I was resolved to adopt the only means which were left me of even partially fulfilling my pledge to the public. On the 21st October, I therefore called on Messrs. Galloway and Co., and solicited the loan of the Manchester engine for a few experiments, under the promise that the maximum velocity attained should not exceed from 20 to 25 miles per hour. With a liberality for which I feel greatly indebted, Messrs. G. and Co. granted my request, merely requiring a guarantee that I would return it in as good condition as I received it. On examining the state of the engine, it was found that the pistons required repacking; but as we could not expect to come to any very decided result, (the velocity being limited,) it was thought unnecessary to make any alteration for a first trial. On the 24th October, Mr. Robert Stephenson, sen., and Mr. Gill, accompanied me, therefore, to Whiston; and the Railway Directors having accommodated us with empty waggons, we proceeded, after loading them with coal, to the trial of such experiments as we deemed compatible with safety, and likely to produce some data, whereon an opinion, pro. or con. could be formed.

It is necessary that I should here state, that the Whiston branch line was completed by Mr. McKenzie, under contract. That gentleman had previously given me a section, and although, upon that section, the summit levels were, no doubt, accurately defined, no intermediate levels had been denoted, either on the section or by stakes, on the ground itself; our only course, therefore, was to start from such parts of the descending line from the colliery, as would prevent our attaining a dangerous velocity, and to ascertain how far the train would rise on the opposite ascent; marking the starting and resting points, until future levels could be taken. Had the inclinations been regular, this precaution would have been unnecessary, as the measurement of the distances would, in such case, have determined the elevations. But the Whiston line forming one extensive undulation, varying according to the surface of the land, no criterion could be formed from such calculation.

An accident, which some time ago occurred to the Manchester engine, which left the rails, when descending the Sutton inclined plane, had unfortunately given her the character of an unsafe engine at high velocities; and it was evident that, on the present occasion, both the engineer and fireman were afraid of her. We, however,

made eight experiments; Mr. Stephenson, myself, or Mr. Gill, accompanying the engine-man on each occasion. Our load was 80 tons ; which, considering the condition of the engine, was an ample one, as she was proved to be only capable of drawing on that day about 15 tons up an inclination of 1 in 84, her steam being at from 40 to 50 lbs. on the inch pressure, though partially escaping between the piston and cylinder.

By these experiments, we were enabled to prove one very satisfactory circumstance— which was, that, notwithstanding the many disadvantages under which we labored, the train invariably rose to a higher summit than that from which she had previously started. For instance, in the first experiment, the train started from a given point, which was carefully denoted, and rose to a higher point on the opposite ascent, which was also denoted ; the total distance being 760 yards—time, 2' 35". The power then being reversed, the train rose 34 yards higher than it had originally started from; again being reversed, the train rose 64 yards higher than on the first experiment; total distance 862  $\frac{1}{4}$  yards, time 2' 26". The power being again reversed, the train rose 38 yards higher than before—total distance 900 yards; when again reversed, the train rose 171 yards higher than before—total distance 1071 yards; and on the next occasion the total distance was 1167 yards.

On the 7th trial, no accurate result could be deduced, as some of the brakes were on the waggon wheels.

On the 8th experiment, the steam was brought down to 10 lbs. upon the inch ; and I have every reason to believe, that when I am enabled to transmit to you a precise statement of the level from which it started and at which it rested, it will be found that the 80 tons were conveyed at that low pressure, very nearly, if not quite, from summit to summit.

Your readers will, I fear, be disappointed, and by no means satisfied with the rude statement which I now feel it imperative upon me to publish ; but until I have a better opportunity of deciding the full merits of the question, I can only put them in possession of facts as they really occurred— this I have done myself. In justice to myself, however, and to the cause which I have conscientiously advocated, and still continue to advocate, I ask them, what could I have done more? or what, under existing circumstances, can I do: All men of science must, I am persuaded, sympathise in my regret, that experiments of such a nature should be delayed, when such delay could be so easily avoided; and with regard to any chance of a satisfactory conclusion being come to, by employing the Manchester engine, I need only refer to Messrs. Galloway & Co. themselves, who, I am sure, will hear testimony to her being in every point of view unsuitable to the purpose. She is, as before observed, an engine capable of drawing heavy loads at moderate velocities, but her many moving parts and general construction, render her altogether unfit for the trial in question. It was my wish to have sent with this letter a correct section of the Whitson branch, with the exact distances denoted thereon, which the train traversed at our recent experiments; but severe indisposition, which has, since the end of October, with the exception of a few days, confined me to the house, has prevented my paying that attention to the subject which I should otherwise have done. Wishing, however, to have an impartial survey of the line made, I wrote to Mr. Hall, of Warrington, begging him to prepare the necessary sections, showing the various levels, &c.; but he has not yet been able to undertake it, owing to his time being entirely occupied in completing a survey of the Grand Junction line, to deposit for Parliament: when the section alluded to is completed, I will forward you a copy of it. As a proof of the unfitness of the Manchester engine, for the trial of experiments on

the Whiston line, I need only remark, that over a great portion of each undulation, her power was not only ineffectual, but she was almost an incumbrance, owing to the loaded waggons attaining, by gravity, a greater velocity than she could effectually command in advance of them. This will easily be understood by those who consider the difference in the friction of a railway waggon, and a locomotive engine of her description. It also shows, that upon deep undulations, such as the Whitson line (where we have a fall of more than 30 feet in 500 yards), none but engines capable of sustaining an excess of speed above that which is produced by gravity, can be employed with *u/i effect*. Such was my view when, in allusion to the Whitson line (see page 214, No. 516), I said, " *the full effect of practical experiment must depend upon the momentum acquired by the combined forces of gravity and steam being safely and effectually maintained down the descending line of each undulation.*" For the same reason, also, I have before mentioned that, for general practical purposes, a dip of about 15 feet in a curve of 1,000 to 1,200 yards, would be the proportion I should most strongly recommend: though exceptions might, of course, be advantageously made, where the nature of the ground required it—especially in passing under or over cross-roads, canals, &c., or where the inclined planes would not be so deep or so extensive as to produce a dangerous velocity without the employment of the brakes—considering, as I do, that velocity on railways is always dangerous when the engine (her full power being employed) is not able to keep up a dragging influence on the succeeding carriages, or, if behind the train, a propelling influence on the carriages in advance.

So convinced did I feel that no further impediment would be thrown in the way of a full and impartial trial of the undulating railway theory at Whiston, that at the meeting of the British Association at Edinburgh, in September last, I as publicly announced my intention of immediately bringing the question to issue, as I had previously done in your pages. I hope, therefore, I shall not be accused of any disrespect to your readers, to yourself, or to the public at large, for a breach of engagement which it has been entirely out of my power, for the present, to obviate. I am, Sir,

Yours most respectfully,

RICH. BADNALL.

Farm-hill, near Douglas, Isle-of-Man,  
Dec. 31, 1834.