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TASMANIA.

HOUSE OF ASSEMBLY.

MAIN LINE RAILWAY.

MR. S. V. KEMP'S REPORT.

Laid upon the Table by the Attorney-General, and ordered by the House to be printed, September 3, 1874.

Launceston, May, 1870.

Sir,

In accordance with your verbal instructions, I have the honor to submit for the consideration of the Government the following Report upon Messrs. Doyne, Major, & Willett's estimate for a Line of Railway between Hobart Town and Launceston; and in doing so, I will premise by stating, that I have carefully examined the plans, sections, report, and estimated cost furnished by that engineering firm to the Government.

With reference to the route selected, I think it my duty to inform you that I know nothing of the most difficult part of the country between Brighton and Ross, and my knowledge of the other portions is only what I have seen from the coach while travelling between Launceston and Hobart Town; therefore, I am not in a position to state whether in my opinion the best and most economical route has been selected.

I consider the time allowed Messrs. Doyne, Major, & Willett to survey and report upon the Main Line insufficient for them to determine the best and shortest route between Hobart Town and Launceston; and, judging from their plans and sections, I am impressed with the idea that the portion of the Line from Brighton to Ross is a very difficult country to decide upon, and would require much patient study and examination before deciding which route will afford the best curves and gradients, and ensure the smallest amount of works. I venture in the most respectful manner to surmise, from the wording of Messrs. Doyne, Major, & Willett's Report, that they are not exactly satisfied themselves that the best route has been determined upon between the points alluded to. In which case, should there be any doubt, I would urge upon the Government the necessity of having a careful and detailed examination of that portion of the country, to determine the best mode of overcoming the apparent difficulties before committing the country to the route proposed.

Respecting the estimate furnished by Messrs. Doyne, Major, & Willett, in which they state that the Main Line of Railway, upon the 5 feet 3 inch gauge, can be constructed for £850,000, which gives an average cost per mile of say £6700, without any allowance for land, severance, and law charges; upon this point I will premise by stating that not being furnished with the quantities or the basis of the data upon which their estimate is founded, I am not in a position to point out the great discrepancy between the amount of our respective estimates. But I have after considerable labour, without any assistance, taken out approximate quantities from the plans and sections made by them and furnished to me by you, and have after a careful consideration arrived at a very different result from that presented to the Government by them. I estimate that the cost of constructing the Main Line of Railway upon the 5 feet 3 inch gauge as surveyed by them will be one million one hundred and fifty-nine thousand four hundred and fifty-five pounds (£1,159,455), which has been arrived at upon the following details:—

DETAILED Estimate of the Cost of constructing a Line of Railway upon the 5 ft. 3 in. Gauge from Hobart Town to Longford, as surveyed by Messrs. Doyne, Major, & Willett: such Estimate is made from the Plans and Sections presented last Session to the Parliament of Tasmania by that Firm.

Description of Work.	*Rate.*	*Amount.*	TOTAL.
Lands.	£	£	£
To purchase of lands, including severance, compensation, and law charges, 127 miles, 8 acres to the mile = 1016 acres, at	30	30,480	30,480
The Land of the Launceston and Western Railway will cost about £40 per acre.			
Fencing.			
Length of Line, 127 miles, 2 for both sides = 254 miles, at	60	15,240	15,240
The Fencing on the Launceston and Western Railway is scheduled at £238 per mile.			

The Hon. the Colonial Secretary, Hobart Town.

Description of Work.	*Rate.*	*Amount.*	TOTAL.
	£	£	£
Clearing and Grubbing the Line between the Fences. Say half the whole length = 64 miles, at	50	3200	3200
Earthwork. Total quantity about 2,700,000 cube yards, divided into side cutting, rock ditto, sandstone ditto, and earth ditto, estimated at 1*s.* 4*d.*, 3*s.* 6*d.*, 2*s.*, and 1*s.* 7*d.* per cube yard respectively, (£2126 per mile)	Average 2*s.* per cube yard	270,000	270,000
The Earthwork on the Launceston and Western Railway will cost about £1450 per mile.			
Draining. Including ditches on each side of the Line varying from 1′ 6″ deep to 3′ deep; also drains at foot of slopes in cuttings.			
Length of Line, 127 miles, at	100	12,700	12,700
The side drains on the Launceston and Western Railway are scheduled at £113 per mile.			
Culverts. There are about 270 culverts shown upon the Sections without any description or size being given. I have estimated that they will vary from 12 inches up to 10 feet, and will cost altogether about £200 per mile.			
Length of Line, 127 miles, at	200	25,400	25,400
The culverts on the Launceston and Western Railway will cost about £215 per mile.			
Bridges. The Sections shew about 5000 lineal feet of timber bridges at various points along the Line, at	5	25,000	
I have also added extra for crossing the Derwent at Bridgewater	(Say)	22,500	
The Sections also shew about 100 lineal feet of stone or brick bridges at various places, at	25	2500	
This amount gives an average of £393 per mile. The cost of timber bridges is £128 per mile, and brick bridges is £428 per mile, on the Launceston and Western Railway.			50,000
Tunnelling. The Section shews about 1900 lineal yards of tunnelling, which I estimate will cost £70 per lineal yard, including excavation, lining with brick or stone where required, with inverts and facings at each end of the tunnel, 1900 lineal yards, at	70	133,000	133,000
Level Crossings. 10 Main Road crossings, each	150	1500	
38 Public ditto	140	5320	
50 Occupation ditto	30	1500	
Add for others not shewn	..	1680	
This will give an average cost per mile of nearly £80.			10,000
The gates on the Launceston and Western Railway will cost about £165 per mile.			
Road Diversions. The Sections and Plans shew numerous road diversions. I have estimated their cost at £60 per mile = 127 miles, at	60	7620	7620
The cost of the road diversions on the Launceston and Western Railway will be £42 per mile.			
Soiling and Sowing Slopes of all embankments, 127 miles, at	90	11,430	11,430
The soiling and sowing of embankments on the Launceston and Western Railway will cost £93 per mile.			
Ballasting. I have estimated 3680 cube yards of ballast to the mile at 5*s.* per cube yard = £920 per mile, multiplied by 127 =	..	116,840	
Add 7½ per cent. for sidings, &c., say 9½ miles, at	920	8740	
The cost of the ballast on the Launceston and Western Railway will average £1106 per mile, without allowance for sidings.			125,580
NOTE.—I consider the quantity of ballast used on the Launceston and Western Railway excessive, and not required for the traffic that will pass over that Line.			
Sleepers. 1760 sleepers to the mile, at 4*s.* 6*d.* = 396, say £400 : 127 miles at	400	50,800	
Add 7½ per cent. for sidings, say 9½ miles, at	400	3800	
This will give an average cost per mile of £430. The sleepers on the Launceston and Western Railway will cost about £416 per mile.			54,600

Description of Work.	*Rate.*	*Amount.*	TOTAL.
Labour laying Permanent Way.	£	£	£
All labour laying permanent way, including points and crossings, and all carriage of materials, say £200 per mile, 127 miles......	..	25,400	
Add 9½ miles sidings	200	1900	
The cost of laying the permanent way on the Launceston and Western Railway will be £226 per mile.			27,300
Rails.			
A 70 lbs. rail is proposed on the inclines and a 60 lbs. rail on the other portions of the Line. I have therefore adopted the weight per mile at 65 lbs. 127 miles, at	1270	161,290	
Add 9½ miles sidings	..	12,065	
The weight of rail in use on the Launceston and Western Railway is 72 lbs. to the lineal yard, and cost per mile £1306, with fastenings.			173,355
Rolling Stock.			
I have estimated that £700 per mile will be required for this purpose. Length of Line, 127 miles, at	700	88,900	88,900
Stations.			
I estimate the stations, workshops, tools, gatekeepers' houses, furniture, offices, gas, watering stations for locomotives, approach roads, semaphores, lamps, tarpaulins, clocks and watches, points and crossings, and a number of other matters too numerous to mention, will cost £750 per mile. 127 miles at................	750	95,250	95,250
Engineering.			
I estimate the engineering and supervision at £200 per mile. 127 miles at	200	25,400	25,400
The engineering of the Launceston and Western Railway cost £400 per mile.			
GRAND TOTAL	..	..	£1,159,455

This Grand Total of £1,159,455 will give an average cost of £9129 per mile, without allowing any item for contingencies.

NOTE.—This estimate is based upon the assumption that the works are to be carried out nearly in the same mode, and to be of the same description, as those of the Launceston and Western Railway: if anything, I have, in several instances, given a shade under the cost of such works, as the details will show; in others, a little higher.

In presenting the Government with the details I beg to say, that I have such confidence in their general correctness, that I am willing that they shall be submitted, together with Messrs. Doyne, Major, & Willett's plans and sections, to either Mr. T. Higinbotham, Engineer-in-Chief of Victoria, or Mr. Whitton, Engineer-in-Chief of Railways of New South Wales, or both if thought desirable.

Reference has been made to the cost of the Launceston and Western Railway; which undertaking, I beg to say, will cost £10,000 per mile when completed.

The length of the Line, according to Messrs. Doyne, Major, & Willett's sections, will be—

	Miles.	*chains.*	*links.*
From Hobart Town to Longford..........................	127	10	39
From Longford to Launceston..........................	18	48	38
Total	145	58	77
The length of the road from Hobart Town to Launceston....	120	0	0
Additional distances by Railway	25	58	77

The comparatively light appearance of the works, viewed from the longitudinal section, arises from the fact of their being drawn upon the small scale of 6 chains to the inch horizontal, and 60 feet to the inch vertical.

The works would appear very considerably heavier had they been plotted to what is termed a working section scale; viz.—2 chains to the inch horizontal, and 20 feet to the inch vertical.

In accordance with your further instructions, I have the honor to lay before you the difference of cost between a line of Railway constructed upon the 5 feet 3 gauge, 4 feet 8½ gauge, and 3 feet 6 gauge, based upon the assumption that the description of works of each gauge are similar in character to the works of the Launceston and Western Railway, and by using the same sections, rates, and prices for each description of gauge I arrive at the following results:—

5 feet 3 in. gauge will cost per mile £9129 or £1,159,455 for the whole length of the Line from Hobart Town to the Junction at Longford as shown upon the plans, without any charges for interest upon Debentures during construction.

4 feet 8½ in. gauge will cost per mile £8578 or £1,089,419 for the whole length of the Line from Hobart Town to the Junction at Longford as shown upon the plans, without any charges for interest upon Debentures during construction.

3 feet 6 in. gauge will cost per mile £6483 or £823,394 for the whole length of the Line from Hobart Town to the Junction at Longford as shown upon the plans, without any charges for interest upon Debentures during construction.

The items of cost principally affected between the 5 feet 3 in. and 4 feet 8½ in. gauges in favor of the latter are the rolling stock, sleepers, ballast, land, earthworks, culverts, bridges, and tunnelling; all the other items in the estimate remain unaffected by the substitution of gauges: whereas, by adopting the 3 feet 6 in. gauge nearly all the items in the estimate are affected in favor of such gauge; independent of which, by adopting this gauge the Line is capable of being shortened considerably by using sharper curves, which would materially affect the cost per mile.

Should the Government be disposed to adopt a cheaper description of Railway, I have no hesitation in stating that a cheaper Line can be made by following the surface of the country to be traversed as closely as possible, thereby causing steeper inclines and sharper curves, and by taking only just sufficient land to meet present requirements. Using a lighter and cheaper description of fencing. By making the cuttings and embankments to the narrowest limits, curtailing the drainage, using open log culverts, making all the bridges of timber of the cheapest designs, lining the tunnels (if any) in the cheapest manner, dispensing with such lining and inverts where practicable, doing away with the level crossing gates, and substituting water ditches on each side of roadway instead. Making the cheapest kind of road diversions. Doing away with the soiling and sowing of slopes of embankments. Using a lesser quantity of ballast. Splitting the sleepers instead of sawing them. Doing away with the bolting of the sleepers. Using a lighter section of rail. Making the rolling stock of the lightest and plainest description, and by curtailing the station and platform accommodation to the barest limits. By doing all this I believe a Line of Railway could be made from Hobart Town to Launceston at the following rates per mile:—

5 feet 3 inch gauge, per mile £6000, or for a bulk sum of £762,000 for the whole length of the Line from Hobart Town to the Junction at Longford, as shown upon the plans, without any charges for interest upon debentures during construction.

4 feet 8½ inch gauge, per mile £5600, or for a bulk sum of £711,200 for the whole length of the Line from Hobart Town to the Junction at Longford, as shown upon the plans, without any charges for interest upon debentures during construction.

3 feet 6 inch gauge, per mile £4200, or for a bulk sum of £533,400 for the whole length of the Line between Hobart Town and the Junction at Longford, as shown upon the plans, without any charges for interest upon debentures during construction.

Of course it must be obvious that, by constructing a Line of Railway upon these figures, the cost of maintenance would be considerably increased, and the renewals would more speedily follow.

I beg to remind you that I have all the particulars showing how the costs of the respective gauges have been arrived at, but fearing by inserting all the data it would have the effect of confusing this Report, it has been withheld from it, but can be supplied at any time should you deem it desirable.

With reference to the 5 feet 3 inch gauge, I think Messrs. Doyne, Major, and Willett have asserted in their Report to the Government all that can be said in its favour, and with your permission I will repeat it:—

"As the gauge of the Western Railway is now a settled question, and its working must dovetail into that of the Main Line, there is an additional and a very strong reason for adopting the same gauge, 5 feet 3 inches. In England the break of gauge between the 7 feet and the 4 feet 8½ inches has proved to be so great an evil, necessitating the transfer of passengers and goods wherever the gauges meet, or the expensive and complicated contrivance of a third rail to enable both classes of rolling stock to pass over the same line, that, although the latter is by no means the approved gauge in the present day, being too narrow for the working parts of the engine, the absolute necessity of having a uniformity of gauge on all Main Lines that are, or may become connected, is universally accepted, and the broad gauge is being gradually removed, and replaced by the others, which is the ruling gauge of the country.

The experience of England on all these points has led to the adoption of an intermediate gauge, by which the excessive weight of rolling stock, and the consequent increased wear and tear on the 7 feet gauge, is avoided, while more space for the working parts of the engine is given than the 4 feet 8½ inches affords. These intermediate gauges are 5 feet 3 inches, and 5 feet 6 inches. They are almost universally used in countries which are not already committed by extensive Railways to another gauge: Ireland, India, Victoria, and New Zealand have adopted one or other of them, not as a matter of necessity to avoid break of gauge, but as that which experience has proved to be on the whole the best. When Mr. Whitton, the present Engineer-in-Chief of the New South Wales Government, took charge of the Railways in that Colony, he found that several miles had been made with the 4 feet 8½ inches gauge, and he recommended that they be altered to 5 feet 3 inches as a better gauge, and to avoid the break with the Victorian gauge where the two Lines should meet. Financial considerations, however, decided his Government not to adopt the suggestion, and the inconvenience will be duly felt when the now rapidly converging lines are joined.

A review of all the considerations here set forth induces us to advise strongly that the gauge of the Main Line shall be 5 feet 3 inches; the weight of the rails 60 lbs. per yard for the lighter sections, and 70 lbs. for the heavier; and the character of the rolling stock generally similar to that of the Western Railway, subject, of course, to any improvements which may be satisfactorily established in the meantime."

In submitting the 4 feet 8½ inch gauge for your consideration, it must always be borne in mind that this gauge has been adopted almost universally throughout England and Europe for *Main Lines*, and has been thoroughly tested, and has met all commercial requisites for convenience, speed, and economy, and safety, for considerably over thirty years; and it is a question if these countries had to inaugurate a railway system, whether they would adopt any other than the 4 feet 8½ inch gauge for *Main Lines*, notwithstanding all that has been said in favour of the 5 feet 3 inch gauge.

The projected Line between Hobart Town and Launceston, if carried out, will always be the main artery of communication through the Island, and into which Line numerous feeders and new sources of traffic will eventually flow; it is therefore chargeable on us to construct such a Line that will meet all present requirements and future emergencies incidental to a large influx of population consequent upon the discovery of new gold-fields or the development of existing ones: independent of which we must not lose sight of the Colonial Defence question, which must of necessity claim our attention ere long; and no system of defence would be acceptable without the means of rapid transit across the Island.

To illustrate the capabilities of a 4 feet 8½ inch gauge Railway, I beg to refer you to the Reports of the London and North Western Railway in England for 30th June and 31st December last:—"28,770,185 passengers were conveyed during the year; 17,009,931 tons of goods were carried; 23,279,660 miles were run by trains; £6,604,842 of revenue was obtained; and 1477 miles of railway were worked."

I believe that this enormous amount of work is performed annually at a less cost per mile for working expenses than any of the 5 feet 3 inch or 5 feet 6 inch gauges.

With reference to the 3 feet 6 inch gauge, I beg to intimate to you that there are so many conflicting opinions both for and against this gauge, that I am somewhat embarrassed in my attempt to put the matter clearly before you. The evidence I have collected from Engineers of good standing, whose arguments all tend to one conclusion, state that where cheap Railways are required in thinly populated countries, it is the best and most economical description of gauge to adopt.

I gained considerable knowledge of this gauge during my visit to Queensland, and I most unhesitatingly assert that I consider, with the engineering difficulties peculiar to that country, that they have adopted a wise course by using such a gauge. This Line was commenced when skilled labour was scarce, and, before they were in possession of data to enable them to judge of the best and most economical route, consequently many unforeseen blunders were committed which have had the effect of increasing the cost per mile of their lines.

With your permission I will quote a letter written by Mr. J. E. Boyd, a Civil Engineer of some repute in Canada, which he wrote to the President and Directors of the Toronto, Grey and Bruce, and Toronto and Nipissing Railway Companies on the 19th July, 1867:—

GENTLEMEN, *Saint John's, N.B., 19th July*, 1867.

"I have the honor to submit the following information on the Light Railway System of 3 feet 6 inches gauge:—

The chief points in question are the cost of construction, the cost of maintenance, and the working expenses, the traffic capacity, the speed attainable, and the safety of these narrow gauge lines as compared with the ordinary lines of 5 feet 6 inches.

It is claimed that a line of 3 feet 6 inches gauge can be built for one half the cost of a 5 feet 6 inches line, constructed in the usual way, and in some districts possibly for less. It may seem strange that the mere reduction of two feet in the gauge can exert so important an influence over the cost of a Railway, but it is nevertheless true, and it is believed that any statements here made will bear the fullest investigation.

It will not be disputed that the resistance due to curves and imperfections in the track decreases as the width between the rails is reduced. The greater portion of curve resistance is due to the sliding motion produced by the difference in the space to be passed over by two wheels of equal diameter keyed fast to opposite ends of an axle common to both. Inequalities in the surface give the wheels a tendency to bind diagonally across the track. It can easily be understood, therefore, that both these resistances diminish with the length of the axle—or what is the same thing, the width of the gauge. It is by taking advantage of this ability which the narrow-gauge lines possess, of adapting themselves to the natural surface of the country by sharper or more frequent curves without the result of a corresponding loss of power from increased resistance, that a great part of the saving in earthwork is effected. The remainder is due to the decreased width of the cuttings and embankments. The saving in earthwork naturally leads to a saving in masonry; if the embankments are narrower and lower, the culverts are shorter, and the bridge abutments of less height and width. As the engines and trains are lighter, the bridge superstructure is much less costly. The comparative cost of one mile of permanent way on the two gauges is as follows:—

Five feet six inch Line.

	Dollars.
100 tons rails, at 50 dollars per ton	5000
Fish-plates, bolts, and spikes	800
Sleepers, 2263	700
Ballast, 3000 cubic yards	1200
Tracklaying	400
	8100 dollars.

NOTE.—This represents in English money a sum equal to £1800.

Three feet six inch Line.

	Dollars.
60 tons rails, at 50 dollars per ton	3000
Fish plates, bolts, and spikes	400
Sleepers, 2263	500
Ballast, 2250 cubic yards	900
Tracklaying	300
	5100 dollars.

NOTE.—This represents in English money a sum equal to £1133 6*s.* 8*d.*"

"In Queensland, 200 miles of 3 feet 6 inch Lines are now being worked, and some 250 miles more are in progress. Mr. Fitzgibbon, the Chief Engineer to the Government says, in his Report:—

"It was found, on a calculation of the quantities of work, that the cost of the Line with 4 feet 8½ inch gauge would exceed that of the 3 feet 6 inch gauge by more than threefold."

"This is, it is true, an extreme case, because the country was exceedingly difficult: but, on the other hand, it must be remembered that the comparison is between the 3 feet 6 inch gauge and the 4 feet 8½ inch, not the 5 feet 6 inch. Major Adelskold, Swedish Royal Engineers, who has constructed several of these Railways, says:—

"Their principal advantage is their original cost, which is so considerably below that of the broader (4 feet 8½ inch) gauge both here and in Norway."

"The Editor of *The Engineer*, commenting on his Report, says:—

"We are indebted to Major Adelskold for his valuable information on the Swedish Railway system, and agree with his views of the economical advantages of the narrow gauge system. After the experience gained, we think it may be safely stated that the cost of a Railway diminishes in proportion with the gauge."

"M. Carl Pihl, Chief Engineer of the Norwegian Government Railway, says:—

"The formation width for the Line of 4 feet 8½ inch gauge is generally from 15 feet to 18 feet, say 16½ feet on an average; and for the 3 feet 6 inch gauge, it is here 12 feet 6 inches.

The average height of the bank and cuttings on the narrower gauge is less than on the broad, owing to the greater facility of adoption to the country. With us the height is 10 feet, whereas had the broader gauge been adopted it would have been 12 feet to 14 feet, say 13 feet. This would make the proportion of quantities nearly as 4 to 7."

"Sir Charles Fox and Son, speaking of such a Line in this country, says:—

"We have appended an estimate of the cost, in which we believe we have fully provided for contingencies, and which amounts to £3000 per mile."

"Mr. Frank Shanly estimates the cost of a light 5 feet 6 inch Line on your route, fully equipped and including right of way and fencing, at 15,400 dollars (£3465) per mile; but he says elsewhere that the first cost of such a Line would exceed that of a 3 feet 6 inch Line by from 5 to 10 per cent.: the deduction of 5 per cent. (Sir Charles Fox estimates the difference at 30 per cent.) would make the cost 14,630 dollars (£2291 15*s.*) per mile. Mr. Shanly's professional standing and his knowledge of the district prevent any doubts as to the reliability of this estimate; and I must, therefore, be safe in estimating the probable cost of your Railway at 15,000 dollars (£3375) per mile.

"I wish particularly to impress upon you that none of the advocates of the light narrow gauge Railways proposes to arrive at this saving in first cost by inferior construction or the use of inferior materials, and I would be the last to advise such false economy. The object is to construct Lines which, though their first cost be low, will not be expensive to work and maintain. And in order to meet these two important requirements, it is necessary that the materials and workmanship should be of the very best description, and properly proportioned to the services they have to perform.

"Of the Queensland Lines, Mr. Fitzgibbon says:—

"As regards the quality and durability of the works, of the rolling stock, and the equipment of the Line, nothing is left to be desired. And again: the construction of the road, and the various appliances employed, are, in all respects, equal to any railway in the world (excepting only that they are limited in power to the wants of the case)."

"Sir Charles Fox & Son, the consulting Engineers of the Queensland Government, say:—

"The principle adopted on these Lines is to make them in the very best manner, and to spare no necessary expense to ensure materials and workmanship of first-class quality. The rolling stock is of the very best description, and the passenger carriages quite equal for comfort to the best in this country."

"Mr. Charles Douglas Fox says of the Norwegian Lines, of which he made a thorough examination:—

"I would again testify to the excellent condition of all the works on the Lines; the permanent way, some of which has stood the test of two Norwegian winters, is, without exception, the smoothest road I have been on."

"The cost of maintenance of the narrow gauge must be less than that of the broad, if only for the reason that the perishable parts are less expensive to replace.

"Major Adelskold says:—

"The working expenses have also been considerably lower, partly because the resistance on the curves with the same speed diminishes in proportion with the gauge; partly also because the dead weight of the carriages comparatively diminishes with the gauge; and, finally, because the light locomotives on a narrow gauge line do not wear out the rails so easily as a heavier engine on a broader gauge."

"Mr. Robert Mallet, Member Institution Civil Engineers, at the discussion of this question before the Institution, said:—"That in proportion as the gauge was reduced, both the first cost and working expenses will be diminished." My own impression is, that while the cost of repairs will be less per mile, the actual expense of moving a passenger or a ton of goods would be about the same per mile on either gauge; and this seems to be Sir Charles Fox's view when he says that these Railways "will, under proper management, be worked and maintained at least as low a per-centage as ordinary lines."

"Mr. Fitzgibbon estimates the capacity of the Queensland Railway at 400 tons of goods and 800 passengers per day of 12 hours, equal in all to about 146,067 tons per annum, and adds:—"By running night trains this estimate may be doubled, and by laying down a second line of rails it may be increased six-fold." Major Adelskold estimates the capacity of the Swedish lines at 100,000 passengers and 150,000 tons of goods, equal to about 158,333 tons per annum. In the first of these estimates allowance must be made for the steep gradients of 1 in 50, some of which are of great length, combined with sharp curves on the Queensland lines; and in the second, for the limited supply of rolling stock on which the estimate is based. Both these estimates are therefore within the mark, for Sir Charles Fox says the locomotives are capable of drawing with ease trains weighing 150 tons gross, equal to about 85 tons net, up gradients of 1 in 100, with curves of 330 feet radius, at a speed of 20 miles per hour; and assuming this as a basis, 6 trains per day would carry 160,000 tons per annum, and there would be no difficulty in having double that number of trains if necessary.

"Mr. F. Shanly's estimate of the probable traffic to be drawn from the district through which your Line will pass is 300 tons freight and 200 passengers per day, which would only require four trains. M. Pihl says of the Norwegian lines:—"Should that fortunate time arrive when the traffic has developed to such an extent that the Line as originally constructed proves iusufficient, then I believe that a double Line would naturally suggest itself as meeting the requirements of increased traffic every way better than a single Line of wide gauge. The cost of the addition would, based upon calculations made for the purpose, be rather more than 50 per cent. of the original cost of the Line proper, stations and rolling stock not included, and the total of the double Line would then cost about the same as the single 4 feet 8½ inch would originally have cost," and consequently less than a single 5 feet 6 inch Line would originally have cost.

"It is clear that with this facility of adding at any time to the capacity, it is bad policy to expend twice the amount required for present purposes merely to meet a want which may not be felt for thirty years, and is simply to expend in interest alone a large sum which would be much better employed in extending Railways into other districts. The traffic on the Government Railway of Nova Scotia has never exceeded 161,000 passengers and 70,500 tons goods per annum, and in New Brunswick 149,000 passengers and 55,500 tons goods, so that a Line of 3 feet 6 inches gauge would so far have accommodated all their traffic quite as well as the present 5 feet 6 inch Lines.

"The present tendency is everywhere towards a reduction rather than an increase in the gauge of Railways. The Great Western Railway Company of England have laid down a third rail to the 4 feet 8½ inch gauge on their 7 feet Line; and it is their intention, as the broad gauge rolling stock wears out, to replace it with that adapted to the narrow gauge.

"As the centre of gravity is lowered, and the engines and cars are constructed with an angle of stability which is nearly the same on either gauge, the absolute safety must be quite as great on the 3 feet 6 inch Lines as on the 4 feet 8½ inches or the 5 feet 6 inch Lines. The ordinary speed of express trains in Canada and the United States is from 25 to 30 miles per hour, including stoppages; and mixed and freight trains are not, or should not be, run faster than from 15 to 20 miles per hour.

"It is found from actual experience that the Queensland Railways already in operation are perfectly capable of conducting goods and passenger traffic at an average rate of from 20 to 30 miles per hour, including stoppages, with ease and safety :—

"On Swedish Lines the general speed for mixed trains is 16 miles per hour, but it has on several occasions been brought up to thirty to thirty-five miles when carriages and wagons moved with perfect steadiness."

"Mr. C. D. Fox, in his Report on the Norwegian Railways, says :—

"The train on which I was consisted of six carriages and a break van, and we ran with great ease and perfect steadiness at the rate of thirty-two miles per hour; the ordinary working speed does not, however, exceed 15 miles per hour, including stoppages.

The Line is kept in a most creditable state of repair, not surpassed by any English Railway, and my impression certainly is that the running of the trains is particularly free from any vibration."

"Speaking of another Line, he says :—

"The train with which I came consisted of six goods wagons full, one empty, one cattle wagon full, four passenger carriages nearly full, and the brake-van, or an aggregate gross load of 118 tons, which we ran with at sometimes thirty miles per hour with perfect ease. Nothing can exceed the steadiness of both engines and carriages."

"Mr. Pihl, in a letter to the Editor of *Engineering*, 7th of March, 1867, says :—

"The regular trains are run here at 14 miles an hour, including stoppages, or 16 to 20 miles between stations, the very same speed at which the mixed trains run on the 4 feet 8½ inch gauge here. As to the safety of fast running, engines and carriages appear to run as safely and steadily at 30 miles an hour on the 3 feet 6 inch gauge as they do on one of 4 feet 8½ inch; and I have run the very engine illustrated in your journal of 21st December last upwards of 40 miles an hour, with as much feeling of ease and security as I have felt when running any engine on a broader gauge."

"Sir Charles Fox says of the 3 feet 6 inch branch of the Madras Railway :—

"The Line has now been worked for some time most satisfactorily, the trains having on several occasions attained a speed of 40 miles an hour, and the working expenses being moderate."

"As the question of adopting a light system of broad gauge lines has been brought up, it may be well to say a few words on them.

"Mr. F. Shanley, while he recommends them, says, they will cost 5 to 10 per cent. more than the 3 feet 6 inch lines. Sir Charles Fox in his Report to the Madras Railway Company, makes the difference 30 per cent.

"Now the weight of rails is the same as on the 3 feet 6 inch lines, the weight of engines is the same, and consequently the adhesion available for traction is the same; and it necessarily follows that the engines cannot possibly draw any heavier load on the light 5 feet 6 inch line than on the 3 feet 6 inch line. Neither Sir Charles Fox nor Mr. Shanley claim that they will draw any more. Indeed, with the same curves and gradients they could not draw so much, because of the greater curve resistance on the broad gauge. Why then expend 30 per cent., which on a line 100 miles long would amount to 450,000 dollars (£101,250) or even 10 per cent., which would amount to 150,000 dollars (£33,750) more in construction, if you are to get no greater traffic capacity for it, especially as the main argument, the break of gauge, has no weight in the case of your proposed lines?

"I have preferred, instead of entering into arguments based on mere theory, to give the testimony of engineers who, having constructed and worked lines of 3 feet 6 inch gauge, can speak from actual experience of their success in other countries. All the gentlemen whose opinions I have quoted are of high professional standing, and hold positions of responsibility, and they would not express themselves so decidedly in favour of the light narrow gauge system unless they were fully satisfied of its advantages.

"I now beg to direct your attention to the following statements which I have prepared, showing the probable traffic which may be created by Railway communication, and the estimated cost of working such traffic; following which are statements showing the amount of Debenture capital that will be required to construct a Line of Railway upon each of the gauges. Likewise statements showing the profit and loss account occasioned by the adoption of the different gauges.

"In preparing these statements I desire to say that I have endeavoured to represent every detail in its proper light, and have not purposely omitted or concealed anything.

I have, &c.,

(Signed) JOHN E. BOYD, *C.E.*"

Having disposed of the description of gauges, I now beg to subjoin Statements showing the probable Revenue and Expenditure, also Statements showing the probable Profit and Loss Account which will be incurred by adopting each of the gauges :—

A.

STATEMENTS showing the estimated REVENUE *and* EXPENDITURE *that may reasonably be expected from and to Hobart Town and Launceston by Railway Communication.*

REVENUE ACCOUNT.

	£	s.	d.
Traffic Returns taken from Mr. Penny's Report, (See Parliamentary Report, No. 22)—			
Table F.—Passenger Traffic	38,629	15	5
Goods Traffic	9854	13	0
Wool Traffic	1390	6	0
Hawkers	362	18	0
It is customary in estimating traffic for a Railway to multiply the road returns by three; but I think I am justified in assuming the traffic will be doubled from the increase of population consequent upon the expenditure of the greater portion of the construction money, and the increased facilities afforded to the public for travelling, transmission of goods, &c.	38,629	15	5
	9854	13	0
Mail Service and Parcels	1500	0	0
Estimated cost of maintenance of Main Line Road, less tolls	1500	0	0
Saving in the transmission of Public Officers, Police, Prisoners, &c.	1000	0	0
	£102,722	0	10

I have not made any allowance for the new sources of traffic that will be created upon the opening of this Line, and the very many indirect advantages which will be derived from the same cause.

WORKING EXPENSES.

The distance from Hobart Town to Launceston, as shown upon Messrs. Doyne, Major, & Willett's Plans and Sections for the Main Line, is 145 miles.

Estimate 4 trains per day, (*i.e.*) two up and two down trains each day, taking 313 working days in the year. Also reckon two trains upon each Sunday during the year, one up and one down—

		Miles.	Miles.
Week trains	4 × 313 days ×	145 =	181,540
Sunday trains	2 × 52 days ×	145 =	15,080
Total number of miles			196,620

	£	s.	d.	£	s.	d.
Cost per train mile, say 6*s.* 6*d.* × 196,620 miles =	63,901	10	0			
Tollage from Launceston to Longford, 2*s.* per train mile, payable to the Launceston and Western Company for running over that portion of their Line	7322	8	0			
				71,223	18	0
Profit				£31,498	2	10

The working expenses are usually taken at 50 per cent. upon the gross takings. The Victorian Lines are worked at 44 per cent. The New South Wales Lines at 48 per cent.; and in South Australia at 48 and 49 per cent. It will be observed that my estimate of working the Line for the first year is nearly 70 per cent.

***STATEMENTS** showing the amount of Capital it will be necessary to borrow upon Debentures after the description of Line and Gauge has been determined upon.*

Estimate for the 5 feet 3 inch Gauge.

	£	s.	d.	£	s.	d.
Estimated cost of a 5 feet 3 inch gauge				1,159,455	0	0
Assuming that a 5 per cent. loan can be floated at the present time in England at £97, or 3 per cent. discount; allow 2 per cent. for commission and other charges, making £95 for every £100 Debenture sold.						
Probable amount of capital required to carry out a Line of Railway upon the 5 feet 3 inch gauge	1,310,000	0	0			
Less discount on Sale of Debentures	65,500	0	0			
Total amount available for construction	1,244,500	0	0			
Assuming that the Line will take three years to construct, therefore 5 per cent. upon £1,310,000 for three years will amount to	196,500	0	0			
Deduct probable earnings by Bank deposit, interest, &c., say 3 per cent. upon £1,244,500 for 3 years	112,005	0	0			
Amount of interest chargeable to construction	84,495	0	0	84,495	0	0
Total cost of Railway upon the 5 feet 3 inch gauge	..			£1,243,950	0	0

Estimate for the 4 feet 8½ inch Gauge.

	£	s.	d.	£	s.	d.
Estimated cost of a 4 feet 8½ inch gauge				1,089,419	0	0
By using the same data as assumed for the former gauge, the probable amount of capital required to carry out a Line of Railway upon the 4 feet 8½ inch gauge will amount to	1,230,000	0	0			
Less 5 per cent.	61,500	0	0			
Total amount available for construction	1,168,500	0	0			
Assuming that the Line will take three years to construct; therefore 5 per cent. upon £1,230,000 for 3 years	184,500	0	0			
Deduct probable earnings by Bank deposit, interest, &c., say 3 per cent. upon £1,168,500 for 3 years	105,165	0	0			
Amount of interest chargeable to construction	79,335	0	0	79,335	0	0
Total cost of a Railway constructed upon the 4 feet 8½ inch gauge	..			£1,168,745	0	0

Estimate for the 3 feet 6 inch Gauge.

	£	s.	d.	£	s.	d.
Estimated cost of a 3 feet 6 inch gauge Line				823,394	0	0
By using the same data as assumed for the other gauges the probable amount of capital required to carry out a Line of Railway upon the 3 feet 6 inch gauge will amount to	930,000	0	0			
Less 5 per cent. discount	46,500	0	0			
Total amount available for construction	£883,500	0	0			
Assuming that the Line will take three years to construct, therefore 5 per cent. upon £930,000 for 3 years	139,500	0	0			
Deduct probable earnings by Bank deposit, interest, &c., say 3 per cent. upon £883,500 for 3 years	79,515	0	0			
Amount of interest chargeable to construction	£59,985	0	0	59,985	0	0
Total cost of a Line of Railway constructed upon the 3 ft. 6 in. gauge	..			£883,379	0	0

In preparing this statement I have not lost sight of the probability of portions of the Line being opened for traffic before the expiration of the three years allowed for the completion of the whole Line; and I have made allowance for such portions earning something to assist the interest during construction.

I have also assumed that the whole amount of the loan required for the projected Line would be floated in one sum, so as to take advantage of the present favourable state of the money market.

STATEMENTS showing the probable Profit and Loss Account that will be incurred by adopting each of the Gauges.

	£	s.	d.
By adopting the 5 feet 3 inch gauge the probable amount of capital required to construct such a Line of Railway, as shown by estimate, will amount to £1,310,000 at 5 per cent.	65,500	0	0
The estimated cost of working the traffic, as shown in detail in former Statement marked A., amounts to	71,223	0	0
	136,723	0	0
Estimated traffic, as shown in detail in former Statement marked A., amounts to	103,722	0	0
Estimated annual deficiency to make good out of the General Revenue of the Colony	£33,001	0	0

4 feet 8½ inch Gauge.

	£	s.	d.
By adopting the 4 feet 8½ inch gauge the probable amount of capital required to construct such a Line of Railway, as shown by estimate, will amount to £1,230,000 at 5 per cent.	61,500	0	0
The estimated cost of working the traffic, as shown in detail in former Statement marked A.	71,223	0	0
	132,723	0	0
Estimated traffic, as shown in detail in former Statement marked A.	103,722	0	0
Estimated annual deficiency to make good out of the General Revenue of the Colony	£29,001	0	0

3 feet 6 inch Gauge.

	£	s.	d.
By adopting the 3 feet 6 inch gauge the probable amount of capital required to construct such a Line of Railway, as shown by estimate, will amount to £930,000 at 5 per cent.	46,500	0	0
The estimated cost of working the traffic, as shown in detail in former Statements marked A., amounts to	71,223	0	0
	117,723	0	0
Estimated traffic, as shown in detail in former Statement marked A.	103,722	0	0
Estimated annual deficiency to make good out of the General Revenue	£14,001	0	0

In considering these statements, I desire again to call your attention that this apparent annual deficiency will be more or less covered by many indirect advantages the Colony will derive by having Railway communication across the Island. I would also direct your attention to the fact that I have not made any allowance for increase of traffic which must eventually follow, nor have I made any reduction in the working expenses, which ought not to exceed 50 per cent. when the Line is in perfect order and properly consolidated.

I desire it to be distinctly understood that I am not in any way answerable for the feasibility of the plans and sections supplied to the Government by Messrs. Doyne, Major, and Willett, and that I have only used such plans and sections as the basis of my calculations in framing this Report, and the different tabulated statements contained therein.

A review of all the considerations set forth in this Report will, I trust, assist the Government in determining the most suitable description of Railway that will be acceptable to the Colony, and one that will meet all requirements for many years to come.

If we had population, heavy traffic, and required a high rate of speed, and had to compete against a rival Company, we would be perfectly justified, if we had the means, in following the best pattern Railway in the world; but looking at the projected line as a matter of public policy in a new country with a very limited population, sparsely settled, unequally diffused over its surface, with only a limited borrowing power, induces me to recommend that a cheap system of Railway construction should be adopted, such as would provide the inhabitants with sufficient ordinary accommodation at moderate speed consistent with safety. Under all these circumstances, I have no alternative but to recommend that a Line of Railway construcied upon the 3 feet 6 inch gauge principle, with Fairlie's newly invented engines, be adopted.

I desire to impress upon you, what are understood as lightly constructed Lines are not necessarily imperfectly constructed Railways,—as it is possible to make a light description of Railway upon quite as durable a principle as a heavy Line upon a broad gauge.

The cost of rails and ironwork used upon Railways materially affects the large portion of the cost of such Railway; and in a country like this, where we possess good durable timber in large quantities, which is obtainable at moderately low prices, I beg to urge the necessity of using a lighter description of rail and more sleepers. In England the cost of timber and iron is the reverse to what it is here. Iron is cheap, and timber scarce and dear, hence the use of heavier rails and smaller sleepers. We have also to bear in mind that every pound of iron used upon our Railways has to be imported from England, the freight upon which forms a very important element in the cost of Railways. I therefore beg to recommend for your perusal the recent correspondence between certain engineers in England and the Victorian Government relative to the use of light steel rails, and which is appended to this Report. The cost of the steel rails in England is about £14 per ton, and the cost of iron rails about £7 per ton, but the durability of steel is equal to 5 or 6 times that of iron. It therefore becomes a matter of economy and calculation for your consideration, whether it would not be advisable to spend a little more in the first cost of rails to procure an article that would last six times as long as the other.

I also believe that the present system of constructing rolling stock is capable of considerable modification without impairing its efficiency. With the present description of stock a great deal of power is lost by having to drag such a large proportion of dead weight to the service load carried: this refers to both passengers and goods. The width of the bodies of all rolling stock used upon the 5 feet 3 inch Lines is 8 feet, and the width of such bodies upon the 3 feet 6 inch Lines is 7 feet; there is, therefore, very little difference between the carrying capacity of the gauges in comparison to their cost. I have appended to this Report articles copied from the *London Times* of the 19th and 20th of October, 1868, under the head of "The Railway Problem," which contain a deal of reliable information.

In conclusion, I beg to repeat that I believe that if the projected Line is carried out upon the 3 feet 6 inch gauge, that the length of the present Line as shown by the sections is capable of being considerably shortened so as to materially affect its ultimate cost. I therefore recommend, after you have determined the description of Railway, a re-survey of certain portions of the present Line with a view of overcoming the apparent difficulties shown in the sections, and of obtaining a fair working gradient as far as the features of the country will allow, without incurring any extravagant outlay. You will then be able to settle what amount per mile a good useful lightly-constructed Line will cost, which I have no doubt will be considerably below the figures I have quoted; but, being tied to data that I believe capable of being modified, I could not arrive at any other result as to cost than I have done in the foregoing estimates.

I should recommend a maximum speed of 18 to 20 miles an hour. The rates of speed upon the Victorian Railways average 25 miles an hour including stoppages, and to maintain this rate of speed the train often runs between the Stations at 60 miles an hour. Of course, in case of emergency, high rates of speed would be obtainable on portions of such a Line as I propose,—viz., 3 feet 6 inch gauge; but it must always be borne in mind that high rates of speed are costly to maintain.

I believe that a Line of Railway such as I have proposed to be well within the limits of the financial capabilities of the Colony, and sufficient to meet our requirements for many years to come. Our Works should all be designed with great care, of a durable character; our Rails should be of sufficient strength to carry Engines that will drag a useful and paying load up our steepest inclines; our Rolling Stock should be of the most economical and lightest description consistent with perfect safety; our Stations should be plain good useful buildings, well planned, and without any elaborate ornamentations: and to effect all this, we must avail ourselves of the experience of countries similarly situated, and not copy the costly example of others.

In recommending the 3 feet 6 inch gauge for your consideration, I have not lost sight of the break of gauge which will be occasioned at the junction of the Launceston and Western Railway at either Longford or Perth. This can be overcome by laying an additional rail on the existing Line from such junction into Launceston, or by purchasing that Line and altering the gauge to 3 feet 6 inches; the present rolling stock could be easily disposed of without loss to 5–3 gauge Lines in the neighbouring Colonies. It would not be desirable to make the Line from Hobart Town to Launceston, say 130 miles, subservient to the Launceston and Western Railway of 45 miles in length.

SAML. V. KEMP, *C.E., Commissioner Launceston and Western Railway.*

For the purpose of affording you further information than is contained in my Report, I have compiled the following documents, which contain statements from Engineers and others who have endeavoured to establish facts relating to Railways and their future extension.

It is worthy of notice that the Governments of England, Russia, Norway, and India have, as it will be seen from articles copied from the London *Times*, sent Representatives to enquire into the narrow gauge system of Railways now working in Wales upon the Festiniog Line, which I believe has received no small encomium from all who have seen this wonderful little Railway.

It will be seen on perusal of the within compiled statements, that I have selected arguments both for and against the present system of Railway construction, and in doing so I believe I am serving the best interests of the Colonists.

With reference to recent Railway extension in Victoria, the Parliament decided, before committing themselves to any costly undertaking, to appoint a Committee to obtain the best professional evidence available in that Colony, and after considerable labour and expense the following Report was presented to Parliament by such Committee. You will perceive that they state—" There are good grounds for concluding that such Railway, including rolling stock and stations, can be constructed for £6000 per mile in Victoria, suitable for all purposes of traffic for many years to come." No attention whatever seems to have been paid to such conclusions, nor am I aware that any attempt has been made to test them. On the contrary, the Government of that Colony have just entered into a contract for the construction of the first section of 60 miles out of the 187 miles, the whole length of the projected Line from Melbourne to Beechworth, at rates considerably over the projected cost, £9300 per mile; but as the portion just let contains the heaviest and most costly works, it is expected the remainder of the Line will be constructed at rates that will come well within the estimated amount, including all stations and rolling stock. The following statements contain a good deal of useful information which I think will assist you in determining the best description of Railway suitable to this Colony.

SAML. V. KEMP, *C.E.*

REPORT.

THE Select Committee appointed by your Honorable House on Wednesday, 26th May, 1869, *to enquire into and report upon the subject of Railway extension in Victoria, with a view to ascertain the most economical mode of construction consistent with safety and stability, have the honor to report to your Honorable House as follows :—*

To arrive at a conclusion as to the best mode of constructing Railways hereafter in Victoria, to open up as well as to meet the present requirements of the country, it is necessary to consider what has been accomplished in other countries, and especially in countries more nearly approaching our own in natural features and in settlement of population.

The present Victorian Railways were constructed after the best pattern of English Railways, and cost £33,930 per mile. The English Railways are admittedly the most substantial and the most costly in the world. The heavy traffic which is carried with great speed, through competition among rival companies, requires heavy engines, and, as the destruction of the permanent way to a great extent depends upon the speed and the weight of the engine, very heavy rails are used, and even steel rails have been adopted in some cases; but as none of these causes exist here, nor can exist for many years to come, as we have neither rival Lines nor heavy traffic, and require only a moderate rate of speed, England cannot serve as a useful model in this matter for Victoria.

We find from the Report of the Royal Commission on Railways, presented to the Imperial Parliament, 1867, that at the end of 1865 there were—

Open to—	*Miles.*	*Cost per Mile, about—*	*Average Dividend.*
		£	*Per cent.*
England	9251	40,000	4·1
Scotland	2200	23,000	
Ireland	1838	14,000	
France	9014	35,400	
Belgium	1247	18,000	7
Austria (1863)	3694	17,600	7½
Prussia (1863)	3777	16,800	7½
We find from other sources there were—			
Canada	2529	12,600 (62,772 dols.)	
United States	35,935	8000 (39,999 dols.)	
India	3332	18,000	

Average Fares.	Passengers per Mile.			Goods per Train per Mile.				
	1st.	2nd.	3rd.	1st.	2nd.	3rd.	4th.	5th.
England	2·11	1·51	0·92	3·37	1·66	1·31	1·07	1·06
France	1·73	1·3	0·95	2·6	2·29	1·67	1·28	0·96
Belgium	1·23	0·93	0·62	1·7	1·16	0·89	0·62	..
Austria	1·87	1·41	0·94	3·6	2·6	1·7	..	..
Prussia	1·57	1·17	0·8	2·3	1·7	1·2	..	..
Canada	1·5	1·0	..	..	..	..	..	..
United States of America	1·5	..	..	3·75 max.	..	..	..	..
India	1·5	0·74	0·5	3·75	2·5	2·0	1·25	1·0
Victoria	3·75	2·74	..	9	7	6	5	4, 3, & 2

Mr. Robert Mallett, President Civil Engineers, Ireland, gave his opinion that Railways might advantageously be constructed in any part of Ireland on a narrow gauge (not for trunk Lines) at from £3000 to £4000 per mile.

Earl Lucan, Chairman of the Great Northern and Western Railway Company of Ireland, stated that the Line was 102 miles in length; that (from Athlone to Castlebar) 72 miles were open; that the land cost from £600 to £700 per mile; that it was a single Line with double earthworks, through easy flat country, and that the total cost per mile would be about £6580; that moneys were wasted on stations, and above £20,000 lost in Parliamentary contests. In Ireland a uniform gauge of 5 feet 3 inches has been established.

Mr. William Haughton, Chairman of the Great Southern and Western Railway of Ireland, stated that the Branch Line to Killarney cost about £6000 per mile, but that the G. S. and W. Railway Company, with proper goods stations, could not do it under £7000 per mile on their Lines.

Mr. Murland stated that they had not such heavy rails in Ireland as in England; that they had not yet had occasion to renew them, and that the Lines were in excellent repair. Mr. Dargan stated that a Line can be kept up much cheaper with a light traffic than with a heavy traffic.

Mr. Stewart, Secretary to the London and North Western Railway Company for nearly twenty years, stated it as his opinion, that cheap Lines on the ordinary gauge (4 feet 8½ inches) are the only Lines that will pay in agricultural districts.

Mr. F. E. Harrison, Civil Engineer in extensive practice, stated that the cheapest Line he ever constructed was one from Tarisk to Malton (ordinary gauge 4 feet 8½ inches), twenty-two and a half miles in length. When completed its cost was under £100,000 (£4400 per mile), including everything but rolling stock.

Mr. A. C. Sherriff, M.P., stated that the Line from Honeybourne to Stratford was constructed by the West Midland Company for less than £6000 per mile.

Mr. G. P. Bidder (Civil Engineer of long practice) stated that the permanent way of a single line,—*i.e.*, rails, sleepers, ballast, and laying,—may be taken at £2500 per mile.

Mr. E. Chadwick, C.B., urged the necessity of cheap Railways, and referred to the Peebles Railway in Scotland, constructed at £5000 per mile, stations included, and paying a dividend of 6 per cent., as evidence of the practicability of the cheap extension of Railways.

Sir Rowland Hill (one of the Commissioners), who made a separate report, was impressed with the importance of reducing the cost of the construction of Railways in the rural districts of the United Kingdom to the lowest amount practicable, in order to develope their resources, by reducing fares and increasing traffic; and believed that the cost, including stations, rolling stock, and every other expense, might be brought within an average of £5000 per mile. He mentions that Sir John Macneill gives detailed plans and estimates of a Line 11 miles long and 3½ feet gauge, which he proposes to construct between Downpatrick and Newcastle, at an average cost per mile (including land and rolling stock) of £3533; the speed to be 15 miles per hour.

The Commissioners say:—"The cost of a Railway varies from £4000 per mile to £1,000,000 per mile, according to the district in which it is placed. For instance, a densely-populated district, occupied by a manufacturing or mining population, has far different wants from an agricultural population; and the mountain districts of Scotland, or the sparsely-inhabited portions of Ireland, could be supplied with Railway communication suited to their wants by means of a very different mode of construction from that necessary for South Staffordshire or the Metropolis."

Referring to the United States of America, they say:—"The progress of Railway communication in America has been far in advance of that in this country, but no just comparison can be made between the English and the American Railways. The mode in which the land is occupied is essentially different; the condition of society is also very different. In America only one class of passengers is recognised, except in the case of emigrants. There the Railways form to a great extent the only main roads of the country."

The plan pursued in America generally is to construct the Lines lightly and rapidly, to increase their strength and them as traffic increases and dividends improve, so that their ultimate condition depends upon the work they do.

In the evidence before the Committee it will be found that,—

Mr. Heginbotham, Engineer-in-Chief, is of opinion that a light Line of Railway (rails weighing 40 lbs. per yard) might be constructed in Victoria through an ordinary line of country for about £6000 per mile, but would not recommend it where there are steep gradients and a heavy traffic.

Mr. Mais, Engineer-in-Chief, South Australia, states that light Lines have recently been constructed in South Australia, including stations and rolling stock, for about £5000 per mile.

Mr. Zeal expressed his absolute opinion that a substantial Line of Railway can be constructed for £6000 per mile from Melbourne to the Murray.

Mr. Brady, Civil Engineer, who had charge of the construction of 51 miles of Railway in Queensland, states that a substantial Line to Albury, with 60 lbs. rails, could be constructed for £6000 per mile.

Mr. J. G. Griffin, Civil Engineer, states that he was engaged on the construction of the Varna and Rustchuck Railway in Turkey; that its length is 138 miles; and that it cost about £5000 per mile, including a portion of the rolling stock; and he believes a substantial Line could be constructed for from £5000 or £6000 per mile in this country.

The Engineer-in-Chief, Mr. Heginbotham, considers it advisable to provide for the maximum amount of traffic with as few trains as possible, in order to work a line economically; and that to do this, powerful engines and a permanent way, with rails of 72 lbs. per yard, are necessary where there are heavy gradients, and in this Mr. Watson and Mr. Greene, resident Engineers on the Victorian Railway, concur with him.

Your Committee fully appreciate the reasons which induced the Engineer-in-Chief and the resident Engineers to recommend that our railways should be constructed in a very substantial manner; but as a question of public policy your Committee are of opinion that, in a new country, with a limited population, sparsely settled, and with a limited borrowing power, the most advantageous system of railway construction is that which will provide the inhabitants with sufficient ordinary accommodation at moderate speed and moderate fares, and in this opinion your Committee are supported by the opinions of the great majority of eminent English Engineers, as recorded in the English Royal Commission Report of 1867.

In the opinion of your Committee there are good grounds for concluding that such railways, including rolling stock and stations, can be constructed for £6000 per mile in Victoria, suitable for all purposes of traffic for many years to come.

Your Committee would direct your attention to the fact that the net tonnage due to the Sandhurst and Echuca Line for 1866 is under 27,000 tons, carried by two trains each way per day ordinarily, with extra trains during very busy times. That, to provide for the maximum amount of traffic, heavy engines are employed on 72 lb. rails, whereas double the amount of regular traffic could be carried with gradients of 1 in 50 by 25 ton engines on 50 lb. rails, in two trains per day each way, with the same expense and damage to the permanent way.

Your Committee would draw the attention of your Honorable House to the Table of Fares herewith. There can be no doubt that, as Railways increase, the public demand for cheap carriage will compel a reduction of fares; and as the wear and tear of the permanent way (whether light or heavy, if the weight of the Engines is in due proportion to the weight of the rails) will depend upon the traffic it has to sustain, in the opinion of your Committee it is desirable to begin with the least costly permanent way and rolling-stock.

Your Committee are of opinion that judicious economy can be effected in the items of rolling-stock, fencing, gates, goods-sheds, and station-houses, by constructing them in the simplest and cheapest form, and that only where absolutely required.

REPORT ON THE NORTH-EASTERN RAILWAY.

The following is the Report of the Engineer-in-Chief on the subject of Railway construction, presented to Parliament yesterday:—

Engineer-in-Chief's Office, Railway Department, Melbourne, August 2, 1869.

The Hon. J. F. SULLIVAN, Commissioner of Railways.

SIR,

I HAD the honor, on the 28th May last, to submit for your consideration some observations on the construction of the proposed North-Eastern Railway. Since that time the subject of Railway construction generally has been much discussed, with the view of inducing the Government to adopt a very light mode of construction on that line; and in accordance with your desire that I should do so, I now beg to offer some additional remarks on the subject.

The advocates of what are described as cheap Railways have been anxious to show that there were no sufficient grounds for the estimate of traffic on the North-Eastern Railway in my memorandum of 7th September, 1868; and therefore that, if this Line were not constructed for a much smaller sum than I had estimated it would cost, it would be a burden to the colony; but I think it will now be admitted on all hands that the receipts on the proposed line have not been over-estimated, and that in the course of the full enquiry and discussion which have taken place, it has been proved that there is now existing on the Sydney-road an amount of traffic which will pay both the whole of the working expenses of the Line and the interest on the sum which I have estimated that the Line will cost, while the increase of traffic resulting from the substitution of a Railway for the present road—which, for its length, is the worst in the colony—must be very large, and yield a considerable profit.

The estimate of the traffic on the proposed North-Eastern Railway having proved to be unassailable, the estimate of the cost of the Line has been called in question, and it is urged that sufficiently good Railways may be made in any part of this Colony for £6000 a mile, including rolling stock and stations, and that to spend more than this sum on any line is impolitic, and will prevent the extension of Railways to other parts of the Colony, because the borrowing powers of the Government are limited.

None of the witnesses who gave evidence to the Select Committee of the Legislative Assembly which has lately reported on the subject of Railway construction, that the North-Eastern Railway could be made for £6000 a mile, had examined the route of the Line between Essendon and Belvoir, nor did they profess to have any knowledge whatever either of the section of the Line, of the quantities of earthwork to be executed, the rivers and streams that have to be crossed, and the floodways that must be provided, or of the materials for Railway construction to be found in the District, though such information is essential in framing a reliable estimate. The only basis, so far as I can discover, for the estimate of £6000 a mile, at which rate it is proposed that all new Railways in the Colony shall be made, is that certain Railways, or parts of them, have been made in England, Ireland, and Scotland, in the United States, in India, and in Queensland, for that sum per mile.

An estimate arrived at in the way I have described ignores the consideration not only of the physical features of the country through which a proposed Line of Railway is to be made, but of the rates of wages which rule in different countries, and which are a main element in determining the cost for which any given work can be executed.

Labour of all kinds, whether skilled or otherwise, is at least twice as dear in this country as it is either in England or Scotland, and nearly three times as dear as it is in Ireland; but, notwithstanding this, it is gravely maintained that the cost per mile of a Main Trunk Line of Railway in Victoria should not exceed that of any of the cheapest minor and branch Lines which have been constructed under circumstances the most favourable to economy in England, Ireland, or Scotland.

I shall be able to show you that, if the price of labour in this country be taken into account, the proposal to construct Railways in Victoria for £6000 a mile is, in effect, a proposal to construct them for a much lower rate per mile than has been found possible, except in a single instance, under circumstances the most favourable to economy, in any part of the United Kingdom.

The following Lines are instanced by the Select Committee of the Legislative Assembly as examples of cheaply constructed Railways; namely:—The Great Northern and Western Railway of Ireland, cost, without rolling stock, £6580 per mile; the Killarney branch of the Great Southern and Western Railway of Ireland, cost, without rolling stock, £6000 a mile, (the Chairman of this Company states that its branch Railways, as a rule, cannot be made for less than £7000 a mile); the Malton and Thirsk branch Railway, cost, without rolling stock, £4440 a mile; the branch Line from Honeybourne to Stratford, cost, without rolling stock, £6000 a mile; the Peebles Railway, cost, without rolling stock, £5000 a mile.

I propose to take each of these cases for the purpose of showing what each Line would have cost if constructed by labour paid at Victorian rates; and, with a desire to understate rather than overstate the case that I am laying before you, I will assume that the price of labour here is only one and a half times higher than in England and Scotland, and only twice as high as in Ireland. I will assume also that the weight of the rails on each Line is the same as I propose for the North-Eastern Railway—namely, 72lb. to the yard—this latter assumption being the least favourable that I can make for the purpose of my argument. You will observe that I have made allowance in the following calculations for the higher price paid for land in the United Kingdom than here, and also for the Parliamentary and law expenses incurred there:—

Great Northern and Western Railway of Ireland.
Cost per mile.

	Ireland.	Victoria.
	£	£
Permanent way materials	1106	1382 *a*
Ballast	629	1258 *b*
Sleepers	462	462 *c*
Laying	99	198 *b*
Works and supervision	3438	6876 *b*
Land, say	650	100
Parliamentary and law expenses	196	Nil.
	£6580	£10,276

Great Southern and Western Railway of Ireland.—Branch Lines.

	Ireland.	Victoria.
	£	£
Permanent way materials	1182	1382 *a*
Ballast	629	1258 *b*
Sleepers	462	462 *c*
Laying	99	198 *b*
Works and supervision	4004	8008 *b*
Land, say	650	100
Parliamentary and law expenses	50	Nil.
	£7000	£11,408

Killarney Branch Railway.

	Ireland.	Victoria.
	£	£
Permanent way materials	1106	1382 *a*
Ballast	629	1258 *b*
Sleepers	462	462 *c*
Laying	99	198 *b*
Works and supervision	3004	6098 *b*
Land, say	650	100
Parliamentary and law expenses	50	Nil.
	£6000	£9408

Malton and Thirsk Branch Railway.

	England.	Victoria.
	£	£
Permanent way materials	1106	1382 *a*
Ballast	998⅔	1198 *d*
Sleepers	437	437 *c*
Laying	132	198 *d*
Works and supervision	1266⅓	1899½ *d*
Parliamentary and law expenses	50	Nil.
Land, say	650	100
	£4440	£5214½

(*a*) Plus 25 per cent. for freight, &c. (*b*) Double for difference in labour. (*c*) Same in both countries.
(*d*) One half extra for difference in labour.

Honeybourne to Stratford.—Branch Line.	England.	Victoria.
	£	£
Permanent way materials	1106	1382 *a*
Ballast	798⅔	1198 *d*
Sleepers......................	437	437 *c*
Laying	132	198 *d*
Works and supervision	2826⅓	4239 *d*
Land, say	650	100
Parliamentary and law expenses	50	Nil.
	£6000	£7554

The Peebles Railway.	Scotland.	Victoria.
	£	£
Permanent way materials	1106	1382 *a*
Ballast	798⅔	1198 *d*
Sleepers......................	437	437 *c*
Laying	132	198 *d*
Works and supervision	1826⅓	2739½ *d*
Land, say	650	100
Parliamentary and law expenses	50	Nil.
	£5000	£6054½

(*a*) Plus 25 per cent. for freight, &c. (*b*) Double for difference in labour. (*c*) Same in both countries. (*d*) One half extra for difference in labour.

The average cost of these Lines, excluding the Malton and Thirsk Railway, would be, without rolling stock, if made here, and by labour paid at the rates ruling in Victoria, £8940 per mile, or with rolling stock, £9940 per mile; and my estimate of the cost of the North-Eastern Railway, with rolling stock, and with an allowance of £800 a mile for contingencies, is £9300 per mile.

The Committee has come to the conclusion that for the sum of £6000 a mile sufficiently good Railways, including rolling-stock and stations, may be constructed in Victoria ; but you will observe that if rolling-stock be added to the cost of the Lines which the Committee instances as justifying this conclusion, the cost of these Lines in every case exceeds, and in every case but one (the Malton and Thirsk) largely exceeds, £6000 a mile.

The Malton and Thirsk Railway is described by the Engineer (Mr. Harrison) in his evidence before the Royal Commission on Railways, as having been made under circumstances exceptionally favourable to economy, and through a country so flat that every road is crossed on the level, and in the whole length of the line (22½ miles) there are only three bridges.

The cost of that portion of the Southern and Western Railway of Queensland which extends from Toowoomba to Dalby was stated in evidence to the Committee of the Legislative Assembly (question 1004) to have been £3900 a mile, exclusive of rolling-stock, which would cost £500 a mile more (question 1026), making a total of £4400 a mile. This statement of the cost of the Line is incorrect, though I have no doubt it was made without any intention to mislead. It has been ascertained from the Queensland Government that the cost was not £4400, but £6000 a mile. This portion of the Queensland Railways is the cheapest of all, and £6000 a mile by no means represents the average cost. The average cost of the whole Line from Ipswich to Dalby is £11,400; and the average of the Northern Railway from Rockhampton is £9000 a mile. The Queensland Railways are of very narrow gauge, 3ft. 6in. only; the rails are very light, 40lb. to the yard; the ballasting is imperfect, and the bridges are for the most part built of timber, iron girders being used for the larger spans. The cheapest portion of these narrow gauge Lines has cost £6000 a mile, or the same sum which the Committee of the Legislative Assembly has reported to be sufficient to provide Railways in Victoria suitable for all purposes of traffic for many years to come.

The Madras Railway, which is referred to at page 15 of the Report for 1867-8 of Mr. Juland Danvers, Government Director of Indian Railways, as setting "an example of economy both in construction and management," is a single Line 492 miles long, with passing places. It has cost £12,000 a mile, including rolling-stock. The rails weigh 76lb. to the yard, and the general character of the Line is easy.

The Middleton and Strathalbyn Railway, in South Australia, has been lately opened, and has cost up to this time £5261 per mile, including rolling-stock and stations. This Line is about 22 miles long, the gauge is 5ft. 3in., and the rails weigh 40lb. to the yard only. It has not been decided whether it shall be worked by horses or by locomotive engines. The sum provided for rolling-stock is only £300 a mile, and either this is inadequate, or the traffic must be very light, not more than one-third of that between Sandhurst and Echuca. The country through which this Line passes is much easier than that on the North-eastern Line, and the worst gradient is 1 in 95. Mr. Mais, the Engineer of the Line, who was here lately, told me that the circumstances of the two cases were so entirely different that no comparison between the cost of the Strathalbyn Line and that of the North-Eastern Line could be of any value.

The Lucknow and Cawnpore branch Railway in India was laid with rails which weighed 40lb. to the yard, the gauge was 5ft. 6in., and it was worked by locomotive engines; the traffic was very light, but, notwithstanding, the 40lb. rails failed within twelve months of the opening of the Line. (See Report of Oude and Rohilcund Railway Company for the half-year ending 30th June, 1868.) An attempt, therefore, to work a Line like the Middleton and Strathalbyn Railway with locomotives, must at best be considered a very doubtful experiment.

In reply to question 730, a statement was read to the Committee of the Legislative Assembly, from which I make the following extract :—

"To provide against the ill effects above mentioned, modern Engineers have devoted their attention to 'light' Railways as a remedy for the evils experienced in the working of first-class high-cost Railways.

"A striking instance of this is exemplified in the construction of the 'Central' Railway from Dunkeld to Forres, by Mr. Joseph Mitchell, an eminent Scottish Engineer. This Railway is reported* to be 104 miles in length, 'with eight viaducts, 126 bridges over streams, 119 public road bridges, and 1159 culverts, 18in. to 36in. square;' and has cost the comparatively small sum of £8860 per mile. The Report further shows :—'In one week 21,000 sheep were carried over it, the summit level of the line being 1500 feet above the sea.'

"Professor Rankine, speaking of the Report containing the above facts, says 'the information contained in the great collection of facts would be most valuable.' He likewise speaks of 'the moderate cost and substantiability of the works, and the remarkable judgment with which the works had been adapted."

* Journal of Science, vol. 4, fo. 594.

A full description of this Railway, which is called the Highland Railway, was read by Mr. Mitchell at the Meeting of the British Association for the advancement of Science, held at Dundee in September, 1867, and will be found in the Reports of the Association for that year, from which I have obtained the following information :—"The ruling gradient of the Highland Railway is 1 in 70, the rails weigh 75lb. to the yard, and the Line is worked by engines of 17in. cylinders and 24in. stroke." It appears, therefore, that this Railway, which is undoubtedly an admirable example of both good and economical construction, is worked by engines equal to the largest and heaviest of those on the Victorian Railways, and is laid with rails which weigh 3lb. to the yard more than those which I propose to use on the North-Eastern Railway, while the ruling gradient is only 1 in 70 against 1 in 50 on the North-Eastern Line.

I beg to call your attention to this case in particular, because it shows how necessary it is to use caution in accepting statements made on this side of the world as to what is the practice of English engineers. Mr. Mitchell is quoted as having adopted a light mode of construction for Railways in a thinly peopled district, and as having, therefore, set an example that we should do well to follow. I believe the Highland Railway is an example to be followed, but I have shown you that it is not constructed as a light Railway.

I extract the following passage from Mr. Mitchell's paper, which shows what are his opinions on the subject of Railway construction :—

"In planning these works, the writer, while having every regard to economy, felt the importance of their being of the most substantial character, seeing that they were exposed in these districts to every vicissitude of climate and flood; but indeed he feels that all permanent public works, involving the safety of the lives of the community, should be of undoubted stability."

The cost of the Highland Railway from Dunkeld to Forres, through a country parts of which are very difficult, was £8860 per mile without rolling stock. The cost of the same line made here would have been £11,451. In the same paper, Mr. Mitchell describes the northern portion of the Highland Railway from Invergordon to Bonar, which has been constructed at a cost of £5888 per mile, exclusive of rolling stock. This Line is described as passing through a comparatively level country; the rails weigh 70 lbs. to the yard, or only 2 lbs. to the yard less than those which I propose to use on the North-Eastern Railway.

Mr. Bidder, the well-known Civil Engineer, gave evidence before the Royal Commission on Railways in 1866, and, when asked (question 17,171) what would be the cost of Branch Lines made in the most economical manner, said, "I cannot give a general answer to that"—"the permanent way may be taken at £2500 a mile for a single Line, to include rails, sleepers, ballast, and laying." This sum exceeds that which I estimate the permanent way of the North-Eastern Railway will cost, when the difference in prices in England and here is taken into account, and shows that Mr. Bidder would provide for an English Branch Railway made in the most economical manner as heavy rails as I propose to use on the North-Eastern Railway.

It would be easy to multiply examples to prove that English Engineers do not fall into the mistake of confounding light construction with economy. To effect economy, they use single lines whenever these are sufficient for carrying on the traffic, and steep gradients and sharp curves to avoid expensive works; they protest against expensive Parliamentary contests and the enormous price paid for land; but they do not advocate light rails, which require to be renewed after two or three years' traffic, or light engines, which make two trains necessary when one would be sufficient to do the work.

No one would think of proposing, with a view to economy, that the traffic of the Sydney Road should be carried in drays drawn by one or two horses instead of the large waggons, drawn by powerful teams, which are now used: but such a proposal would not be more extravagant than that of using light engines for working the North-Eastern Railway.

If only one additional train be run daily each way between Melbourne and Belvoir, the cost of working the Line will be increased by £14,500 a year. This sum, at twenty years' purchase, amounts to £290,000, or £1600 per mile on 181 miles of Railway.

American Railways have been instanced as examples which might, with great advantage, be followed in this country; but I believe that further acquaintance with the subject would lead to a different conclusion. The American system of construction is condemned for its extravagance and inefficiency by very high American authorities,—namely, Messrs. Colburn and Holley, eminent American Engineers, in their work on the "Permanent Way and Coal-burning Boilers of European Railways," published at New York, 1858; by the *American Cyclopædia*, article "Railways," published in 1861; by the *American Railway Times*, a standard periodical published weekly at Boston, which is constantly employed in pointing out the bad and even dangerous condition of the permanent way of American Railways, and the necessity for better and stronger carriages, as those now used afford no protection in case of accident. Sir Morton Peto, in his work on America, published in 1866, condemns the way in which American Railways have been constructed, and points out its extravagance.

The average cost of American Railways has been rapidly increasing. The *American Cyclopædia*, already referred to, gives the average cost of American Railways in 1861 at less than £8000 a mile. *Hunt's Merchant's Magazine*, Vol. 55, for 1866, page 94, a standard work, gives the cost of 8232 miles of well constructed American Lines at £12,000 a mile; and Sir Morton Peto in 1866 says :—"American Railways are almost invariably single." "The outlay upon American Lines has been from £8700 up to £15,000 per mile." The cost of the cheapest American Railways in 1866 was, therefore, but little below the estimated cost of the North-Eastern Railway.

That American Railways are so bad as they are (having cost so much as they have done) can only be accounted for by the fact that they were badly made in the first instance, and that the permanent way is much too light for the engines that run on it. The weight of the engines used in America is quite equal to that of the engines used in England and here. A people who use "American waggons" drawn by powerful teams on their roads were not likely to fall into the mistake of using weak engines on their Railways.

In considering the most economical method of making Railways, the cost of maintaining and working them when they are made ought not to be omitted; but the advocates of "cheap" Railways for Victoria exclude altogether from their calculations the cost of working and maintenance. Such an imperfect way of examining the question is misleading.

The *American Railway Times* of 1st February, 1868, gives, from official sources, the cost of working the Railways of the State of New York—which are probably good specimens of American Railways—for the year 1867. The cost of working these lines was 75·99 per cent. of the gross receipts for that year.

The cost of working the North-Eastern Railway is estimated to be the same as that for which the Sandhurst and Echuca Line is worked—namely, 45 per cent. of the gross receipts. These receipts are estimated at £159,402 a year, and the net receipts would, therefore, be £87,672; but if the cost of working the North-Eastern Railway were as great as that of the Railways in the State of New York, the net receipts would be £38,273 only. In this instance there is a loss of net revenue amounting to £49,399 per annum, or, at 20 years' purchase, £987,980, which shows that, if money can be borrowed at 5 per cent., it would be worth while to spend £5458 per mile additional on the North-Eastern Railway, if by doing so it can be worked for 45 instead of 75·99 per cent. of the gross receipts.

The Melbourne and Hobson's Bay Railway is almost perfectly level from Melbourne to Sandridge, and in the first instance was laid with rails weighing 55lb. to the yard. The Line was worked by engines the weight of which was under 25 tons; but, notwithstanding the light engines, the 55lb. rails failed in less than three years from the time when they were laid down, and the Line was re-laid about 12 years since with rails weighing 75lb. to the yard. These rails are still in good order.

The St. Kilda branch of the Hobson's Bay Railway was laid in 1857 with 55lb. rails, and, with a view to give them additional support, longitudinal sleepers of hardwood were used instead of the cross-sleepers which had been used on the Sandridge Line. These rails had to be taken up within two years, and the road was then re-laid with 75lb. and 80lb. rails, which are still in good condition. The worst gradient on the St. Kilda Line is 1 in 131; it is exclusively a passenger Line, and was worked by engines weighing less than 25 tons.

Too much importance cannot be attached to these facts. They are beyond dispute; and the circumstances of each case are such as every one here can judge of for himself. In these respects they are in striking contrast to the vague statements which have been so freely made about Railways in distant countries, which those who speak about have never even visited.

The Government is urged, by the advocates of "cheap Railways," to adopt for the North-Eastern Railway, which is a main trunk Line, with very heavy gradients, a mode of construction which failed in less than three years on the Sandridge Line, and in less than two years on the St. Kilda Line, both Lines having been worked during these periods with very light engines.

The whole saving that would be effected in the first cost of the North-Eastern Railway by using 55lb. instead of 72lb. rails would be £40,000, or, at five per cent., £2000 a year. I have already pointed out to you at how great and disproportionate an annual increase of expenditure this small saving in first cost must be obtained.

I forward with this a letter which I have received from Mr. Elsdon, the Engineer of the Melbourne and Hobson's Bay United Railway, to whose opinion I attach great value.

I have the honor to be,
Sir,
Your obedient Servant,
(Signed) T. HIGINBOTHAM, *Engineer-in-Chief.*

[Copy.]

"*The M. and H. Bay United Railway Company, Chief Engineer's Office,*
" *Sandridge, July* 26, 1869.

"THOMAS HIGINBOTHAM, Esq., Engineer-in-Chief Victorian Railways.

" SIR,

" IN acknowledging the receipt of your letter of the 13th instant, requesting my opinion as to whether it would be prudent or economical to adopt a rail of less weight than 72lb. per yard for the proposed North-Eastern Main Trunk Line of Railway, being a single Line with gradients of 1 in 50, &c., I have the honor to inform you that in my opinion it would not be judicious to do so, taking into consideration first cost and the increased annual expense of working and maintaining a Line constructed with light rails.

" I am confirmed in this opinion by the result of my experience on the Melbourne and Hobson's Bay Line for the last 15 years, and also on the United Company's and St. Kilda and Brighton Lines for several years past, where there have been rails from 55lb. to 80lb. in use, and where the lighter rails, after a very short lifetime, had to be abandoned as totally unsuitable for the traffic. The branch Line to St. Kilda, as you may be aware, was at first constructed with 55lb. rails upon longitudinal sleepers, which had to be replaced within two years with 75lb. and 80lb. rails, which have stood the test of nine years already, and, with few exceptions, are all in good condition and working order. The Sandridge Line was originally laid with 55lb. rails on transverse sleepers, and were replaced nearly 12 years ago with 75lb. rails. They have also given every satisfaction. The extension of the Brighton Line I laid with 65lb. rails about seven years ago, but time has only served to strengthen my belief, derived from both observation and experience, of the inutility of light rails for main trunk Lines.

" Although it may appear to be travelling beyond the record to refer to my evidence before the Goornong and Albury Railway Extension Committee in May, 1865, as I am not required by the terms of your letter to do so, yet it may be necessary, as the printed report (which I saw for the first time about three weeks ago) appears at first sight as if I gave a preference to a 60 lb. or a 65 lb. rail, whereas the contrary is the fact. See Questions 210, 241, and 242. If the qualifying clauses in my replies, however, are taken into consideration, it will be seen, as in Question 210, where I give the preference to an expenditure of from £7000 to £8000 per mile to make the Line of a permanent character; and, also, from the Appendix No. 1, at the close, where all my calculations are based upon a 72 lb. rail, that I am not in favor of light rails. I have simply referred to the above for the purpose of neutralising the erroneous impression which some at first sight might entertain upon reading the evidence.

I have the honor to be,
Sir,
Your very obedient Servant,
(Signed) WILLIAM ELSDON, *C.E.*"

THE OVENS RAILWAY CONSTRUCTION BILL.

To the Editor of the *Argus.*

SIR,

THE advocates of heavy expenditure on the Ovens Railway fail singularly in their analogies when instancing precedents for the course they follow. The ex-Commissioner of Mines is reported in this day's *Argus* to have spoken of the failure of light rails on the Hobson's Bay Line. What are the facts? On the Hobson's Bay Line the rails are of 72 lb. to 80 lb. per lineal yard; they are subjected to an enormous traffic. The rails near the seaboard are worked under the combined disadvantages of sea air and spray, producing constant oxidation, and a granulating never-ceasing wear from the action of sea sand, which travels and asserts itself all over the superstructure of the Railway. From the Melbourne terminus 233 trains arrive and depart each working day, giving an average of one train every 4 min. 23 sec. during the hours of 7 A.M. and 12 P.M., or one train every 3 min. 34 sec. between 8 A.M. and 6 P.M.; and such is the traffic that the best iron ever forged succumbs to the constant wear and tear, and the use of steel rails is seriously contemplated. In the teeth of these facts Honorable Members are recommended to adopt similarly heavy rails for the Ovens Line as those laid down on the Hobson's Bay Company's Roads.

* * * * * * * *

Mr. Hanna says (fol. 3, "Ovens Railway Inquiry") that during seven years—1861 to 1867 inclusively—on the main Sydney-road there passed every working day, to and from Wallan Wallan, 122 tons of goods; to and from Seymour, 111 tons 12 cwt.; and to and from Wangaratta, 93 tons of goods; or an average of say 55 tons each way per day.

This is definite information. I accept Mr. Hanna's figures, though the Engineer-in-Chief will not, he preferring the somewhat mythical process of "framing an estimate," though in Question 314, fol. 14, he admits Mr. Hanna's statistics confirm his estimate. I therefore claim Mr. Hanna's figures as reliable.

Now for the test. Take the largest estimate of traffic on the Ovens Road, viz., that of Wallan Wallan, and one train each way per day would carry double the amount of goods and passengers which have passed over the Ovens Road during the past seven years.

We likewise find the Resident Government Engineer, Mr. Watson, asserts (fol. 110, same inquiry) that an engine weighing 25 tons will convey double the average quantity of goods which have passed over the Ovens Road from 1861 to 1867, at a speed of 10 miles per hour, over the worst gradient on the Line.

This is the testimony of Government witnesses, the deliberate utterance of those gentlemen to whom were entrusted the exposition of the Government scheme.

I ask any unprejudiced person if their evidence does not prove what Messrs. Mais, Brading, and Griffin have clearly stated—does it not prove the injustice of the remarks of Hon. Members, who, apparently, not having read the report or studied the evidence contained therein, blindly give in their adherence to an expenditure as uncalled for as it is absurd and wanton?

I respectfully invite Hon. Members to read for themselves the Report of the Royal (English) Commission, 1867, the *Transactions of the Institute of Civil Engineers*, and other standard British works, and not to condemn unthinkingly and unfairly the honestly intentioned views of those whose only interest in the matter is the desire to make the Government Loan as beneficial in its effect as the most genuine colonist would desire it to be.

I am, Sir,
Your obedient Servant,

October 1. (Signed) W. A. ZEAL.

THE RAILWAY PROBLEM.

UNDER this title *The Times* has just published (October 19 and 20) two papers of such great general importance, that I have deemed it expedient to consider them in a separate article. Two prodigious statements have been made during the present year in regard to railways, which forcibly illustrate the extent to which they have been and still are mismanaged. The first is a statement made by Mr. Laing as to certain branch lines constructed for the Brighton Railway—that the shareholders who subscribed the capital of £4,000,000 towards their construction might as well for any benefit which can accrue to themselves have taken bank notes to this amount and used them to light their pipes with. That is certainly a vivid description of the waste of money laid out in branch lines which can bring no return.

The other prodigious statement is one which has been made in nearly the same terms by Mr. Haughton, of the North-Western Railway, in a letter to *The Times;* by Mr. Fairlie, in a paper lately read before the Society of Arts; and by Mr. Haggard in his pamphlet entitled *A Mile of Railway*, and relates to the enormous disproportion between the net and tare of train loads. "In Mr. Haggard's pamphlet it is stated, on figures furnished by Mr. Haughton, that every passenger carried by rail weighs a ton; in other words, that supposing a passenger and his luggage to weigh in reality 2 cwt., the rolling stock which has to be set in motion in order to convey him to his destination multiplies his weight tenfold, so that for every passenger a ton has to be hauled. Mr. Haughton then corrected his figures, and in a letter addressed to *The Times*, as well as in his paper read to the Society of Civil Engineers, showed that every passenger weighs two tons; and Mr. Fairlie asserts that the calculation has further to be corrected, for the actual weight of a passenger as carried by rail is not less than two tons and a quarter. In this last statement of the case Mr. Fairlie is confirmed by another engineer, Mr. Samuel, who declares that for every ton of passengers the engine has to draw 33 tons of load, and who reckons the average real weight of a passenger at 1½ cwt., not as Mr. Haughton at 2 cwt. In the goods trains the disproportion between the paying and nonpaying weights is not so extravagant, though it is great enough in all conscience. According to Mr. Haughton's calculation no more than 30 per cent. of the load which is hauled by a goods train represents paying weight; the remaining 70 per cent. is dead weight. Such a statement as this would of itself be astonishing, were it not eclipsed by the statement as to the passenger trains that only five per cent. of the load pays, according to Mr. Haughton, and only three per cent. according to Messrs. Fairlie and Samuel, the remaining 95 or 97 per cent. being mere dead weight, without which it is said to be impossible to carry the poor little per centage of paying load. Let us think for a moment what this means. An ordinary omnibus may be assumed to weigh a ton, and its two horses with their harness are over-estimated at another ton. It carries 28 passengers, who, having little or no luggage, may be estimated at two tons. The paying and the non-paying loads thus balance each other. There is 50 per cent. of the one and 50 of the other. This is what occurs on ordinary roads where traction is difficult. What should we expect on the rail where traction is easy? Is it not monstrous that the average dead weight of our passenger trains should by the lowest reckoning be 95 per cent. of the entire weight? that to compare the figures with those of the omnibus it is necessary for the carriage of two tons of passengers to set in motion, not as in the omnibus twice, but actually twenty times that weight of rolling stock and freight combined? or, to return to the succinct statement of Mr. Haughton, that every passenger should weigh 2 tons, and of Mr. Fairlie that he should weigh 2¼ tons? Surely there is a gigantic mistake somewhere. Surely this enormous waste of power cannot be necessary. Surely it must be a severe reproach to mechanical science, so long as a ton of passengers means according to one calculation 20 tons, or according to another 33 tons of load to be carried, and that not on rough ordinary roads, but on rails.

While Mr. Haughton sees no means of remedying this gigantic evil, it is consolatory to know that Mr. Fairlie seems to have experimentally solved the difficulty. He is "now exhibiting at the iron works at Hatcham a steam-carriage which goes through a surprising performance. The carriage is 43 ft. long; and yet it is driven at the rate of 20 miles an hour on a line of rails laid in a small cabbage-garden of about half an acre in extent. It wisks round curves of 50 ft. radius with perfect ease, with scarcely any noise, and without the slightest danger. If the curves had been still sharper, say 25 ft. radius, the engineer declares that his carriage could curl round them with not less ease, and, if possible, with even greater assurance of safety. The result thus obtained is very striking and full of interest to all who care to study the question of railways; but we should state at once that we give it the first in the record of what Mr. Fairlie has attempted, not because the means by which these sharp curves are rendered practicable are wholly of his invention, but because they lie at the base of whatever subsequent improvements in the construction of rolling stock he had been able to suggest. An ordinary train cannot pass round sharp curve, because the carriages have a rigid wheel base, of considerable length. Get rid of this rigidity and we can make the carriages turn. Every one knows how an ordinary four-wheeled carriage is made to turn sharp round on an ordinary road. It is because the front wheels are not rigidly attached to the carriage, but have a horizontal movement underneath it and independent of it. Now, if we imagine a carriage in which the wheels behind have a horizontal movement similar to that of the front wheels we shall have a very fair model of what is known in the railway world as a "bogie carriage," and can understand the principle on which Mr. Fairlie works. "Bogie" is a north-country word for a spirit, a goblin, the devil; and bogie-carriages were first used many years ago in Newcastle where it was necessary for the coal waggons to double about the quays. They were so named because they were supposed to turn upon one like a spirit, and to face one when least expected. You saw a bogie-carriage going off in a particular direction in full force; in a moment it wheeled round an unexpected curve and was down upon you. "It's Bogie himself," cried the miners; and so the waggon was named. The waggon instead of being supported on four wheels rigidly combined in the same or parallel planes was placed on two small but strong trucks, called bogies, which represent the front and hind wheels of the ordinary carriage to which we have referred. Each of these trucks may be supported on one, two, or three pair of wheels, according to the size and strength required, and in the centre of each is a pivot—the bogie pin as it is called—on which the coal waggon rests. The advantage of the system is that its wheels can encounter a very rapid curve of rails, because they are not locked into the system of a rigid wheel base belonging to the whole waggon. Each of the small trucks under the waggon is independent, and the engineer who has to calculate the curves of his line has in effect to calculate curves for the passage not of enormous waggons, but of small trucks on which the waggons are poised. The system worked so well at Newcastle that it was adopted in America as best suited to the rude roads of so vast an extent of country, and admirably has it served them, making the traffic easy, where, without carriages, it would be very rough and difficult. And now Mr. Fairlie has adopted the method of poising a carriage upon the wheels as the basis of his scheme for light railways. In testimony of its success he shows, as we have said, a passenger train in working order, careering at 20 miles an hour round a small cabbage garden. It is important to make this demonstration, because, if railways are to advance, we may be sure that many sharp turns are in store for them. To avoid these sharp turns, both in town and country, most expensive tunnellings, cuttings, and viaducts have been undertaken, which in the new order of things, fast coming, will no more be tolerated. The rail must be taught to double round a street corner or a steep hill; and in the garden at Hatcham we are shown how this may be done. Most people who have gone to Paris have made a trip to Sceaux, and seen the singularly ingenious contrivance by which the train is made to turn round at the Sceaux station, so as almost to take the form of a serpent biting its own tale. That is a complicated contrivance unfit for general use. At Hatcham we became acquainted with a simple device which may be used on the roughest roads, and at great velocities."

So far, Mr. Fairlie claims no credit for originality, but he deserves the credit of being the first to show the great uses to which the bogie can be turned in the future working of Railways. According to the present system, the superincumbent weight of a Railway carriage or waggon rests at each end of the axle-tree within the wheels. On coming to a rough bit of road there is a jolt; the carriage is jerked on one side, and its weight comes down on the other wheel, which, in like manner, conveys the force of a heavy blow to the rail; so that every bit of rough road there is a set of oscillations which occasions a destructive system of hammering, as it were, on the rail, and severely injuring the permanent way. "And how," says the writer of *The Times* articles, "is it avoided or lessened by the use of bogies? It is so, because the load—be it a carriage for passengers or a waggon for goods—is poised on pivots in the centres of two bogies. The load rests on two points which follow a line midway between the rails. There may ensue from this some slight oscillation of the carriage; but it is not an oscillation which hammers alternately on the wheels, and which can disturb to any great extent the centre of gravity. The centre of gravity is maintained in the centre of the line, so that the shock from side to side is reduced to a minimum, the comfort of passengers is promoted, and much tear and wear of rails is prevented. The point is well worthy of notice, because, in fact, we here touch upon the chief advantage of the bogie. The most obvious advantage of the bogie is that of quick turning, from which it derives its name. It renders practicable to trains the most rapid curves, and curves of an intricacy which, according to the system now in vogue among us, it would be madness to attempt. But if its power of adapting itself to curves constitutes its most obvious and showy characteristic, its most important characteristic, and that which most of all recommends it to the Engineer who seeks to solve the mighty problem of Railways, is the power which it possesses of adjusting and equalising the load upon wheels, and of steadying the train. It is a matter of no little importance that on the Railways of the future we should be able to turn about in a small space, and the bogie is, indeed, a good bogie that will help us to such an achievement. But bogie is most of all a good and clever bogie if it will lighten our load and make it easy, like the lubber fiend of the fairy tales that works for us of his own good will. And it is to this power possessed by the bogie of adjusting, equalising, and easing a load that we are now chiefly to turn our attention in discussing the problem of Railways."

It is universally admitted that in travelling round sharp curves both the existing system of coupling carriages and the system of buffers are imperfect, endangering the stability of the train and damaging the permanent way. In Lines of much curvature the buffer-heads cannot be jammed together, and hence much knocking, bumping, discomfort, and breakage. Besides which, on goods waggons and cattle trucks it is impossible in almost any case to have tight coupling, and hence much damage to goods and much suffering to the cattle; hence, also, the necessity of making these waggons stronger and heavier than they need be in order to resist the force of frequent concussions. Get rid of the buffers altogether and couple the carriages close, says Mr. Fairlie, and you will get rid of these concussions. "It is well known," he says, "nothing is so beautifully delicate in its movements as an engine passing from rest into motion. Those who may have stood on the footplate and started an engine, even without a train, know that it is done in the most graceful manner. Therefore by coupling up the train in one solid mass its movement must be as delicate as that of the engine itself, and all the damaging effects of the present system" are obviated. But how is this to be done, at the same time providing for the flexibility of the train? The ends of the carriages and waggons at present meet each other square. Mr. Fairlie proposes in the first place, that these carriages, where they meet, should present to each other a circular front. This would give them, instead of as at present, in the buffer two points of contact the positions of which are invariable, a single point of contact the position of which would be variable. If the carriages are in a straight line, they will touch in the apex of the curves which they present to each other. If they meet each other at an angle, a new point of contact will be formed upon the curve to right or left of that apex. But for this purpose the carriages must be coupled after a new method. According to the present method the coupling chains or bars hold on to the ends of the carriages—from points on the middle of the ends. But this arrangement is obviously impossible if, as Mr. Fairlie proposes, the carriages constructed with curvilinear ends are to meet normally in the middle of these curves, and are to have free play to move round each other from side to side. It is, therefore, proposed that the junction of carriages shall be effected, not between the ends where they meet, but by a draw-bar passing underneath the carriages from centre to centre. Whichever way the carriages may turn, this draw-bar, being made up of two radii of two circles which are in contact, must always be of equal length.

We have next to consider what is most peculiar to Mr. Fairlie's system, and how he proposes to work out such results, that whereas each passenger now carried weighs from 40 to 45 cwt., he shall in future weigh only 5 cwt. This is to be effected by the bogie, whose great principle is, that it distributes, economises, and eases the load. Hence it makes extremely light Railways possible, while at the same time it makes extremely heavy ones, such as are now in general use, more manageable than they ever previously were. Mr. Fairlie's theory is, that passenger trains on all Railways should be much lighter than they now are, and that goods trains should be much heavier. And not only is the question of how to deal with heavy traffic more pressing than that which concerns light, but also in examining how the bogie can be turned to account in the solution of the heavy problem, we can see its working more clearly and fully than in the case of light Railways. Let us examine the question, therefore, first of all as appertaining to heavy loads on existing Railways.

For heavy goods traffic, heavy locomotives are used; but those now employed have two faults. They eat up the rails, and their strength is limited. It is calculated that the blows produced by the violent oscillation of a locomotive going at 30 miles an hour may be taken at 60 per cent. added to the weight upon the wheels. If the nominal weight upon the wheel of a locomotive is eight tons, then the momentum of concussion may be taken as raising the weight to more than 12 tons. It is to check this tremendously destructive system that Mr. Fairlie comes forward with his bogie notion. Even before him it was deemed advisable by several Engineers who were satisfied of the good effect of the bogie to rest the locomotive upon one; that is to say, one end of the machine was made to rest upon a bogie, while the other end was sustained in the usual manner upon axles. By this means the oscillations were diminished, but they could not be entirely removed, and the locomotive made quite steady, while at one end the load was so arranged upon axles and wheels that there was a see-saw movement from side to side, coming down upon each pair of wheels with a violent shock. If the oscillation is to be entirely dissipated, there must be a complete surrender to the principle of the bogie. Mr. Fairlie, for the first time, laid the locomotive on a pair of bogies—making even its driving as well as its carrying wheels the wheels of bogies. He had in this way been so successful in getting rid of violent and destructive oscillation that Captain Tyler, the Government Inspector, declares of the Fairlie engines, on which he travelled at a speed of 50 miles an hour, that it was absolutely free from oscillation, and that its motion was so smooth as to be comparable only to flying.

The other fault of the locomotive—that of comparative weakness—only became apparent as the magnitude of loads increased. A load of 300 or 400 tons is now of daily occurrence, and the locomotives employed for such loads are ruinous in the extreme to the permanent way. We have reached the limit beyond which we cannot construct more powerful locomotives. Mr. Fairlie has come to the rescue with his answer, which is, "that by adopting the bogie system of carriage in its entirety we can solve the problem, for we can adjust the weights of the locomotive more equably, we can move it with less disturbance, and we can increase its length without lengthening the wheel base." Accordingly, he has constructed several locomotives which are not heavier than heavy locomotives usually are, which have the load so distributed upon the wheels, that upon any pair the pressure is not so severe as it is on some of the wheels of locomotives of the current type, and which, nevertheless, possess two boilers with two pair of cylinders, capable of driving a goods train loaded to 800 tons. One of these locomotives, entitled Progress, is now employed on the Midland Railway, and at a public trial of its powers performed as follows:—There is between Hendon and Kentish-town a rising gradient of 1 in 180 for more than a mile. Up this gradient the locomotive hauled from 60 to 70 loaded coal-waggons, weighing 700 tons, at a speed of 15 miles an hour. The engine is only of medium size, according to this principle of construction, and yet it possesses about twice the power of the heaviest in ordinary use.

Mr. Haggard has made the remarkable calculation that if but one penny a mile could be saved on all the miles of train run in the United Kingdom in the course of a year, there would be an additional sum of £618,000 to distribute among the ordinary shareholders. The cost of running a goods train is, on the average, about 3*s.* a mile, while its gross earnings are about twice that sum; but suppose that you double the size of the goods train, and therefore earn double, does it follow that you double the expenses? Nothing of the kind. One of the Fairlie engines, capable of performing double the task of an ordinary heavy engine, does not cost nearly double. The original price of the one may be set down at £2500, and that of the other at £3500. The fuel, oil, tallow, &c., which the one consumes is not nearly double the consumption of the other. It does not require anything like twice the number of men to attend to it. The locomotive laid upon bogies is even less destructive to the permanent way than the ordinary engine; and if the bogie principle could be adapted to the goods trucks, their wear and tear of the rails would also be diminished. Mr. Fairlie, as we understand, claims that the extra expense of the double-loaded goods train would be less than 1s. per mile, but probably this is a sanguine reckoning. Suppose we say 1*s.* 6*d.* a mile. Still there is a tempting profit left which is worth grasping at. It is calculated from the last Railway Returns that the average earnings of a goods train on our best lines are, as we have said, about 10*s.* a mile, and that its expenses are about half this sum. If trains could be doubled, the average earnings of each would be 12*s.* a mile, while the expenses would be increased to less than 4*s.*, as Mr. Fairlie maintains, but to be within the mark we say 4*s.* 6*d.* There remains on the transaction a clear gain by the new method of 1*s.* 6*d.* a mile for the dividends of shareholders. Besides which, by having one train in place of two, the road is cleared, the risk of accidents diminished, and companies are saved the necessity of constructing at great expense a third line of rails.

Turning from goods traffic to that of passengers, we meet with extreme differences of opinion. "On the one hand are Mr. Raphael Brandon, Sir John Bowring, and Dr. Farre crying out for a uniform rate of 1*s*., which will cover the cost of transit from London to John o'Groats, as well as from London to the Crystal Palace. On the other hand is Mr. Haughton, strenuously insisting on the impossibility of reducing Railway fares, and declaring just now that the engineers get the very most out of the locomotive, and present it freely and 'exuberantly' to the pessengers. On the one hand, again, there is Mr. Haggard, in his pamphlet, insisting upon the necessity of reducing the number of trains in a day; on the other hand are his critics (ourselves among them), protesting loudly against any such reduction. But at the basis of all that has to be considered there lies the fact, which cannot be too often repeated, that a ton of passengers involves, according to Mr. Haughton's calculations, a train load of 20 tons, and, according to Mr. Samuel and Mr. Fairlie, a train load of 33 tons. It is impossible to persuade us, as Mr. Haughton thinks we can be persuaded, to accept such a state of things as, under the circumstances, the best that is possible. And we cannot help regarding with some interest Mr. Fairlie's statistics when he assures us that it is quite within the reach of engineering science to carry passengers in such a manner that each one in the train shall count only for 5cwt. of a load, and not for the 40cwt. which, according to Mr. Haughton, they at present involve. In putting the comparison thus, however, it is open to misconstruction, for by a passenger Mr. Haughton understands an average weight of 2cwt., counting luggage; while Mr. Fairlie, taking note of the millions and millions of passengers who make excursions without any luggage whatever, insists that 1½cwt., or 12st., is a fair average figure at which to rate the passenger. The comparison may perhaps, therefore, be better rendered by saying that whereas Mr. Haughton declares that a ton of passengers weighs in a train no less than 20 tons, and whereas others declare that it weighs no less than 33 tons, Mr. Fairlie asserts that it is quite within the reach of engineering science to make it weigh no more than four tons. And, *primâ facie*, it must be admitted that the presumption is all in favor of Mr. Fairlie.

How the scheme will work is shown in the small cabbage garden at Hatcham, to which we now return. This garden has been visited in the last few weeks by thousands of persons—engineers, directors, shareholders, and inquisitive travellers—who are interested in Railways, and who have now the opportunity of judging for themselves what can be done. The carriage exhibited may best be described as a steam coach, with compartments, as in an ordinary Railway carriage, capable of holding 66 passengers with the usual comfort, and weighing, when fully loaded, about 18½ tons. With regard to the number of passengers which it can accommodate it should be stated that, according to the Railway Returns for 1867 (the last published), the average number of passengers to a train

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Built at a cost originally of £2000 a mile, it has yielded a dividend of 30 per cent. upon its capital, £36,000. As, however, in the course of years, £50,000 has been taken out of revenue, spent in improvements, and therefore treated as so much additional capital laid out, the dividend paid upon this total amount of capital, £86,000, is about 12½ per cent., and the Line is still improving. This marvellous little Railway, which runs from Festiniog to Portmadoc, has a gauge of no more than 2ft. It has curves which have been described as being as sharp as the sweep of Oxford Circus? It has gradients of 1 in 80; it has tunnels, one of 60 yards and another of 730 in length; and the inclination of the whole Line with its curves is such that in one direction the train goes down the steep by mere force of gravity.

This Railway was originally worked by horses. Engineers and locomotive builders were afraid of the steam-engine as applied to so narrow a gauge, on so steep an incline, varied by such rapid curves. Ten years ago the foremost engineers declared on Parliamentary Committees that locomotive power could not safely or usefully be applied to such a Line. And when at length the Engineer of the Line, Mr. Spooner, determined to test this opinion and to try the effect of a locomotive upon it, he could find no locomotive builder but one who would guarantee the satisfactory performance of locomotives upon the Line. That one was Mr. George England, of the Hatcham Iron-works. His locomotives began to work on the Festiniog Line in 1863. They did so with perfect success and without accident of any kind; but in course of time it came to pass that the requirements of the traffic called for still stronger engines, and then it became necessary to resort to Mr. Fairlie's system of the double bogie. Accordingly two very powerful locomotives of his construction, one called the Little Giant, the other the Little Wonder, have been placed on the Line, and by their extraordinary performance add to the wonders of what is itself the most wonderful Railway in the kingdom. These results are notable, not as meaning that Railways of two-foot gauge are the sort of Railways which it would be our aim to construct, but as showing that even on such a gauge, with all its disadvantages of curvature and gradient—disadvantages which the leading engineers ten years ago declared to be insuperable—the double-bogie engine has been found to triumph.

The last point discussed in these articles is the question of gauge. Is it essential to cheapness that the gauge of small Lines should be diminished? If this question should be answered in the affirmative, it still remains doubtful whether the advantage of saving thus effected is sufficient to counterbalance the inconvenience of isolating this or that branch from the general railway system of the country, established on the universal gauge of 4 feet 8½ inches; but we may state that since a gauge of 4 feet 8½ inches has been found sufficient for the heaviest requirements of our heaviest Lines, such as the North-Western Railway, it seems very absurd to widen the gauge, a widened gauge implying heavier rolling-stock, for thinly populated districts where the traffic is not to be compared with that of our Midland Counties. In Ireland the engineers ("exuberantly," as Mr. Haughton would say) widened the gauge to 5 feet 3 inches. In some of our Colonies they are still more exuberant, and for the dear delights of additional expense, lay down a gauge of 5 feet 6 inches. It is a mistake, for in fact great breadth of gauge is one of those causes which must tend to increase the load of a light goods train. Increase the size of the gauge, and you must still more increase the size of the waggons adapted to it. Diminish the size of the gauge and you can diminish the size of the waggons, diminishing, therefore, the disproportion between the goods to be carried and the capacity of the train to carry them.

THE RAILWAYS OF THE FUTURE.

(Copied from *The Times.*)

MANY persons in England are apt to suppose that we have come to the end of Railway extension. The country is so well furnished with Railways, and their financial results are so disappointing, that people are naturally loth to contemplate any further experiments on the established system. We are most grateful to the Shareholders who have been so good as to supply us with these admirable roads, which have gone far to change the character of our civilization; but there are not many of us who care to follow their example, and we cannot be surprised if they should themselves be unwilling to continue the sacrifice of their fortunes for our benefit. Still, those who are acquainted with the demand for Railways in foreign lands, in our colonies, and even in many parts of our own country, must be aware that we are speaking literally when we say that Railways are as yet but in their infancy. There is an enormous demand for them in India, for instance; and yet every man of common sense must admit that, judging by all English examples, it is perfect madness to construct them on the received system, which means ruinous expenditure and dead loss. So thoroughly is the need of a great revolution in the Railway construction perceived that some months ago we had to make the startling announcement that the Governor-General of India, dissatisfied with the slow progress and excessive cost of Railways in his dominion, had actually sent to the United States for Engineers who might confer with him as to the introduction of a more effectual and economical system—as if this were beyond the capacity of English Engineers; and we propose now to give some account of further most important investigations tending to the same result as that so earnestly desired by Lord Mayo, whose conclusions, it may be mentioned in passing, coincided substantially with those formed independently by the Duke of Argyle at home.

It may be well to begin by reminding our readers that in October last (the 19th and 20th) we gave a pretty full account of what is known as the Fairlie system of Railway working—a system by which lines of the lightest construction and very narrow gauge may accomplish work hitherto deemed within the means only of lines of ponderous construction and broad gauge, and by which also the established lines of standard gauge may either partly diminish expenses, or, without additional cost, well nigh double their carrying capacity. The characteristics of the system will appear in the sequel; for the present we proceed to state that Mr. Power, the Vice-chairman of the Poti and Tiflis Railway Company (a Railway ot 300 versts in the Caucasus), and Mr. Crawley, the Contractor for its construction, were so struck with the merits of the Fairlie system, that they strongly recommended its adoption to the Russian Government, not only for the line prepared in the Caucasus, but also for all lines throughout that vast empire, where Railways are of prime necessity, and where now, according to the new plan, five miles can be provided at a cost which was swallowed up in three miles, according to the old one. The recommendation carried the greater weight, inasmuch as the work of the Poti and Tiflis Railway were far advanced, and on a length of 15 versts the rails are actually laid down. The proposition, therefore, was that the Russian Government would find their advantage, even on these conditions, of changing the plans on which so much work had been expended, taking up the rails which have been laid down, and constructing the line on a gauge of 2ft. 6in., or exactly half the standard Russian gauge. The Minister for Public Works, Count Bobrinskoy, seized upon the idea. Mr. Fairlie went to St. Petersburg to explain his scheme in detail; and the result ot all is that an Imperial Commission has been sent over to this country to inspect the actual working of the system in various places, but chiefly on a wonderful little Railway of two-foot gauge in Wales.

The chief of the Commission is Count Alexis Bobrinskoy, cousin to the Minister of Public Works. He is accompanied by a considerable staff of Engineers, foremost among whom may be mentioned Professor Saloff, of the Russian Imperial Institute; and Mr. Roehrberg, the Manager of the most successful Railway in Russia, and by personal friends, as Count Ramoyski and Count Alexander Berg, who take an interest in the question of Railways. At the same time Mr. Fairlie offered to the Indian Government the opportunity of witnessing the experiments to be instituted for the Russian Commissioners; and they, being themselves anxious for the means of improving and economizing their own Railway system, at once resolved to take advantage of the offer. They appointed a Commission, consisting of Lieutenant-General Sir William Baker, R.E., and a Member of the Council of India; Mr. Thornton, Secretary of the Public Works Department in the India-office; and Mr. Danvers, Government Director of Indian Railway Companies, to accompany the party. Captain Tyler also, the Government Inspector of Railways, who has already reported favourably on the Festiniog Railway of two-foot gauge, attended on behalf of the Board of Trade, and Mr. Pihl, Chief Engineer of Railways in Norway, was present on the part ot the Norwegian Government. Besides these gentlemen, who went to witness the trials officially, others took an interest in the various proceedings in a private capacity; chief amongst them being the Duke of Sutherland and Count Béla Széchenyi, son of the Hungarian patriot of that name, who was well known in England some 20 years ago. The Duke took an especial interest in the inquiry, as he is not only a Director of the North Western Railway Company, but is himself the proprietor of a considerable length of Railway on his Sutherlandshire estates.

The party thus constituted started off on Thursday morning last in a special train of saloon carriages, and halting at Crewe to view the magnificent works of the North Western Railway, the largest in Europe, with the exception of those at Creuzot, in France—proceeded by Shrewsbury into Wales. At Welshpool they entered upon the Cambrian Railway system, and, with the advantage of brilliant weather, were conducted by Mr. Elias through the very picturesque country, up hill and down dale and round curves of hill sides, by which the Line passes to Portmadoc. At Portmadoc is the terminus of the Line known as the Festiniog Railway, of two foot gauge (really one foot 11½ inches), which was the principal subject of investigation.

The Festiniog Railway, which is pronounced by no less an authority than Captain Tyler, the Inspector of Railways, to be the most instructive Line in the three kingdoms, and which seems destined by its success to give a new impulse to Railway engineering, is itself one of the oldest in existence. The Act for it was obtained in 1832, but in the first instance it was constructed only for horse traction. It is a single Line, 13¼ miles in length, with a branch of one mile connecting the slate quarries of Festiniog with the quays of Portmadoc. The terminus at Festiniog has 700 feet of elevation above that at Portmadoc, the average gradient being one in 92, which is enough to secure the descent of the trains on the return journey from Festiniog to Portmadoc by the impetus of gravitation—or, as the Welshman puts it, "by its own impittence." The line runs through a rude rocky country, and has to adapt itself to an endless variety of curves along the contour of the hills, so that a train of any length has frequently to wriggle in serpentine fashion along two or three reverse curves, some of them sharp enough—the radius being 1¾ chains. On these curves the cant or super-elevation of the outer rails is never more than three inches. The line, in the old days when it was worked by horses, was originally laid with rails of 16 lbs. to the yard. When, about eight years ago, it was adapted to the locomotive, it was fitted with rails of 30 lbs. to the yard, most of which have been in use ever since. These, however, were found too light for the work, and are now being replaced by double-headed rails of 48½ lbs. to the yard. The wheels of the carriages being less than 2 feet apart, it is found convenient to arrange most of those for passengers after the fashion of an Irish car, with footboard overhanging the wheels. In this way the carriages are so low hung, and even carriages of the ordinary build are so near the ground in consequence of the small diameter of the wheels, that the expense of platforms at the stations is avoided. The whole expense of constructing and reconstructing the Line, including tunnels, one of them 700 yards in length, with branch Lines to the slate company's inclined planes and the quays at Portmadoc—in all 14 miles, has been £75,000, or at the rate of £5378 a mile. The value of the rolling stock on the Line is £28,000, or at the rate of £2000 a mile. And now comes the most important point of all, which is that the original capital of the company is £36,185, and that all the extra money which has been laid out upon the Line has been taken from revenue. In this sense, therefore, as the net revenue of the company is £10,622, it appears that the Line yields a dividend of 29½ per cent. on the original capital. A sum of £50,000, however, paid out of revenue for improvements and reconstructions, has been capitalised—making the total capital £86,185. In this sense the net revenue of the Line yields a dividend of 12½ per cent. Whichever way the fact is to be stated, it is a most remarkable one, and must fill many a shareholder's heart with envy.

The chief cause of this wonderful result is the narrowness of the gauge, which has enabled the Festiniog Company to economise in many ways. Thus, for example, the trucks for goods or minerals, even when fully loaded, have le-s of dead weight on a narrow than on a broad gauge. The best waggons on the standard gauge of 4 ft. 8½ in. are reckoned to weigh about 8 cwt., and to carry 12¼ cwt. of pig iron or coal for every foot of their length, the dead weight being in the proportion of 56 to 100 of the *maximum* paying load, or 36 per cent. of the entire load. On the other hand, the waggon for a three-feet gauge is calculated to weigh 2¼ cwt., and to carry 3 cwt. for every foot of its length,—the dead weight in this case being a very little over the proportion of 31 to 100 of the *maximum* paying load, and under 24 per cent. of the entire load. But there is still another point of view from which it can be shown that the waggons for goods and minerals on a line of narrow gauge are not so disproportionate in weight to the weight carried as they are on the broad gauge. In goods traffic it is well known that the dead weight of a train is enormous—something like 70 or 80 per cent. of the total weight hauled. If goods are to be delivered on a long line of railway, they are in this country arranged in many more waggons than are necessary to hold them, because a goods waggon cannot, like a passenger carriage, unload itself, and the train cannot wait till the unloading at a particular station is finished. It has to pass on, leaving the waggon of goods for that station behind; and it is more than probable that for this purpose the waggon has been but half or a quarter loaded. This becomes serious when waggons that weigh several tons carry but a fraction, often a small fraction, of their own weight. Such a source of expense disappears to a large extent on a narrow-gauge line, where the waggons are comparatively small, and it is but one example of the saving which may be effected in the working of such a line in addition to the saving of cost of construction in the first instance.

This remark would hold good of the narrow gauge in itself and worked according to the ordinary system; but it is in the working of the Fairlie system that the greatest saving of all is effected, and it is mainly, indeed almost entirely, in consideration of the economy, the increased power, and the diminished wear and tear which this system implies that a much narrower gauge than that now in general use has begun to find favour in the eyes of practical men. It was long before the Festiniog Railway Company could get an engineering firm to undertake to build a locomotive for a line of such steep gradients, combined with sharp curves, which they could guarantee. At last Messrs. George England & Co. undertook the task, and supplied engines which worked with perfect success, and then people began to believe in a railway of narrow gauge. One of Mr. Fairlie's engines has now been built for the line—it is called the Little Wonder, as the other engines which have preceded it have been called the Welsh Pony, the Little Giant, as well as by other diminutive names—and the result has so surpassed expectation in the power it exerts, in its gentleness of action, in its economy of fuel, in its saving of the rails, and in its adaptation to troublesome curves and gradients, that for the first time practical men have discovered that a gauge of 2 ft. 6 in., or of 3 ft. at the very utmost, is enough for the heaviest traffic. It is no secret that two engineers of eminence, Mr. Fowler and Mr. Fairlie, have pronounced a 3 ft. gauge to be ample for all the requirements of India, and there were men of position in the party which went down to Wales, men with characters to lose, who made what seems to us the hazardous statement that on a gauge of even 2 ft. 6 in. they would undertake, with the Fairlie engine, to work the heaviest traffic in the world—that of the London and North-Western Railway. Be that as it may, it must be strange for those who can remember the battle of the gauges to find that what was then known as the narrow gauge is now in its turn attacked as being much too broad, and is even described in the terms which have been applied to more than one scheme of the Brunels as a gigantic folly. Our 4 ft 8½ in. gauge is now established in so many countries—it is used not only in Great Britain, but also in France, Belgium, Switzerland, Italy, Austria, Prussia, Denmark, Egypt, the Cape of Good Hope, Australia, the United States, and Central America—that we seem to think of it as a standard of perfection. In some countries there will be found a still broader gauge—as in England itself, in Ireland, in the United States, in Canada, in Australia, in India, in South America, in Portugal, in Spain, in Russia; but in very few will a narrower gauge be found. In England we have 14 miles on a 2 feet gauge, and a few more on a slightly broader gauge; in Belgium there is a 3 ft. 8 in. gauge; in France a 3 ft. 4 in. gauge; in India may be found a 4 ft. gauge; and in Norway and Sweden one of 3 ft. 6 in.; on the Mount Cenis Railway there is a 3 ft. 7½ in. gauge; and in Queensland one of 3 ft. 6 in.; and now we have opinion tending towards a gauge of 2 ft. 6 in., or of 3 ft., as the standard for the future.

It is easy to determine on light Railways of narrow gauge, and to construct them. The difficulty is to work them, and to work them in such a manner that their capacity and their economy shall bear comparison with Railways of larger design and more elaborate construction. Hitherto Railways of light construction and narrow gauge, that is, narrower than 4ft. 8½in., have been in little favour, because of the limited power and destructive effects of the locomotive. Take, for example, the oscillation. This is very destructive on the standard gauge; it is, indeed, the chief cause of destruction to the permanent way—a fearful item of expense. But it is still worse on a narrow gauge, and necessitates diminished speed on battered rails. Therefore, practically, a narrow gauge was but of limited application to ordinary traffic until a locomotive such as that of Mr. Fairlie could be invented free, or nearly free, from oscillation. And again, since a narrow gauge generally implies lightness of construction, and since lightness of construction implies sometimes roughness of workmanship, and nearly always such an adaptation of the Railway to the surface of the country that it must dispense to a great extent with cuttings, viaducts, and other works, and must be ready to accept to the fullest extent possible a Line of sharp curves and heavy gradients, it was necessary to devise a locomotive for it capable of good and safe speed on these conditions; and there was none such of sufficient note in existence until the double bogie engine of Mr. Fairlie was produced, which combined great size and power with freedom from oscillation, and with a short wheel base that could be worked round curves of 60ft. radius and even less.

We must reserve for a day or two a full description of the performances of Mr. Fairlie's engines in Wales, because it is desirable to give the results of all the experiments, with their success and their failure together. The last of the experiments is made to-day, and we shall state all when we know all; but in the meantime we cannot be wrong in saying that there was an absolute unanimity of opinion among all those who witnessed the working of that narrow gauge Railway at Festiniog that the standard gauge of 4ft. 8½in. is far beyond all ordinary requirements. There may be some difference of opinion as to the precise gauge which is best. Mr. Spooner, the Engineer of the Festiniog Railway, strongly advocated a gauge of 2ft. 6in., and he was supported in this view by practical men of great experience; others seemed to hold that a gauge of 3ft., giving greater freedom of space, would be best, but all appeared to be convinced that a gauge much narrower than that now in general use is capable of work which is at present little imagined in the Railway world. If this view be correct, it involves some most important results. Thus, let us take an ordinary Line costing £15,000 a mile, and compare it with one of narrow gauge worked in the new system, with power of carrying equal paying loads, and costing, as we have already indicated, three-fifths of the price of the other,—namely, £9000. With a traffic return of £20 every week for every mile, and deducting 50 per cent. for working expenses, the one Railway would yield a dividend of about 3½ per cent., while the other would yield very nearly 6 per cent.; and this calculation makes no allowance for the more economical working of the narrow gauge, which is one of the main features of the system. If such a result be possible, it implies for public Lines not a little encouragement to carry the Railway system into every nook and corner of the kingdom where a moderate traffic may be obtained; and for Government Lines the reduction of tariff to the lowest point.

There seemed to be a unanimity of opinion also as to the success of Mr. Fairlie's engine adapted to the narrow gauge, and also on the broad gauge; but it remains to be seen, from the Reports which will be furnished to the various Governments, how far this unanimity extends. That the engine did some extraordinary work is clear, as we shall have to show in a future article; but whether it is or is not to be recommended for adoption as a means of making the narrow gauge available to the utmost is a point on which we have no information.

THE RAILWAYS OF THE FUTURE.

(Copied from *The Times.*)

THE object of the experiments of the Welsh Railways was to ascertain whether or not the Fairlie engine increased the carrying capacity of a railway or diminished the cost of working it. With this view two engines were put on their trial—one, the Little Wonder, on the Festiniog Railway of 2ft. gauge, in North Wales; the other, the Progress, on the ordinary gauge of 4-8½ in South Wales.

The Fairlie engine consists of one long boiler, having two sets of tubes, with double firebox between, and poised on two bogies. The arrangement is such that an enormous increased power is gained, with an extraordinary facility of movement upon swift curves, and with a freedom from oscillation which makes the Fairlie engine less destructive to the rails than locomotives of much less weight and power. The value of the system depends chiefly on the two bogies. It may be necessary to explain for some readers that a bogie is simply the name for a small truck. Instead of resting a waggon or a locomotive upon wheels of its own, which would make a long wheel-base that could not by any possibility get round very sharp curves, and that might get round moderate curves, but only with an amount of flange-friction destructive to the rails and retarding speed, the waggon or locomotive is poised on two independent trucks which have a short wheel-base, and which can, therefore, find little difficulty in curves of exceeding sharpness. In the small cabbage-garden at Hatcham, half an acre in extent, and laid out with rails of the ordinary gauge, Mr. Fairlie exhibits a steam-carriage of 45 ft. in length travelling at a speed of 25 miles an hour round curves of 50 ft. radius; and they could with equal ease and even greater safety travel round curves of 25 ft. radius, which is only about that of an ordinary engine turn-table. The engine, therefore, on a pair of bogies is prepared for a circuitous line of country, even on the standard gauge, which engines of the current type could not attempt.

The excellence of the bogie, however, does not merely consist in its adaptation to curves. It has an extraordinary effect in reducing oscillation. An ordinary carriage rests directly upon the ends of axles, and when, through any defect in the road, there comes a disturbance in the plane of movement, the carriage, the waggon, or locomotive rock from side to side with immense violence in a series of oscillations that hammer the rails to their destruction. It is calculated that these oscillations in a train going at the rate of 30 miles an hour add more than half as much again to the normal weight upon the wheel; and this is very serious in the wheels of locomotives, each of which may be loaded up to seven or eight tons. The oscillation is reduced to a *minimum* by means of the bogie, inasmuch as the vast superincumbent weight of the locomotive is balanced on a pin, called the bogie-pin, in its centre. The bogie is a flat table upon wheels, with a great pivot in the middle of it. This table, and the wheels which support it, must naturally submit to whatever deflections there may be in the road, and so far it is impossible to get rid entirely of oscillation; but the great mass of weight above, being poised in the centre of the roadway, is comparatively free from the influence of rocking, and transmits little or no hammering to the rails. A child can understand this by watching at see-saw the difference between placing a weight in the middle of the plank and dividing it between the ends. Now it is an enormous advantage thus to steady the locomotive, to reduce the tendency to oscillate, and to get rid of the violent impact upon the rails. To steady the locomotive is to make its motion safer, and to diminish the chances of its leaving the rails—a point of considerable importance on the narrow gauge. The most important point of all, however, is to save the rails, which are so perishable under the demands of a heavy traffic that there are instances in which the strongest steel rails have to be replaced in six months. The rails where the line has any curve are torn up by the flange-friction of monster engines with an immense wheel-base, and, whether the line is curved or straight, are hammered out by the oscillations of the steam engines. We have already explained how, in the Fairlie engine, the flange-friction is reduced by the substitution of bogies with a short wheel-base for the old plan which necessitates a long one; and there is an absolute unanimity of opinion as to the disappearance of oscillation with the use of the double bogie.

We have only one word more of preface before we proceed to state what were the experiments with the Fairlie engine, both on the narrow and on the broad gauge. It is that the statements we are about to make do not rest solely on our authority. The various Commissioners and other observers met together under the presidency of the Duke of Sutherland, compared their notes point by point, and came to a perfect agreement as to the facts which they were prepared to vouch for. Our facts, therefore, have the authority of documents signed by the Duke of Sutherland, as chairman of the different meetings which were held; by the Russian Imperial Commissioners; by the Commissioners of our Indian Government; by Captain Tyler, of the Board of Trade, who acted as secretary, and was mainly instrumental in putting the facts into proper form; and by others who were well able to judge.

The Little Wonder is an eight-wheeled double-bogie engine of four cylinders 8 3-16 inches in diameter, with a stroke of 13 inches. The diameter of its wheels is 2 feet 4 inches; its average steam pressure is 150 lb.; its weight is 19½ tons; its total length is 27 feet; its total wheel-base is 19 feet; and the wheel-base of each bogie, which practically has alone to be considered, is 5 feet. This engine was first of all made to carry from Portmadoc to Festiniog a train made up of 90 slate-waggons, weighing 57½ tons; 7 passenger carriages and vans, weighing 13½ tons; and 57 passengers, weighing 4 tons—in all, 57 tons. Add to this its own weight, and we have a total load of 94½ tons. This weight, it will be seen, was considerable, if we take into account the size of the engine, the narrowness of the gauge, the steepness of the gradients, and the sharpness and multitude of the curves. But the chief point of interest in this experiment had reference to the length of the train, which was 854 feet—nearly the sixth part of a mile. A train of such a length on such a line had to run often upon two or three reverse curves, some of them with a radius as short as 1⅞ chains, and it curled and doubled upon itself as it wound among the Welsh hills so that the passengers in the front carriages could, sitting in their seats, make signals to the passengers sitting in the hindmost ones. The engine, being in full gear, took this very long train up the hills and in and out among the curves at an average speed of 14¼ miles an hour, and at a *maximum* speed of 26¼ miles. Let us here add by way of parenthesis, in order not to refer to it again, that some days afterwards a similar train of 140 empty and seven loaded waggons, weighing in all 101 tons, and measuring in length 1323 feet—*that is, a quarter of a mile*—a train so long, in fact, that there were parts of the road on which it had to run on no less than five reverse curves—was by the same engine hauled up the hills at an average speed of 12½ miles, and a *maximum* of 16¼. Now, what was the result observed in wriggling along these curves? It was generally observed (we now quote almost *verbatim* from the protocol signed by the chief witnesses) that even on curves of $1\frac{3}{4}$ chains radius, and at *maximum* speed, there was very little perceptible oscillation or movement on the engine or in the carriages, and by no means such as is felt on comparatively easy curves on ordinary Railways. Nor must this remarkable point be forgotten—a fact almost incredible, but yet certified by competent witnesses—*that the oscillation diminished as the speed increased.* The speed, let it be added, is naturally less on a narrow gauge than on a broad one. Captain Tyler, the Government Inspector of Railways, was at first so doubtful of the safety of a high speed on a Railway of such narrow gauge and such wild curves as that at Festiniog that he insisted on limiting the Company to a *maximum* speed of 12 miles an hour. Since then, however, his doubts have been so completely dispersed that he has removed all restriction as to the rate of speed, and as a matter of fact the Little Wonder, when necessary, works up to 30 and 35 miles an hour.

Next day the oscillation of the Little Wonder was put to a further test, and compared with that of the other engines—the Welsh Pony and the Mountaineer—which are of the ordinary type. In this series of experiments the speed was confined to ten or twelve miles an hour on a comparatively level line, the gradient being only 1 in 1200; and the line was laid with rails weighing only 30 lb. to the yard, and not fished at the joints. On the Welsh Pony and the Mountaineer, tank engines of the ordinary type, weighing, the one ten and the other eight tons, it was found that there was a strong vertical oscillation and a lateral oscillation not so strong. On the Little Wonder, the double-bogie engine weighing $19\frac{1}{2}$ tons, it was found that when riding on the foot plates there was no oscillation whatever, vertical or lateral, perceptible—only "a smooth floating movement;" and that when riding on the bogie frames there felt a slight lateral oscillation, though was less than on the other engines. It is added that the oscillation of the Fairlie Engine being confined to the bogie, the influence of impact on the rails from the flanges of the wheels was far less than in the case of the Welsh Pony and the Mountaineer, the whole weight of these engines being in the course of their oscillations brought to bear upon the rails.

Next followed some rather tedious but very interesting trials as to the comparative powers of the two classes of engine. The Welsh Pony was selected to represent the common type of engine. It is a four-wheeled locomotive, weighing 10 tons, with cylinders $8\frac{1}{2}$ inches diameter, having a stroke of 12 inches, and with wheels 2 feet in diameter. It was in the first instance tacked on the load of 50 slate waggons full of slate, weighing $123\frac{1}{4}$ tons. To this add $3\frac{3}{4}$ tons for passengers and 10 tons for its own weight, and we get the entire load of 137 tons. With this the Welsh Pony started from Portmadoc, and, running along the comparative level (1 in 1200) of the Traeth Mawr Embankment, stopped on a gradient of 1 in 85, unable to proceed further, with 160 lb. to the square inch of steam pressure. Hereupon half the number of waggons was removed, and the load (including passengers and the engine itself) was consequently reduced to 72 tons 17 cwt. With this load it was found that the Welsh Pony could mount the gradient of 1 in 85 easily enough. Being successful with 25 waggons, the question arose could it manage more? It was then tried with 30 waggons, but on the gradient of 1 in 85 it was found that it could not start, though, since the engine-wheels did not revolve, there was no lack of adhesion. Then again the load was reduced to 26 waggons, weighing (with passengers and engine) 73 tons 16 cwt., and it was found that this was the limit of the Welsh Pony's power. It started with such a load on the gradient of 1 in 85, and carried it as far as was necessary at the rate of five miles an hour—the average pressure being 150lb. to the square inch. If the Welsh Pony could carry nearly 74 tons up such a gradient, and with this load also start on it, what could the Fairlie engine, the Little Wonder, do? It was supposed that it ought to pull double. If the Welsh Pony could, on a gradient of 1 in 85, manage 26 waggons full of slate, weighing with all else 74 tons, surely the Little Wonder could manage 52. Mr. Fairlie said he was quite prepared for this; he would stake the credit of his little engine on its power to carry such a load; and to show that he could be generous, he even added 3 waggons to the load; he thought his engine could manage 55 waggons. However, as the Welsh Pony had first of all been tried with an excessive load, it was but fair that the Little Wonder should be similarly tried. A train was prepared of 72 loaded waggons of slate, weighing 138 tons 17 cwt., with empty ones weighing 43 tons 10 cwt.; and when you add to this 56 passengers, weighing 4 tons, and the weight of the engine itself, $19\frac{1}{2}$ tons, you have a total load of 206 tons. With this load the Little Wonder started from Portmadoc (steam pressure, 165lb.), and passing along the level embankment, went up the gradient of 1 in 85 with perfect ease, and to the astonishment of all the visitors, who crowded round Mr. Fairlie and shook him heartily by the hand on such a triumph. His engine was warranted to do double the work of ordinary engines, and on trial it was found equal to treble the work. But then arose the question—the Little Wonder has pulled such a load up the gradient of 1 in 85, having had a good start on the level embankment; can it start with this load on the gradient itself? It was, perhaps, scarcely fair to make the trial, inasmuch as the day was wearing late, and the engine-driver had, through misapprehension, let the fire run low. Still the trial was made, and with perfect success. There is this further, however, to be added, that whereas the shorter trains were standing when they started, or attempted to start, partly on a curve of $4\frac{1}{2}$ chains radius, partly on a straight line, the train of the Little Wonder being much longer (it was 648 ft.) stood partly on the curve of $4\frac{1}{2}$ chains radius and partly on a reverse curve of a little wider sweep, which, of course, means an increased resistance, and might be resolved into an increase of gradient. Also let us add here, to complete the statement, what really happened four or five days afterwards, and whereas these experiments last described were intended to test the extreme power of the engines, other experiments followed to show what the Little Wonder could do, not merely in a short run, but in its ordinary daily work between Portmadoc and Festiniog. It took, for example, a train 407ft. long, and loaded to $141\frac{1}{2}$ tons, from Portmadoc to Festiniog, at a *maximum* speed of 15 miles an hour, and an average one of $11\frac{1}{4}$. The usual practical load, however, of the Little Wonder upon the average gradient of 1 in 92 is from 90 to 100 tons (exclusive of engine) at from 12 to 15 miles an hour. On a level it is calculated that its power is equal to the carriage of 450 tons, at a speed of 14 miles an hour.

After the experiments on the Festiniog Railway the exploring party met together in council, under the presidency of the Duke of Sutherland, to hear Mr. Spooner read a paper on the wonderful little Line of which he is the engineer, and to compare with each other their notes and impressions. Mr. Spooner gave ample information on every detail connected with his Railway, which in the year ending June, 1869, had a mineral traffic of 118,132 tons, a goods traffic of 18,000 tons, and a passenger traffic of 97,000 persons, but no night traffic and no Sunday trains. His paper will, no doubt, be published, and those who may be interested in the subject will find it in all the statistics of which we have given the cream. We only state here that he wound up his remarks by stating that he does not recommend for light Railways a gauge so narrow as 2ft. The gauge he recommends is one of 2ft. 6in. The large amount of traffic which can be done with ease on lines of this limit is, he said, really surprising, and with the Fairlie engine it is quite equal to that which can be earned on a 4ft. $8\frac{1}{2}$in. gauge. Hereupon the discussion became general, but we can refer to only a few of the opinions which were expressed. The Duke of Sutherland said he wished he had known more of the Festiniog Railway six years ago. "I have expended" said His Grace "about £200,000 in promoting and making Railways in the north. Had these lines been conducted on the narrow gauge, and had they in consequence cost only two-thirds of the sum that has been expended on them, I should have obtained a direct return on this large sum which I have laid out for the benefit of my estates and of the people in those remote districts. As it is I shall suffer considerable loss." Then Mr. Crowley insisted in a vigorous argument on the perfect sufficiency of a 2ft. 6in. gauge, if worked on the Fairlie system, for the heaviest traffic, and on the folly, if this were sufficient, of adding another inch to the gauge. The argument may be sound as regards heaviness of traffic, but as other considerations besides the weight to be carried have to be taken into account, as, for example, the comfort of passengers, and the bulk of goods, say in a cotton country, it is natural that there should be some difference of opinion as to the precise narrow gauge which is best. It will be seen that Mr. Fowler and Mr. Fairlie have both recommended a 3ft. gauge for India; and it is not at all unlikely that this gauge may ultimately be adopted in Russia. It is important that on this subject we should give the views of Captain Tyler, whose scientific attainments, and whose large experience as the Government Inspector of Railways, give a peculiar value to his opinions. He stated in substance at the meeting of Commissioners what will be found more elaborated in his printed reports. Thus, in a paper which he read on April 11th, 1865, before the Institute of Civil Engineers, he says:—

"It is illegal at present to construct any passenger lines in Great Britain on a narrower gauge than 3ft. 8½in., or in Ireland than 5ft. 3in. The Act 9 and 10 Victoria, cap. 87, provides (section 1), 'that after the passing of this Act it shall not be lawful (except as hereinafter excepted [with reference to broad gauge Railways]) to construct any Railway for the conveyance of passengers on any gauge other than 4ft. 8½in. in Great Britain and 5ft. 3in. in Ireland;' and (section 6), 'that if any Railways used for the conveyance of passengers shall be constructed or altered contrary to the provisions of this Act, the Company authorised to construct the Railway, or, in the case of any demise or lease of such Railway, the Company for the time being, having the control of works of such Railway, shall forfeit £10 for every mile of such Railway which shall be so unlawfully constructed or altered during every day that the same shall continue so unlawfully constructed or altered; and section 7 gives power to the Commissioners of Woods, &c., or to the Board of Trade, to abate or remove such Railways, so constructed or altered, contrary to the provisions of the Act. It would therefore appear to be necessary, before constructing any Railways for passengers on a less gauge than 4ft. 8½in., or before attempting to open for passenger traffic any Railways so constructed subsequently to the year 1846 (in which the above Act was passed), to endeavour to obtain, if not its repeal, at least a modification of its provisions. That Act was passed after the Report of the Gauge Commissioners, when there was a strong feeling against break of gauge, and when there was no immediate prospect of a third and narrower gauge being extensively required. But there is now an increasing demand for branch Railways of a minor class. Many coal and mineral lines are in use on a narrower gauge than 4ft. 8½in., and others are to be constructed with ultimate views of passenger traffic. It would therefore be an advantage if some smaller gauge were recognised; for, however objectionable the existence of different gauges on important through lines of communication may be, it is quite otherwise with respect to the use of a narrower gauge for feeding branches in districts where a similar gauge to those main lines would not be commercially practicable. Passengers change carriages under any system at the junctions of less important branches, and it is considerably cheaper to transfer heavy goods from one Railway truck to another, than to cart them for several miles, perhaps over different roads. The Festiniog Railway, on which the original gauge has necessarily been maintained, in consequence not only of its own works, but also of those of the tramways and quarry inclines running into it, is an extreme example, outdone only by the little engine which does the work of the shops at Crewe on a gauge of 18in.; and the cost of that Railway, under the peculiar circumstances of its original construction and subsequent alterations, cannot be taken as a guide for the future. A gauge somewhat wider than 2ft. would probably be desirable on any line to be now constructed, and it would hardly be worth while to desert the gauge 4ft. 8½in. in Great Brtain for any gauge wider than 2ft. 6in. But whatever the exact gauge, whether 2ft. 6in. or 3ft., or any other dimension that might be considered most suitable for lines of *minimum* traffic, there can be no question that a system of branch lines, costing two-thirds of the branches now ordinarily constructed, and worked and maintained at three-fourths of the expense of those branches, would be of decided benefit to Great Britain and Ireland, and would be most valuable in India and in the colonies; in fact wherever there are people to travel, produce to be transported, or resources to be developed, where it would not be commercially profitable to incur the expense, in the first instance, of a first-class Railway."

On the same occasion he observed:—

"It is important to ascertain what would be a suitable gauge in those instances where the traffic is not likely to be large. Farmers are now using portable Railways for transporting the produce of their fields, for bringing in their harvests, spreading manure, &c., and there seems no reason why districts which could not support a Railway on the gauge of 4ft. 8½in. should be altogether deprived of the advantages of Railway communication. The question of gauge is in one sense a question of speed. Speaking roughly, on a Railway of 2ft. gauge, with 2ft. driving wheels, travelling might be made as safe at 20 miles per hour as on the Great Western, with its 7ft gauge and 7ft. driving wheels at 70 miles per hour. I have travelled on parts of this little line at the rate of 30 miles per hour with every feeling of safety."

And again, in a Report on the Festiniog Railway addressed to the Board of Trade, he says:—

"The adoption of the locomotive power upon this little Line is very important, and has evidently been a very successful experiment. The cheapness with which such a Line can be constructed, the quantity of work that can be economically performed upon it, and the safety with which the trains run over it, render it an example which will undoubtedly be followed sooner or later in this country, in India, and in the Colonies, where it is desirable to form cheap Lines for small traffic, or as a commencement in developing the resources of a new country."

It should be noted particularly that the enquiries instituted by the Russian and Indian Governments had reference not merely to the narrow gauge but chiefly to the narrow gauge as made available by the Fairlie engine. Having examined into the working of the Fairlie engine on the narrow gauge, they proceeded southwards to see the working of another engine of the same type on the ordinary gauge on the heavy gradients of the Mid-Wales Railway and of the Brecon and Merthyr Line. The Progress was, we believe, the first built of Mr. Fairlie's engines, and has several imperfections, being, for instance, deficient in heating surface. But taking it as the first rough exemplar of the system, its performance is certainly remarkable. It is a double engine, with a four-wheeled bogie under each end, the cylinders 15in. in diameter, the stroke 22in., and the wheels (4ft. 6in. in diameter) are coupled together in both bogie frames, so that all the wheels of the engine are driving wheels. The extreme wheel base is 22ft., but, what has alone to be considered in practice, the wheel base of each bogie is only 5ft. The heating surface is on the fire-box 92ft. and in the tubes 1901ft., making a total of 1993ft. The total weight of the engine when fully equipped is 54 tons, including 1¾ tons of coals and 2000 gallons of water. Also, the engine is fitted with the Chatellier steam break, which Mr. Fairlie was the first to introduce into this country, and its extreme length from buffer to buffer is 32ft.

On the 14th of February the Progress left the Three Cocks Junction on the Mid-Wales Railway with 39 loaded waggons, 3 break vans, and about 50 passengers and workmen, making a total weight of 526 tons, including the engine. It measured 732ft. in length. The day was bitterly cold; the hour was late; Mr. Fairlie was anxious to hurry on; and not waiting for the engine-driver, who knew the road, he mounted the engine himself, and set off with his load. The result proved that though he may be a first-rate Engineer he is not a good engine-driver. A man may be a very good judge of horses and yet no jockey. An engine requires as careful management as a horse; and Mr. Fairlie, driving his own engine, made it go through its heaviest work; but when he came towards the end of the journey, and there was a trifle more to be done, it turned out that there was not steam enough to go on. The amateur engine-driver, unacquainted with the gradients, had turned on the water supply at the wrong place, and soon found himself deficient in steam. The same experiment had, therefore, to be repeated next day under the guidance of the regular engine-driver, when it was perfectly successful. The engine had to carry the load of 526 tons up several gradients and on reverse curves; the gradients were 1 in 75, 1 in 162, and 1 in 90. The total distance run was 14 miles, from Three Cocks to Builth, which was done in about an hour, including stoppages. On the same day the engine was taken to some still more severe gradients on the Brecon and Merthyr Railway. She left Tall-y-llyn with a load of 190 tons at 2·51 p.m. After running for three miles for the most part on a descending gradient of 1 in 40, she was brought to a stand at Talybout station, where her tanks were filled. She started from Talybout at 3·13 p.m., with a steam pressure of 140lb., and ascended a gradient of 1 in 35 for half a mile. She then mounted a gradient of 1 in 38 for 6⅝ miles, and passed the summit of that gradient at 4·16, with 120lb. of pressure. She passed through the tunnel--660 long, a rising gradient of 1 in 68—in 2¼ minutes, and was stopped at the Torpantan station at 4·18 p.m., the pressure continuing the same. This portion of the line, as well as the rising gradient of 1 in 38, contained curves of 12, 16, and 20 chains radius, and the train was so long that sometimes it had to pass over reverse curves. These are facts formally authenticated by official witnesses: but further authentic reports have reached London stating that since these trials the Progress has done work still more characteristic of a Hercules.

Her performance showed clearly that as the Little Wonder makes a narrow gauge Railway of 2ft. do work hitherto deemed within the means only of a much broader gauge, so the Fairlie engine, on the standard gauge, enormously increases its working capacity, and that, too, without additional cost in proportion. There is but one opinion of the engineers of the lines examined—Mr. Broughton and Mr. Henshaw—as to the effect of the Fairlie engine upon the rails. It does far more work than any ordinary engine, and yet it is far less destructive to the permanent way.

The invention of the double bogie, by which this result is brought about, is exceedingly simple—so simple that one wonders it was not thought of before. It is like the egg of Columbus—when once it was poised anybody could do the same thing. Now, when we see by the double bogie how to poise an engine so that it shall not oscillate, so that it can be indefinitely increased in size, and so that it shall not murder the rails in its violence, one is inclined to say, "We knew all this before; there is nothing novel here." There is nothing novel, the principle is obvious; but it was never before so applied as to have a practical result, and Mr. Fairlie has the credit of introducing into the construction of the locomotive one of those slight changes which lead right on to a prodigious development and almost to a revolution. We are on the brink of a new era in Railways—the narrow gauge era—an era of renewed activity, when every village, almost every farmstead, may have its Railway, and if such an era be now at hand it is mainly because the Fairlie engine, by its increased power, by its adaptation to the sharpest curves, by its economy on the rails, and by its freedom from oscillation, even upon rude roads, has rendered it possible. Bogie has arisen to the incantations of Mr. Fairlie, and promises to make the old Railways work better than they ever did before, and to make new Railways, of lighter, smaller, cheaper construction, that will vie in performance with any of the old.

THE FAIRLIE RAILWAY SYSTEM.

(From the *Sun*, 14th February.)

Further trials of the Fairlie "bogie" engines and rolling stock have been made at Hatcham, in the presence of a commission from Russia, a representative from the Swedish Government, another from Norway, the governor of the Bank of England, the chairman of the Great Indian Railway, and other gentlemen from all parts of the world. The Fairlie system of placing the carriages and engine upon trenches, or "bogies," has excited universal interest. It is designed to solve that difficult but most important problem for the future of our Railways—of how far it is possible to reduce the dead and unprofitable weight upon Railways, to make the locomotive earn more than it does at present, and thus to secure for the proprietors in them a larger portion of the gross receipts of our Railways. The latest experiments at Hatcham have proved entirely successful. A double "bogie" engine, just completed for the Swedish Government, was first tried, with satisfactory results—the course being round the "Cabbage Garden" which has become so famed. The steam carriage, which consists of an engine and carriage, running on a double bogie—the carriage 47 feet in length, and with about 40 of the visitors comfortably seated in it, was next brought out, and its performance was not less successful. Standing in the centre, as the conductor of an equestrian circus might do, the machine travelled round the circle, gradually increasing its speed until something like 20 miles an hour was attained. As it passed along, it presented its broadside full to view, the next instant the front bogie had swung round the curve, and it seemed as if the whole machine were coming full upon the spectator, the front of the bogie being nearly at right angles to the body of the carriage. Following the curve, in an instant the train was on its way along the short portion of the straight permanent way, instantly to meet with another curve equally as sharp, and to be overcome in the same successful manner. The straight lines of the carriage were almost as long as the chord of the arc traversed by the bogies, and the effect was not unlike that of a constant attempt to construct polygons in the interior of a circle, the steam carriage forming at every stage one of the sides of the polygonal figures. The motion of the carriage was singularly smooth and even, but, as might be expected, the permanent way, laid only for a temporary purpose, did not present that evenness of surface which would be obtained upon a well-ballasted road. The next trial consisted of attaching two ordinary ballast trucks, lent by Messrs. Kelk, Waring, and Co., the contractors, to the engine, and running these round the circus with the steam horse. These trucks were fitted with curved heads, so as to admit of their adjusting themselves to the curves as they passed round, and were attached by drawbars secured to the centre of the trucks, instead of by the usual form of couplings. The train, made up in this manner, passed round several times with complete success. Not a wheel left the rails, and the confidence of Mr. Fairlie and his many friends was shewn by the readiness with which they accepted seats in the trucks as they were dragged round the Hatcham circus. But when an ordinary truck was tried, it got off the Line immediately. "Everyone present could see at a glance the manner in which trucks fitted with the usual axles and couplings act on sharp curves, and how frequently accidents must occur to trains while passing round sharp curves."

RAILS AND ROLLING STOCK.

The following Report by certain English engineers on the rails and rolling stock of the new Victorian Railway, the North-Eastern, was sent to the Victorian Government last mail by Mr. Verdon, the agent-general. The Report is drawn up in answer to a memorandum drawn up by Mr. Higinbotham, Engineer-in-Chief of Victorian Railways, at the request of the late Government. The documents, as published by the Victorian press, speak for themselves, and their appearance is peculiarly opportune in Tasmania at the present time:—

(Copy.)

Engineer-in-Chief's Office, Railway Department,
Melbourne, 29th December, 1869.

SIR,

I HAVE the honor to forward herewith, for the consideration of the Hon. the Commissioner of Railways, a statement of the case to be submitted, if it meet with his approval, to such English engineers as Mr. Verdon may determine to consult. I beg to suggest that it would be convenient to print the statement to be sent home, and to forward several copies to Mr. Verdon.

The section referred to, and also a map of the Colony, showing the position of the North-Eastern Railway, will be ready in a day or two.

I have, &c.,

(Signed) T. HIGINBOTHAM, *Engineer-in-Chief.*

W. H. WRIGHT, *Esq., Secretary for Railways.*

(Memo.)

Engineer-in-Chief's Office, Railway Department,
Melbourne, 28th December, 1869.

NORTH-EASTERN RAILWAY, VICTORIA.

1. THIS Railway will extend from Melbourne to Belvoir on the River Murray, a distance of 186 miles, and is to be a single Line with passing places, but sufficient land for a double Line will be secured throughout.

2. The Line follows generally the route of the main road from Melbourne to Sydney, and there appears to be no reason to doubt that it will become a portion of a main trunk Line connecting these cities. There will, however, be a break of gauge at the border Line between Victoria and New South Wales.

3. A section of the North-Eastern Railway is attached, from which it will be seen that the ruling gradient, for the first 60 miles from Melbourne is 1 in 50, and for the remainder of the Line 1 in 75.

4. The curves are throughout easy, there being no curve on the Main Line of less than 40 chains radius.

5. The Engineer-in-Chief's estimate of the cost of the North-Eastern Railway is £9330 per mile including engines, rolling stock, stations, land, and engineering expenses.

6. Existing goods traffic is estimated to average 100 tons a day throughout the year; but a large increase may be expected on the opening of the Railway.

7. It has been urged on the Government by professional gentlemen and others that in constructing the North-Eastern Railway it would be a great mistake to adopt a system which, though suitable in an old and thickly populated country, is unsuitable in a new and sparsely peopled one; that in a new country the economical and true principle is to construct railways in the first instance at the smallest possible cost, consistent with stability and safety, improving them afterwards as the wants of the traffic require it; that expensive and substantial stations are not required, that high speeds should not be provided for, that heavy engines are destructive to the permanent-way, and that a light rail and light engines should be used on the proposed Line, as these will be sufficient for the traffic for many years to come; lastly, that if the light system of construction be adopted the North-Eastern Railway may be constructed for £6000 a mile, instead of £9300 (the Engineer-in-Chief's estimate), and with the saving thus effected, the Government will be able to extend the advantages of Railways to other districts besides the North-Eastern.

On the other hand, the Engineer-in-Chief has advised the Government of Victoria to use on the proposed North-Eastern Railway a double-headed T rail, weighing 72 lb. to the lineal yard, and the same class of engines and rolling-stock as are now in use on the lines now in operation, which are 254 miles in length, and has framed his estimate accordingly. He supports this advice on the grounds that the North-Eastern Railway will be a Main Trunk Line; that, with a view to economise construction, very steep gradients have been adopted; that on a Line with such gradients, with light rails, and consequently light engines, the traffic cannot be worked economically; that uniformity of rolling stock on all the Main Trunk Lines is important, with a view to economy in working, and that it would be unwise to adopt on the North-Eastern Railway a mode of construction which would prevent the engines which work the existing lines being used on it. Lastly, that he believes this Line will be the route for the European Mail, *viâ* Suez, to and from New South Wales and Queensland, and it must compete with the Southern Railway of New South Wales (which is constructed in the most substantial manner) for the trade of an important district in that Colony, and ought, therefore, to be a line on which trains can be run if required at high speeds. The Engineer-in-Chief denies that an alteration in the mode of construction would reduce the cost of the line from £9300 to £6000 a mile.

The Government of Victoria desires to obtain the opinions of engineers of eminence on the following questions:—

(*a.*) What kind of rail and fastenings they would advise to be used on the proposed North-Eastern Railway of Victoria.

(*b.*) What weight of rail they would advise.

(*c.*) What class and description of engines, and generally of rolling-stock, they would advise to be used.

NOTE.—The majority of the trains on the proposed line will be mixed trains travelling at moderate speed, say 20 to 25 miles an hour average. Very good ballast and sleepers are obtainable. Mr. Brereton can give full particulars with respect to the engines and rolling-stock now in use on the Victorian Railways.

(Signed) T. HIGINBOTHAM, *Engineer-in-Chief.*

(Copy.)

RAILWAYS.

8, *Victoria Chambers, Victoria-street, Westminster, S.W.*, *25th March*, 1870.

SIR,

WITH reference to your Despatches enumerated in the margin [3383, Dec. 7th, 1869; 3585, Dec. 31st, 1869; 3604, Jan. 4th, 1870], having regard to the purchase of material for the Railway Department, I have the honor to enclose herewith a communication received from the Inspecting Engineers forwarding the report of their consultations with Messrs. Bidder and Clark.

I have, &c.,

(Signed) GEO. VERDON, *Agent-General.*

The Hon. the Chief Secretary, Melbourne.

(Copy.)

18, *Duke-street, Westminster, 26th March*, 1870.

VICTORIAN RAILWAYS.

SIR,

IN accordance with your Minute of the 26th ultimo, covering Despatches from the Honorable the Commissioner of Railways and Roads, requesting us to confer with Mr. Bidder and Mr. Edwin Clark, and obtain their opinion on certain questions submitted in a Memorandum of the Engineer-in-Chief, dated 28th December, 1869, we have had repeated conferences with those gentlemen, and after full discussion, have agreed upon the enclosed joint report.

We have, &c.,

(Signed) R. P. BRERETON,
W. H. LEWIS.

GEO. VERDON, *Esq., C.B., Agent-General of Victoria.*

Westminster, March 23rd, 1870.

VICTORIAN RAILWAYS.—PROPOSED NORTH-EASTERN RAILWAY.

SIR,

IN accordance with your minute of the 26th of February last, we have, in conference, carefully considered the questions put by the Engineer-in-Chief in his Memorandum dated 28th December, 1869, relative to the character of permanent way and rolling-stock that should be adopted on the proposed North-Eastern Railway, and beg to submit the following joint report.

We have had before us the sections of the proposed line, the Report of the Select Committee on Railway Extension, 1869, with the evidence and the reports of the Engineer-in-Chief, also the traffic and other returns published by the Board of Land and Works for the year ending 31st December, 1868, and the drawings, specifications, and specimens of the permanent way, materials, and rolling-stock on the existing Government Railways; and we have further availed ourselves of Mr. Elsdon's knowledge and experience of the special circumstances of the country.

We are requested to advise on (*a*) the kind of rail and fastening, (*b*) the weight of rail, and (*c*) the description of engine and rolling stock generally that should be adopted for the new line, but before doing so it may be well to refer to the general conditions of the proposed undertaking.

The contemplated North-Eastern Railway is not to be simply a line into the interior, designed to open up a new country and create traffic for itself, but it is intended to follow the course of a main highway upon which a considerable traffic already exists, and to be ultimately the chief means of communication between Melbourne and Sydney, the two most important centres of population and trade in Australia. It is to be constructed by a Government whose resources enable them to meet whatever present outlay may be necessary or prudent, and who will probably retain the line in their own hands, and would, therefore, suffer any evil consequences that might result from an improper reduction in first cost; and, lastly, it is to be formed in connection with a very important existing system of railways.

It further appears that the country, while admitting of favourable curves, necessitates the adoption of the severe gradient of one in fifty for a very considerable portion of the 60 miles now proposed to be constructed.

Having regard to the above considerations, and to the traffic that may reasonably be expected and which should be provided for, we are of opinion that experience does not warrant the expectation of satisfactorily and economically working the proposed line with locomotives of materially less weight and power than those at present adopted by the Railway Department.

The introduction of a new class of rolling-stock would entail considerable increase in the working expenses, besides being attended with much inconvenience; and apart from such considerations, we are of opinion that no advantage is to be obtained by a change.

The returns published by the Board of Land and Works show the existing state of railways to be on the whole efficiently and economically worked, and we are unaware of any experience that would lead to the belief that more satisfactory results would be obtained from an altered system.

We therefore have no hesitation in recommending that the North-Eastern Railway be laid with such permanent way as will admit of its being worked continuously with and by the same rolling stock as the existing state railways.

The Melbourne and Sandhurst and the Geelong and Ballarat lines, which resemble the proposed line as to gradients, are laid with 80 lb. rails, and we are of opinion that this weight is not excessive, and will prove more economical in the end, but the traffic anticipated between Essendon and Belvoir is not equal to that on these lines, and no doubt the 72 lb. double-headed, recommended by the Engineer-in-Chief (who speaks with the advantage of local experience), might be adopted with perfect safety, although it is the lightest section in iron of which we could approve.

It is possible, however, by adopting a superior material and a modified form, to obtain a rail of greater strength with a slightly decreased weight.

The use of the steel rails within the last few years has been attended with such satisfactory results, their manufacture has become so much more certain, and owing to the expiration of Bessemer's patent, and from other causes, their price has quite recently been so greatly reduced that they are being generally employed in England in situations exposed to specially heavy traffic, and still more commonly in America, Russia, and other countries where a considerable sum for carriage has to be added to the original price of the rail. We think that they are particularly suited to the proposed North-Eastern Railway of Victoria, and by the adoption of a form not requiring chairs, they may at present prices be used without increasing the cost of the permanent way, as compared with a 72lb. double-headed iron rail, with chairs.

A flat-bottomed steel rail, of good section, weighing from 65lb. to 67lb. per yard, would be stronger than a 79lb. double-headed iron-rail, while it would be much more durable, and the saving effected by the abandonment of chairs would go far to cover the increase of cost of the rails, at present prices.

It is impossible to speak of the life of a steel rail under ordinary traffic from actual experience, but under extraordinary traffic the wear of the steel has been found to be at least five times that of the iron, and it is reasonable to expect that a steel rail under ordinary circumstances would last for more than 30 years without turning. It therefore becomes unnecessary to invest capital in a second head with a view to so remote a contingency.

We are informed that the sleepers that will be used will be of red gum, about 10in. by 5in., sawn on all sides; that the red gum is a hardwood timber, and therefore well suited to carry a flat-bottomed rail.

With a rail of this form and sleepers of the above character, the fastenings we should recommend would be what are called "fang bolts,"—that is, bolts passing through the sleepers, and having flat nuts, or washers and nuts on the other side.

Therefore, having regard both to first cost, and particularly to cost of maintenance, the description of permanent way we recommend for the line in question is as follows:—

Rails of steel weighing from 65lb. to 67lb. per yard, and of flat bottomed sections, having about five inches width of base, fished at the ends, and fastened by fang bolts to tranverse sleepers of hardwood, sawn on all sides, and of 10 × 5 scantling laid at distances of two feet from centre to centre at the ends of the rails, and 2ft. 6in. elsewhere.

Passing on to the subject of rolling stock we have already stated our opinion to be that no great reductions could be made in the weight of the locomotives now in use. The present English practice does not point in this direction; and, having regard to the great importance of uniformity of stock, we recommend the type of engine, as designed by Messrs. Gooch and Sturrock (which appear to be working satisfactorily) be adhered to, with only such improvements in detail as recent practice dictates. And that all future engines be made to the exact gauges, so as to secure the similar parts in each being identical, and capable of being interchanged one with another, and if possible with the engines at present in use. But, looking to the gradients of the line, the character of the traffic as described to us, the mode of working, and the speeds contemplated, we are of opinion that the engine, with six five-feet wheels coupled will be best suited to the circumstances of the case, and that it will not be requisite to provide any of the heavier engines with large driving wheels designed for higher speed. It will be time enough to supply these when through communication has been established, and the necessity for express trains has arisen.

From the foregoing observations, it will be gathered that we do not believe any radical change in the character of the rolling stock now in possession of the Government is called for, or would be beneficial. We therefore think it unnecessary to offer any remarks upon the subject of the carriage and waggon stock, the details of which must be determined according to the special requirements of the country and traffic, and can best be settled by those who have obtained experience of both. We may mention that the climate of India has been found to seriously affect the under frames, and to draw them out of shape; and the substitution of iron has led to economy of working. It may be worthy of consideration whether this would be desirable in Victoria.

We are, &c.,

(Signed) GEO. P. BIDDER.
R. P. BRERETON.
EDWIN CLARK.
W. B. LEWIS.

GEO. VERDON, *Esq., C.B., Agent-General for Victoria.*

THE ENGLISH ENGINEERS AND CHEAP RAILWAYS.

To the Editor of the *Argus*.

SIR,

I HAVE read with interest the Report of the four English Engineers in reference to the proposed rails and rolling stock for the Ovens Railway, and take exception to their conclusions on the following grounds:—

Two of the Engineers have been for some time past the Inspecting Engineers in London for this Government, and are therefore influenced to report favourably of the plant which, under their advice, has been from time to time supplied by them.

A reference in the cause "Light Railways *v.* Dear Railways," to be fair and impartial, should have embraced the opinions of eminent American Engineers, whose experience manifestly must be of more practical value than those of Engineers who are unfamiliar with the exigencies and requirements of newly settled thinly peopled countries.

The statement supplied by the Engineer-in-Chief to the referees is *ex parte,* and does not convey the views, or set forth the main facts, adduced by the advocates of light Railways.

British Railways are essentially first-class high cost roads, formed for the traffic of huge cities, and for the conveyance of enormous masses of passengers and goods at high speeds and low fares; whereas on Victorian Railways small freights have only to be provided for at a high tariff.

I wish at the outset of this review to clearly state that, in my opinion, the Engineers entrusted with the reference have given their decisions to the best of their judgment in view of the facts supplied them, but I altogether dissent from their premises, and from the impartiality of a reference to four gentlemen, two of whom sit in judgment upon their own acts.

I advance this proposition with every belief in the honorable character of the referees whose judgment I impugn.

If the Victorian Government desired a reference and a verdict which must have been beyond all cavil, why not have chosen Engineers who knew nothing of the facts or had had previous transactions with the Railway Department? The report of such experts would then have been unquestionably fair.

The foot-note to the Engineer-in-Chief's memo., dated December 28, fully corroborates my assertion.

* * * * * * *

Had a statement embodying the views of the advocates of light Railways been forwarded with that of the Engineer-in-Chief to two British Engineers, previously unconnected with this Government, I take liberty to say their verdict would have been a totally different one to that arrived at by the present referees.

I pointed out the probable result of this reference in your columns in December last. Experience has shown the truth of my observations.

I assert no reliable comparison can be made between Victorian and British Railways with the purpose of determining the description of carriage or rail necessary for the traffic of this colony, simply because the requirements and conditions of each place are entirely dissimilar.

* * * * * * *

In the London *Times* of the 19th and 20th October (which all our legislators should read), and subsequently in your columns, it has been proved to demonstration that every British Railway passenger is encumbered with two tons dead weight, in the shape of enormous engines and carriages. Surely, without courting danger, we may cast off a portion of this incubus. Twenty-five years since British Railways were marvels of commercial success; at this day, with the bitter experience of costly construction, they have been brought to bankrupt exchequers and infinitesimal dividends.

* * * * * * *

We are told nothing less than heavy engines, cumbrous rolling stock, and steel rails, will carry our 50 tons (each way) of daily traffic. Who believes this? Does our Legislature? Do our people? If so, such credulity is truly marvellous.

It has been repeatedly urged that light Railways are dangerous. Is the American buggy dangerous because it is light and elastic; or is it one whit less capable of carrying as many passengers as that antiquated Noah's ark, yclept the English dogcart? In Tasmania to this day its people regard with peculiar veneration the English stage coach with slippered drag, the cumbrous phaeton, and the ancient dogcart of our primitive fathers, and until very recently their coachmen decked themselves in the garb of the Georgian era, and levied black mail for the privileges of the box-seat.

* * * * * * *

Of a verity we are a peculiar people. In discussing the foregoing I wish to disclaim any animus. The Engineer-in-Chief has doubtless an honorable ambition in his design of constructing a first-class Railway, which shall perpetuate his name and fame. Our architects court the same distinction when erecting their handsome houses in our streets and suburbs. Personal considerations, however, should not for one moment have weight with our Government in deciding such momentous questions, pregnant as they are with the well-being and prosperity of the people of this province.

I am, Sir,

Your obedient Servant,

May 21. (Signed) W. A. ZEAL.

RAILWAYS IN AUSTRALIA.

THE following is from a new work on Railways by Sir Cusack Roney, which was still in the press when the mail was despatched. It has been forwarded for insertion in our columns by the author:—

Australia has not made as rapid progress in respect of the construction of Railways as might perhaps be expected. She had not, however, been altogether unmindful of her interests in this respect. Of the four great modern divisions of the Australian Continent, New South Wales had, at the commencement of the present year, 263 miles, and the expenditure upon them had been £2,746,373; Victoria, 272, with an expenditure of £9,905,634; Queensland, 78, with an expenditure of £617,658; and South Australia 56. The expenditure for Railways in this Colony is not stated in the returns before us. It will thus be seen that the aggregate length of the Australian Railways is 669 miles.

In the New South Wales Province there are three main lines, all of which commence at Sydney—the Great Southern, the Great Western, and the Great Northern. The first is to extend through Goulburn to the Murray River at Albury. Although some of the works on this line are very heavy, and there is a long tunnel to complete through the Gibraltar Mountains; nevertheless, it is expected that the line will be completed in 1868. The Great Northern will extend to Muswell Brook on the Hunter River, sixty miles north-west of Maitland, and 153 miles from Sydney. The third, or Great Western Line, is to extend to Bathurst on the Macquarie River, 122 miles from Sydney. New South Wales has its Windsor and its Richmond, and these places are accommodated with Railway communication from Sydney. When the several lines now open and those now in process of construction are completed, the Colony will have 500 miles of Railway within its limits.

The Victorian Railways consist of two main lines, one from Melbourne to Castlemaine (Mount Alexander gold-fields) and Sandhurst (Bendigo gold-fields), 101 miles long; and the other from Melbourne to Geelong and Ballarat, with a branch to Williamstown (the port of Melbourne). The total length of this second line is ninety-six miles. The Geelong and Melbourne Railway was purchased from the shareholders by the Government in 1860. An extension from Sandhurst to the Murray River at Echuca, fifty-six miles long, is in progress, and will be opened next year. Echuca is 150 miles distant from Albury, the terminus on the Murray River of the intended southern extension of the New South Wales Railways. There will, therefore, not be direct Railway communication between Sydney and Melbourne, at all events for the present. The gauge of the New South Wales and Victorian Railways is 5ft. 3in.

The Railways of Queensland consist of two main trunk lines, one for the southern districts from Brisbane, at the head of the Moreton Bay navigation, and one for the northern districts from Rockhampton, at the head of the navigation at Keppel Bay, running nearly due west into the interior, passing through Westwood and other townships, and traversing the extensive Leichardt district, whence it will be eventually extended to Claremont, a township of the Peak Downs, distant 220 miles from Rockhampton. This extension, when completed, will open out a vast territory, and will give the same facilities for the inhabitants of the province to transport their enormous yields of wool to the sea-board as India now possesses for its cotton. The first section of this Railway from Rockhampton is on the eve of completion.

As regards the southern line, it has been open more than a year from Brisbane to Ipswich. Its extension to Toowoomba (sixty-two miles) will, it is expected, be ready for traffic early next year; and later, two forks, one extending north west towards Dalby, and the other south west to Warwick, in the direction of Dumaresq River, which forms the boundary between the southern inhabited portion of Queensland and the northern of New South Wales, will be completed.

The gauge of the Queensland Railways is 3ft. 6in., and the reason for its adoption in these narrow proportions was to save the great additional cost which construction on a wider gauge would have entailed in passing through the extremely difficult country between Ipswich and Toowoomba. Two ridges of hills have to be crossed, one 700 feet and the other 1400 feet above the level of the land at their bases. The main range incline is sixteen miles long, and upon it there are eleven tunnels, the longest of which is over three-quarters of a mile, all of which require lining with stone or brick. The total number of bridges is forty-seven; their total length is 15,196 feet, or eighty-four feet less than a mile. In one locality they are so crowded together that there are eight in three-quarters of a mile. The longest is 535 feet; the greatest in height is seventy-three feet over the rails. The steepest gradient is one in fifty; the longest at that rate of inclination is 1820 yards; the total length of it is 4 miles 280 yards. The average gradient of both inclines is one in seventy.

On the lesser range there are two tunnels, one of 586 yards and the other 120 yards, on a curve of 120 yards or five chains radius. The low-lying country at the base of these two mountain ranges is intersected by streams and water-courses, which in the wet season become heavy torrents, overflowing their banks, and thus necessitating an amount of bridging and water-ways as great as, for a like distance, in any other country of the world. Notwithstanding these heavy works, the passages through the mountain have been constructed at a cost of about £15,000 a mile. On the lengths presenting only ordinary difficulties they have been made at about £6000 a mile.

The South Australian Railway extends from Adelaide in the direction towards Murray River, not far from where it flows into Lake Alexandra.

The number of passengers conveyed on Victorian lines in 1866 was very great—3,361,312. They also transported 482,314 tons of goods. The number of passengers carried on the New South Wales Railways was 751,587; but the amount of goods was nearly equal to that on the Victorian lines—416,707. The South Australian carried on its fifty-six miles of Railway 402,550 passengers and 261,183 tons goods. Owing to the failure of the harvest, there has been a considerable falling off in the business of the South Australian Railways in 1866.

New Zealand opened its first Railway—from Christchurch to Lyttleton—six miles in length, in the summer of 1867. Tasmania is also becoming alive to the importance of its having Railways running from its seaboards to the interior.

COST OF RAILWAY EXTENSION.

To the Editor of the *Argus*.

SIR,

I AM requested by several who take interest in the matter to ask you to publish the following details of the Railway recently opened for traffic between Strathalbyn and Encounter Bay, in South Australia. The line is twenty-two miles long. It is constructed strong enough for use by locomotives at a speed not exceeding fifteen miles an hour. The roadway is ballasted with limestone. It passes along a country that has a high range of hills on one side, and Lake Alexandra on the other. It therefore has to cross various gullies, watercourses, and intermediate rises, necessarily involving cuttings, culverts, and embankments. It crosses the Currency Creek on a viaduct of iron girders, resting on six piers of rubble masonry, with brick quoins, each eighty feet high. Of the seven openings five have a span of thirty feet, the other two are twenty feet each. The total length from abutment to abutment is 280 feet.

The river Finnis is crossed on a bridge of three arches, each twenty-eight feet span. The height from the water-level to the rails is forty-six feet. The total length of the structure is 106 feet. The piers and abutments are of handsome stone, and the arches of brick. The parapet is of brick, with stone dressings. The line approaches the bridge on an embankment thirty-six feet each way, and containing 64,000 cubic yards of earth. The piers first erected were washed away by a flood in the river; the present piers are therefore protected by sheet piling driven round the base of the abutments to a depth of sixteen feet, with the intervening space filled with concrete.

The Black Swamp is crossed on piles 28 feet to 30 feet long, of the best Jarrah and red gum; the framing, of the same timber, rests upon iron girders. There are five spans of 40 feet each, with a height of 44 feet. The sleepers are partly half-round 7ft. 6in. long, and 9in. in diameter; the remainder, of sawn gum, 9ft. long, 9in. wide, and 4½in thick, 2011 being used per mile.

The rails weigh forty pounds per lineal yard, and are fastened to the transverse sleepers by dog spikes. No chairs are employed, and the rails are firmly united together by fishplates, each pair being fastened together by four bolts, and is considered thoroughly adapted for locomotive traction whenever it may be deemed desirable to substitute it for the horses which it is intended to use until the traffic is shown to be large enough to require steam power. The heaviest gradient is one in sixty-four, and that only for one-seventh of a mile, and the line works so easily that on the evening of the day it was opened six horses drew a train conveying 1300 bushels of wheat from Strathalbyn to the port. The stations, sheds, and stables are of wood, covered with galvanised iron. The gauge of this Railway is 5ft. 3in., the same as our Victorian main lines. It seems to me well adapted to combine the great boon of Railway extension with economy in adding to the public debt of the Colony; for it was publicly stated by the Commissioner of Public Works when the line was opened, that it had cost £4500 per mile, which was more than it should have cost, by reason "of mistakes which had been perpetrated."

As a resident on the Wannon, I am convinced that the western districts are paralysed for want of a cheap and certain means of access for their produce to the markets of the colony; and it seems to me that a Railway such as I have described is the very thing we want; for if it worked at a speed of only ten or twelve miles an hour, until it joined the main lines now existing, it would answer every reasonable requirement, at a cost per mile little exceeding that of a metalled line of main road; for it is hardly possible to find a line through the western districts with so many engineering difficulties to each length of twenty-one miles as exist on the Strathalbyn Railway. It further seems to me but fair and reasonable that, as the western districts have to contribute to the support of all Government Railway extension, they should be permitted to partake of its benefits, especially when about to be made to support further extensions for the avowed benefit of Riverina and New South Wales. It has never been disputed that the western districts have contributed a very large portion of the land fund and of the general revenue, and there is no argument yet advanced in favour of the Albury Line that does not equally apply to the western districts, except that of developing our neighbours of New South Wales in preference to, and at the expense of, our own people. Mr. Archer's statistics of 1867 show that on the line by way of Ararat there is a larger mining population than there is on the Albury line; and that the Victorian population to be benefited by that line numbers 39,725, with an annual rental of property of £189,971, of the total value of £1,039,546; while in the western districts, including and west of Colac and Scarsdale, and including and south of Ararat, there is shown a population of 82,864, with property valued at £9,316,726, yielding an annual rental of £978,492.

If the Strathalbyn Railway were to be examined on behalf of Victoria, and found to be suitable for developing the traffic of our thinly-peopled districts, might it not also be found a means of affording Railway extension both to Albury and to our western districts by means of the loan authorised last session?

I am, Sir,

Your obedient Servant,

(Signed) JNO. B. HUGHES.

RAILWAYS AND THEIR CONSTRUCTION.

Mr. Higinbotham, the Engineer-in-Chief, has reported as follows on the plan of Mr. J. B. Hughes for the construction of cheap Railways:—

Engineer-in-Chief's Office, Railway Department, Melbourne, January 14th, 1869.

Sir,

Referring to the memorandum of the Hon. the Commissioner of Railways, dated the 12th instant, instructing me to report for his information "upon the minimum cost per mile at which good Railways can be made, say from Portland to Hamilton, from Geelong to Hamilton, and from Melbourne to Sale, to be worked at a maximum speed of fifteen miles per hour for passenger traffic, station accommodation to be of the cheapest kind possible," I have the honour to report that, assuming, where surveys have not been made, the country between the various points named to be of the same average character as that between Essendon and Belvoir, on the North-eastern Railway, a single line of Railway, with rails weighing 40 lb. per lineal yard, with a low but sheep-proof fence on each side of the line, may be completed, exclusive of rolling stock and stations, for the sum of £4650 per mile. The cost of rolling stock and stations will depend on the traffic on the proposed lines; but if this be very light, say £12 per mile per week, the cost of rolling stock and stations of the cheapest possible kind would probably amount to £1200 per mile, making the total cost of such a line as I have described £5850 per mile. I have not included in this estimate the cost of purchasing land for the Railway, as I have understood that in all the districts named proprietors would be glad to give the land required without charge, if by doing so they could obtain the advantages of Railway communication. The above estimate does not include preliminary expenses in surveying and setting out the lines, but it does include the cost of engineering and all supervision in constructing them. The estimated cost of the proposed North-eastern Railway is £9300 per mile, and this includes engineering, land, rolling stock, and stations. I should be deceiving the Government if I were to lead it to expect that for the sum of £5850 per mile it can obtain, in any of the districts named, a line of Railway at all so durable and efficient, or that can be so cheaply maintained and worked, as the proposed North-eastern Railway; but a line well suited for a light traffic, carried at a speed not exceeding fifteen miles an hour, with light rails and bridges, and culverts built of timber, may, I feel sure, be made in any of the districts named at the rate per mile that I have given.

I have the honor to be,

Sir,

Your obedient Servant,

(Signed) T. HIGINBOTHAM, *Engineer-in-Chief.*

W. H. Wright, *Esq., Secretary for Railways.*

RAILWAY EXTENSION.

To the Editor of the *Argus.*

SIR,

WILL you favor me with space in your journal for a few more remarks on this very important subject, more particularly in reference to the question—" Will new lines in this country pay five per cent. interest on the cost of construction over and above working expenses?"

I shall commence by stating that the cost of the Victorian Railways, 252 miles in length, was somewhere over £8,000,000, or say about £32,000 per mile, the gross receipts from which in 1867 were £552,031, and the working expenses amounted to £267,071, leaving a net profit of £284,960, or about 3·56 per cent. on the outlay. If these lines, however, had been constructed at, say, £6000 per mile, the cost would only have been £1,512,000, and it is probable that the same amount of revenue would have been available, viz., £284,960, thus showing 18·58 per cent. on the outlay.

Let me now estimate a line of fifty miles, to be constructed at a cost of £6000 per mile, which would be a total outlay of £300,000, the interest on which, at five per cent., would amount to £15,000 per annum, requiring a gross revenue of at least £30,000 to meet working expenses and interest—the working expenses being generally about 50 per cent. of the gross revenue, that on the Victorian lines being 48 per cent., and they are not considered to be the most economically managed. The question now is, what amount of traffic is necessary to make up this sum of £30,000 per annum? Sixty tons of merchandise per mile per day at 5*d.* per mile (the lowest rate, I think, on the Victorian lines) would amount to £1 5*s.* per mile per day; at fifty miles would be £62 10*s.* per day, and £19,600 per year of 313 working days. Seventy-five passengers per mile per day, at an average of 2*d.* per mile, would amount to 12*s.* 6*d.* per mile per day; at fifty miles would be £31 5*s.* per day, and £9800 per year of 313 working days. Total for goods and passengers, £29,400; working expenses, say 48 per cent. of gross revenue, £14,400, leaving a balance of £15,000 to meet interest at five per cent. per annum. Again; the gross revenue on the Victorian lines average £2190 per mile per annum; but, as is shown by the above estimate, new Railways at a cost of £6000 per mile require less than one-third of this average income to cover interest and working expenses.

Any district, therefore, that can turn out traffic to the extent above shown (and it must be poor indeed if it cannot do this) need not fear to guarantee interest at 5 per cent. on an outlay of £6000 per mile, because the estimate is surely low enough stated as compared with existing lines to vindicate the prospect of double the amount being the result of actual traffic after completion of the line.

I cannot, however, agree with your correspondent "Subscriber," who, in his letter a few days ago, recommends the combination of shire councils in guaranteeing interest on the outlay, and undertaking the construction of the works. Shire councils have already sufficient work to perform, and for them to undertake such works would lead in many instances to considerable confusion from misunderstandings amongst the various councils, outside the question of Railway management. If Railways are to be constructed under guarantee by any public body let boards in each district be specially appointed for the purpose, having no other conflicting interests to bring into their deliberations besides that of Railway management; or, as I have before stated through the medium of your journal, public companies having a direct interest in the development of the traffic and the resources of the district under control of, and endowed by Government, would, in my opinion, be the easiest and most economically managed, and prove most conducive to the interests of the country.

I am, &c.,

(Signed) J. M. T.

THE following letter has been addressed to the Acting Commissioner of Railways by the Engineer-in-Chief:—

Engineer-in-Chief's Office, Railway Department, Melbourne, 28*th May,* 1869.

SIR,

I have the honor to submit to you the following observations, which, it appears to me, should have due weight given to them before it is decided to adopt for the proposed North-Eastern Line of Railway what is commonly called a cheap mode of construction, but which would more properly be called a light mode of construction, inferior to that which I have advised the Government to adopt, which the North-Eastern district has been led to expect, and for which funds are provided.

To avoid misapprehension, I beg to state at once that my observations apply only to the North-Eastern Railway [5ft. 3in. gauge], and that, when the circumstances of the case are such as to require lines of light construction only, I am in favour of such lines being used. I believe that there are many lines in Victoria where a light mode of construction may be adopted with advantage.

The English correspondence will have shown you that there are no new modes of Railway construction where ordinary circumstances have to be dealt with. Fell's system was designed to meet a case altogether exceptional; one which does not exist here, namely, the crossing of the Alps; and it is a more expensive system than the established one.

The choice, therefore, lies between a substantially constructed line and a lightly constructed one, and should be determined by the character of the work that the railway has to do.

The difference between a light line of railway and a substantial one consists mainly in the weight of the permanent way materials, and the quantity of ballast. The land, fencing, earthworks, bridges, culverts, stations, engine-power, rolling stock, and engineering would be the same, whether a light line or a substantial line be used to do the work of a given district.

The line from Melbourne to Albury, 186 miles long, will form a portion of the main line from Melbourne to Sydney, the whole distance between the two places by this route being, say 506 miles. The New South Wales Government has completed a line of the best and most substantial construction, from Sydney to Goulburn, a distance of 120 miles, so that, on the completion of the line to Albury, there will be a gap in the railway communication between the two cities of 200 miles only.

If a substantially constructed line be made from Essendon to Albury, a saving of twenty-two hours in the transmission of the mails between Melbourne and Sydney may be at once effected, and Melbourne would become the terminus of the mails *viâ* Suez; but this advantage will be lost to a great extent if a light line be made, as the highest possible speed, consistent with safety, on such a line cannot exceed twenty-five miles an hour, and the average will not exceed fifteen miles.

Again, the North-Eastern line is intended to secure to Melbourne the trade of a very large and important district of New South Wales; but it will have to compete for this trade with the line from Sydney to Goulburn; and I need not point out that, if constructed as a light line capable of low speeds only, it will compete on most unfavourable terms with the greatly superior line from Goulburn to Sydney.

As regards the population to be accommodated along the North-Eastern line, Kilmore, which is 37 miles from Melbourne, will, in point of time, if a light line be made, be as far distant as Taradale, which is 62 miles; and Seymour, which is 60 miles from Melbourne, will be as far off as Sandhurst which is 100 miles. Wangaratta, on a light line, will, in point of time, be 96 miles further from Melbourne than if a substantial line be made. The distances to all the other towns along the line will be similarly affected; and the journey from Melbourne to Albury will occupy nearly twelve and a half hours, instead of seven and a half hours.

What will be gained by constructing the North-Eastern Railway as a light line to compensate for all the serious disadvantages that I have pointed out? The only saving will be in permanent way materials and ballast; these have cost, according to an official document published in South Australia, £2269 per mile on the Middleton and Strathalbyn line; and my estimate for permanent way, including ballast, for the North-Eastern line is £3421 per mile. There will, therefore, be a saving by using lighter rails, &c., and less ballast, of £1152 per mile, or on 181 miles of line £208,510, representing, at £5 per cent., an apparent saving of £10,425 a year. But this will not be saved, for the light line, with a given traffic, cannot be worked and maintained as cheaply as the substantial one, and the increased expense in working and maintenance will, I believe, far exceed the saving in interest. The whole cost of the Strathalbyn line, exclusive of rolling stock and stations, is £4676 per mile, and the estimated cost of the North-Eastern line, exclusive of rolling stock and stations, is £7300 a mile; and this sum includes a provision for contingencies of £800 a mile, which may or may not be required. If not required, the comparison will stand as £4676 per mile on the Strathalbyn line to £6500 on the North-Eastern; of this difference £1152 per mile is due to the permanent way of the latter line being of a superior character to that of the former, and the rest to the more difficult character of the country to be dealt with on the North-Eastern line.

No comparison should be made between the rolling stock and stations required for different lines of railway, unless it can be shown that the circumstances are such as to justify comparison. A heavy traffic cannot be done with the same rolling stock and stations that would be sufficient for a light traffic, any more than the traffic of the main Sydney road could be carried on with the same number of horses and waggons as the traffic of a cross-country road.

I have the honor to be,
Sir,
Your obedient Servant,
(Signed) T. HIGINBOTHAM, *Engineer-in-Chief.*

The Hon. J. F. SULLIVAN, *Commissioner of Railways.*

LIGHT RAILWAYS.

To the Editor of the *Argus.*

SIR,

SOME seven weeks since the Commissioner of Railways was asked "if the Government had had under consideration any system of cheap Railway construction?" The reply was—"The various forms of cheap Railways suggested were absolutely inadequate" for the traffic expected "on the North-Eastern Line." This leads to the inquiry, what is a cheap Railway, and in what does it differ from an expensive Line? A cheap Railway is one whose rail level follows closely the surface of the country it traverses, obviating the necessity of costly viaducts on the one hand and heavy earthworks on the other. The masonry, ballast, and permanent way are of equal quality to similar material on costly lines; but a rigid economy governs its general design. If the whole population of Victoria was settled on a Railway, say between Melbourne and Sandhurst, a cheap Railway would serve for all present wants, and those of a future generation.

A dear Railway may be exemplified by quoting the North-Western (English) Railway. This line has similar permanent way for rolling stock to Victorian Railways, yet the English Company does fifteen times the work of our State Railways; *i.e.*, with a lower goods and passenger tariff, the North-Western Company earns £17,206 per day, as against the higher tariff of Victorian lines producing £1572 per day. Surely such elaborate provision is not required here, and is it wise to perpetuate similar mistakes? Our Railways require four goods and four passenger trains each way per day. Has any economist ever considered how many more trains leave either the Euston, the Paddington, the King's Cross, or the London Bridge Stations each day? and can it be gravely argued that in a new country as costly a provision should be made as for those enormous cities and towns through which the English Lines pass?

The population of Victoria is in round numbers 700,000, out of which Melbourne and suburbs, according to Mr. Archer, has to be credited with 170,000. The same authority tells us there is a population of 55,000 on the Ovens line, and 5000 in the territory of New South Wales who would probably use the Ovens Railway. Now, what proportion of the inhabitants of Melbourne would use the Ovens line? This is, of course, a debateable question. I think, however, it may be safely assumed that three-fourths of the inhabitants of Melbourne would not use the Ovens Railway. Therefore, we are about to spend £2,000,000 sterling to accommodate 100,000 people.

According to the official returns for 1867, Victorian Railways have cost £10,885,759 8*s.* 2*d.*, exclusive of compound interest, a vote of £35,000 for contracts then in hand, and the unadjusted claim of the contractors for the Ballarat Railway.

The 263 miles of Railway in New South Wales have cost £2,746,373—just a fourth of our outlay, and any person who has crossed the Blue Mountains between Penrith and Bathurst, will admit our engineering difficulties are trivial compared to those encountered in that mountain chain. Eminent English engineers informed us that at Mount Cenis the locomotive readily surmounts gradients of 1 in 12 over curves of 2 chains radius. Such information should make us pause before plunging the Colony into an abyss of debt from which there is no escape.

When huge towns like Liverpool and Birmingham have sprung up in the interior of Victoria, provision can be made for their wants; in the meantime, let us save both principal and interest. How many miles of Railway would America have possessed had her cheapest lines cost £9600 per mile? And before spending that sum on the Ovens line, should we not duly consider the systems finding favour in new countries? In my judgment, such experience should have greater weight with us than that gained in the densely populated States of Europe. I am aware that in the United States there are hundreds of miles of inferior Railway, but to condemn the whole system because part of it is imperfect is childish, and unworthy our maturer judgment. If this province had been part of the United States, Railways would have covered its surface; the Ovens line would already have been made at £3000 or £4000 a mile, and Melbourne and Fort Bourke would have been in daily communication. For such results we might readily pass over minor imperfections.

In England, in 1845, the following Railways had been made (single line narrow gauge) at a less cost than our Government estimate:—York and Scarborough, 42 miles, cost £6000 per mile; Dundee and Arbroath, cost £8600 per mile; Northampton and Peterborough, 47 miles, cost £9136 per mile. The Great Northern and Western (Irish) Railway, 5ft. 3in. gauge, cost £6000 per mile. In India, the Bombay and Madras line, 330 miles in length, 5ft. 6in. gauge and 72lb. permanent way, cost £7000 per mile. From Arconum Junction to Conjeveram, 19 miles, gauge 3ft. 6in., the cost was £3500 per mile complete; on this line a speed of 40 miles per hour has been obtained. In Norway, from Grundsett to Hamar, 24 miles, a Railway 3ft. 6in. gauge has been constructed by the Government at £3000 per mile; and from Trondlegen to Staren, 30 miles, through a very difficult country, the cost has been only £6000 per mile. In the Department of the Bas Rhin (France) modern lines have been constructed at £7400 per mile. In America thousands of miles of substantial Railways have been made at a less cost than £6000 per mile. A cheap Line in Ohio cost only £1100 per mile. In Turkey English engineers have constructed good Railways at £5000 per mile. In South Australia equally satisfactory results have been obtained at a less sum than £5000 per mile.

Before committing ourselves to a large expenditure (and if the experience of English companies is worth contemplating) we may learn the following:—In 1864, 91 English, 28 Irish, and 11 Scottish Railways paid their proprietors no dividend, the most glaring instance of mismanagement being that of the London, Chatham, and Dover Railway, the most recently constructed of English Trunk Lines.

The Horsham Shire Council in April last affirmed a resolution offering to guarantee five per cent. interest on a Railway to cost not more than £6000 per mile. Such a *boná fide* instance of self-help deserves the consideration and support of Parliament, and an inquiry whether the sum at present voted for Railway construction would not only make the Ovens Line, but afford substantial assistance to the Eastern and Western districts of the Colony.

I am,
Sir,
Your obedient Servant,
(Signed) W. A. ZEAL.

Melbourne, 29th May.

Expensively constructed Railways with elaborate station accommodation, however necessary for densely populated districts, are unsuitable for new countries.

Railways in Europe are now constructed on what is termed the "light" principle.

If substantial Railways could not have been made at a less cost than £9600 per mile (as contended by the Engineer-in-Chief), the entire American continent would practically have been without Railways.

There can be no analogy between the requirements of the Ovens District and that traversed by the London and North-Western (English) Railway, with its capital of nearly £80,000,000, its annual revenue of £6,276,879, and a fixed population more than ten times the aggregate of that of the whole colony of Victoria, and yet the engines and rolling stock proposed for the Ovens District Railway are to be in all their essential requirements as complete as those of the English company.

In 1864, owing to their great cost and reckless expenditure incurred 91 Railways in England, 28 in Ireland, and 11 in Scotland paid no dividend.

As early as 1845, Railways were made in England at a less cost than that proposed for the Ovens Line. The York and Scarborough, 42 miles, cost £6000 per mile. The Dundee and Arbroath cost £8600 per mile. The Northampton and Peterborough, 47 miles, cost £9136 per mile.

In America, upwards of 10,000 miles of good substantial Railway, accommodating districts far more densely populated than any in Victoria, and traversing mountainous regions and ravines, have been constructed at a cost of little over £5000 per mile.

The Great Northern and Western (Irish) Railway cost £6000 per mile, including works not required in a new country.

In India, a Railway from Arconum Junction to Conjeveram (18 miles long, gauge 3 feet 6 inches) cost £3500 per mile, on which trains have run up to 40 miles per hour, including stoppages. The Railway from Madras to Bombay, 330 miles in length (5 feet 6 inch gauge and 75 lb. rails) cost £7000 per mile, including rolling stock, &c.

In Norway, a Railway (24 miles long, gauge 3 feet 6 inches), from Grundsett to Hamar, has been constructed by the State Engineer, at a cost of £3000 per mile, including all contingencies. The Railway from Trondlegen to Staren (30 miles) through a very difficult country (gauge 3 feet 6 inches) cost, including stations, &c., £6000 per mile. The Government Report avers that "these Lines have already more than paid their expenses, and their working has been so satisfactory the system is being extended."

In Turkey, substantial Railways have been made at a cost of £5000 per mile, including rolling stock, stations, &c.

In South Australia, a Railway on which the locomotive is to be worked has cost barely £5000 per mile, and the engineer reports most favourably of it, and recommends its adoption for new countries.

In the department of Bas Rhin (France,) modern Lines have cost £7400 per English mile, whilst the Paris and Orleans cost £23,600, and the Paris and Rouen £26,000 per English mile.

The gross revenue of Victorian Railways, accommodating *three-fifths* of the population of the Colony, barely equals £575,000 per annum, and saddles the province with a *yearly deficit* of £300,000. Assuming the Ovens Railway (at £9600 per mile) to cost £2,000,000 sterling, and calculating the traffic at one-fourth of the revenue of the State Railways—an outside estimate—the *annual deficit will be* £30,000, which the taxpayers will have to make good. If, however, it is constructed at £6000 per mile, it may probably meet its liabilities.

Expensive Railways worked on the English system are altogether unsuited to new countries; too costly to work, and too elaborate in their design, they create pecuniary difficulties, and discourage their extension.

Light Railways worked on the American system, with light and inexpensive rolling stock, would pay in almost any District in Victoria, and tend more towards the settlement of the country and the development of its resources than any enterprise heretofore initiated.

(Signed) W. A. Z.

THE COST OF RAILWAY CONSTRUCTION.

To the Editor of the *Argus*.

Sir,

In the recent letters in the *Argus* I endeavoured to direct public attention to two systems adopted in South Australia, each of which I believe to be more suitable to the means and requirements of Victoria than that which Mr. T. Higinbotham has proposed for the Upper Murray line, at a cost of £9300 per mile for a single line of rails. One system was the guarantee by the Government of five per cent. per annum, on a cost not exceeding £3750 per mile of the permanent way, for which guarantee a London Company have contracted to make and work a Railway that is to extend from Port Augusta to the mineral country, about 100 miles northwards. The terms of the contract invest the Government with a thorough control over the construction and the working of the line.

The other system is that adopted for the construction of the Railway from Strathalbyn to Encounter Bay, made by Government at a cost of £4500 per mile of permanent way, including a heavier per centage of viaducts than could be found on a line through our Western Districts.

I now beg to bring under notice that in the *South Australian Register* of 12th instant there is an account of an official inspection by the Commissioner of Public Works of the extension of the South Australian main trunk line from Gawler Town to the Burra mines—about seventy miles—which is there stated to be constructed at a cost not exceeding £5000 per mile, including rolling stock.

These Railways are intended for the transport of wheat and flour, copper and copper ore, and wool; and being adapted for the requirements of a Colony of men so thoroughly practical as South Australians have ever proved themselves, I should like to hear some justifiable reason why similar lines for similar uses should not be adopted here, as they have been extensively in America.

There is no objection to them on the score of being a new system, or requiring a different gauge or width of carriages as compared with our existing main lines. The gauge is the same in South Australia as it is in Victoria —5ft 3in.; the cost, therefore, should be the same. The trucks used on our main lines could be used at a lower speed on our extensions; and when, as at present, they lack employment after the press of the wool season is over, they would be profitably employed in conveying agricultural products from the Western District, where the seasons are much later than north of the dividing range.

When Railways were first used in England the rails were thirty-five pounds per yard; these Adelaide lines have rails of forty pounds per yard. The Liverpool and Manchester Railway was constructed specially with a view to heavy goods traffic, the three canals then in existence being unable to convey it, although not amounting to more than 1200 tons a day, the carriage costing 18*s*. per ton. That Railway was opened in 1830; in six months it carried 42,697 tons, at an average charge of 10*s* 3*d*. This line was then worked by engines very different to those used on our main lines. The first used was the Rocket, which weighed four and a half tons, each engine being calculated to draw ten times its weight. The keen competition of rival lines has caused the adoption of larger engines and higher speed, until they necessitated for those purposes the employment of locomotives weighing thirty to forty tons each, rails of seventy-six to eighty-four pounds per yard, and the use of carriages weighing five and one-third times the weight of the passengers they could carry. The result is that in the thirty-nine years that have elapsed since the Liverpool and Manchester Railway was opened and worked so successfully, the system has been altered by doubling the speed, while the wear and tear has increased six-fold, and the dead or non-paying load of vehicles from a proportion of three to one to six to one, and the pressure of steam in the engine-boilers has been raised from fifty pounds per inch to one hundred and thirty pounds and upwards. Before the advent of Railways, a stage-coach, weighing eighteen hundredweight, carried fourteen persons at the rate of ten miles per hour, and a modern omnibus, weighing twenty-two hundredweight, carries twenty-six persons.

These plain statements will, I believe, show Victorians that it is not without reason that I suggest a pause and an enquiry whether there is any necessity for adopting the great strength and power of modern English Railways that have been so enormously increased to meet the requirements of their almost incredible traffic. It seems to me that we should adopt the homely adage, and walk before we can run. That we require above all things cheap and certain means of transit, and that a speed exceeding ten miles an hour for goods, and fifteen for passengers, is a luxury we ought to dispense with, if that luxury burdens our common country with a debt of two millions of pounds in place of one million; or, in other words, we ought to enquire whether the borrowing of two millions of money will give us two lines of Railway, each 200 miles long, or only one line.

If such an enquiry is made, I have no doubt there will be found in Victoria an ample amount of evidence that it will do so. I further beg to suggest that if such an enquiry is made, it should be extended so as to ascertain whether shire councils, corporations, and road boards, within a given distance of a Railway, should not, by special rate. provide the Government with one half of any deficiency between the profit of working the Railway and the interest that may have to be paid on the cost of constructing it. The Wimmera Shire Council has already publicly expressed its willingness to do this. I know that many large landholders in the shire of Dundas are willing to do the same; and its principle is so just and reasonable to all parties that I feel sure it would not be seriously objected to.

In my own case, I know that it costs me 19*s*. per bale to convey my wool from my woolshed at Wannon and place it on board a ship in Hobson's Bay. At the rate charged on the Echuca Railway, for a like distance, I should pay 9*s*. 6*d*. to Williamstown pier, or just one half. The Railway would, therefore, save me annually a sum equal to the rates I pay to the shire council of Dundas. I could, therefore, well afford to pay a double rate to the shire council, or, in other words, 2*s*. in the pound in place of 1*s*., if doing so were necessary to obtain for me the use of the Railway, because I should then be at no greater expense than at present, and I should be the gainer by having a Railway to convey my sheep and other produce to market at all seasons, and to afford to my family and friends a means of access to and from all stations on our Railways, far exceeding in speed and comfort anything that at present exists. And if a Railway would so benefit me, it would much more benefit agriculturists, for their produce is in great measure eaten up by wearisome, costly journeys with drays to Ararat, or to Belfast or Portland, at a cost exceeding by many fold the rates that are prevalent on English and European lines—for wheat, one penny per ton per mile; passengers at from a halfpenny to one penny per mile. But I have no fear that a line constructed at a cost of £5000 per mile would require any annual subsidies from local boards or Government after it had been in use four or five years. I am positive that the line to the westward would settle a population on the lands and create a traffic both to and from Ballarat and Ararat, far exceeeding anything now known in the western districts, and that would bear favourable comparison with the surprising increase of traffic created by European and American Railways.

If an inquiry such as I suggest is decided upon, it need not stop the earthworks of the Upper Murray Line. If it is made loyally, and evidence freely called for, it will result in one of the greatest boons our legislators have bestowed upon the colony of Victoria.

(Signed) JNO. B. HUGHES.

Wannon, May 25, 1869.

HIGH SPEED ON RAILWAYS.

There is no doubt an Englishman feels proud of his fast trains, just as a sportsman feels proud of a high-mettled horse. The ponderous strong engine, the trim and polished carriages behind it, the superior bearing of the well-dressed guards, all go to make up a picture, so finished, so dashing, that it stirs the pride of those even who have no other interest in it than looking at it. It is well, however, that individuals should sometimes look at home, and closely examine what their prized and cherished foibles cost them. The speed at which railway trains are driven has of late years been continually increasing, and in spite of improved construction both of roads and rolling-stock, and more efficient management, accidents have been increasing, and railway dividends diminishing. Are there any connexions between these facts?

High speed does not practically mean merely the fast travelling of one or more express trains on any line, for the high speed of one train affects the rate of every other train, and the management of the whole line, no department whatever excepted. If one of the fastest trains is liable to overtake the ordinary train, the speed of the latter must be regulated to avoid collision; and the like arrangements must be made that the ordinary train does not come into contact with the goods train, and this again with the mineral train.

On any of our great lines, the circle of traffic is kept up all the day round; and all the day round, therefore, the speed of that traffic must be regulated by the "high speed" of the fastest trains. The speed of those between stations must, therefore, be regulated by that of the trains preceding and the trains following, so that "high speed" in one train means also high speed for other trains. A fast train, too, may be rated at forty miles an hour, but as the same velocity cannot be maintained with every part of a road varying in inclination, the speed will be diminished on one part, and must be "fetched up" over another, so that the actual rate of travelling at times may be fifty, or even sixty miles an hour.

The additional investment of capital is not the only resulting evil; the working expenses are enormously increased. The engine to maintain high speed must be of excessive *power*, and power means cost of production. It must also be of excessive *size*. To attain great power great evaporation is required. Great evaporation requires great extent of heating surface; great heating surface means large boiling space; large boiling space, demands gigantic engines with corresponding weight and strength in every part. To keep such an engine going a great quantity of fuel is required, and this, a large tender to carry it. The large tender implies heavy draught, and in proportion as this dead weight is increased, so much must the capacity to carry the weight of passengers and goods be diminished.

This is not all. The heavy engine working at high speed needs an excessively strong road to travel over, in the most perfect order; the rails must be of an extra weight, the joints "fished," and the whole laid and constructed with the best appliances, in the strongest manner. Under the head of "Renewals for Permanent Way and Rolling Stock," shareholders pay largely for high speed, for not only are the rails worn and torn by the action of the ponderous engines, but they are ground also by the application of the powerful breaks in descending gradients, and on approaching stations.

Apart from those which occur to individuals from their own neglect, accidents happen on railways generally from the failure of an axle, wheel-tire, or some other portion of the running-gear of the train; from some defect in, or obstruction of the permanent way; from the collision of trains running at different speeds. Although it is the common custom to attribute all casualties to bad materials or to bad management, it will almost invariably be found that the cause belongs to one of these three classes. At high velocities, perfectly smooth rotation of metal upon metal is impossible. In proportion as the speed is augmented, the jerks or jumps become more violent, and, in addition to these, are swayings of the carriages and lateral concussions. The iron used in the manufacture of the wheels may no doubt differ in quality, and one process of manufacture may be better than another; but the very best material manufactured in the most perfect manner, will only bear a certain degree of rough usage. It is customary also to lay some of the blame to frost, but the frost alone is not to be made answerable. No doubt, when the iron is subjected to full strain and violence, the addition of the frost, in rendering the road more rigid, is more than the material of the train can resist, and a tire or axle gives way; low temperature or bad iron is not, however, the cause, but bad usage. The rails, too, may be knocked out of gauge, and give way to the ponderous shocks of the heavy engines of the fast trains.

Another prolific source of accidents lies in the necessity of running against the facing-points at junctions. Any train running against facing-points requires to be driven with great caution, but a train running against them at high speed must be in absolute peril. Collisions are often unjustly attributed to the negligence of some one connected with the conduct of the trains. But a close examination will show they oftener arise from irregularities in the despatch or running of trains of various degrees of speed, or from the impossibility of applying the breaks in time to stop the fast train from running into contact, not because those means were not powerful enough, but because of the difficulty of applying them with the required effect.

Engine-drivers are not ambitious, apart from the inducements of better pay, to drive these fast trains. They know the danger. Not only must every wheel, every flange, every tire, axle, screw, nut, be without flaw, but the two or three hundred miles, and even more, which he has to drive over, must also be in perfect order. One broken rail, one loose chair, one sunken sleeper, may consign him to perdition. An irregularity of time, may be equally fatal to him. An accident to a train in advance of him, or an obstruction on the line, may be the cause of lamentable disasters. His whole attention must be given uninterruptedly and absolutely to looking out, and then he must be dependent on the signals given him by others. The slightest deviation from duty, or an error on their parts, must, he knows, result in an accident, for he is aware that he has to run for hour after hour at a speed which leaves him no command over his train to avert a calamity.

In drawing attention to the danger and costliness of high speed trains, we must not be thought to be advocating low speed and small engines,—all that is contended against is that *extreme* velocity, which taxes the material of both road and rolling stock beyond the power and capability of either.

"THE 3FT. 6IN. RAILWAY GAUGE.

"To the Editor of *Engineering*.

"SIR,

"BY the request of my friend, Mr. C. Pihl, Chief Engineer of the Norwegian Government Railways, I beg to hand you the enclosed paper on the 3ft. 6in. Railway gauge; and knowing well the trustworthiness of his practical experience, I have no doubt that by inserting it in your valuable periodical much additional light would be thrown on the question to which it relates.

"I remain, Sir,
"Your obedient Servant,
(Signed) "W. TOTTIE."

"*Royal Swedish and Norwegian Consulate-General, London, March 7th*, 1867.

"SIR,

"IN *Engineering* of the 4th January I find, in an article headed "Railways in Lilliput," views with regard to the 3ft. 6in. gauge Railway system (as carried out in Queensland, India, and Norway), which are so much at variance with the experience gained in this country, where Railways of this description have been in full operation since 1861, that you will allow me, no doubt, as the Engineer of the Lines, to make a few remarks which may possibly be acceptable to those of your readers who feel interested in this matter.

"In your article you ask what was to compensate for the manifest disadvantages of the 3ft. 6in. gauge, and for an answer refer to a letter which Mr. William T. Doyne, Memb. Inst. C. E., has lately published in Queensland, in which he says he considers that the safe maximum speed on the 3ft. 6in. gauge cannot exceed ten, or at most twelve miles an hour, and that, although he has travelled twenty-two miles an hour on this gauge, he doubts whether the working stock would admit of it, except in cases of the engine running down steep gradients; and he states that he would feel more at his ease on a line of ordinary gauge at 50 miles an hour. He further says—In Queensland the features of the country enforce the use of five chain curves, and consequently a 3ft. 6in. gauge. On this you make the following remarks—'Before engineers inflict a wholly insufficient gauge upon the Railway system of a Colony they should first ascertain whether, even with curves of minimum radii, rolling stock cannot be constructed to work them upon the ordinary gauge;' and in concluding your article, you say that the same remarks apply to India and Norway.

"With regard to the information received from, and opinions formed on, the Queensland Railway, it is not for me to make any remark except where they affect the system, and are at variance with facts gained by experience. My intentions are not, however, to enter into any polemical discussion, as the 4ft. 8½in., as well as the 3ft. 6in. gauge systems, have been in operation here for many years. There is no doubt or uncertainty with us about the question at issue; and I will, therefore, merely give facts and results as supplementary to the information you are already in possession of from Queensland, and which may be of interest to those who wish to investigate the subject.

"When it is said that the adoption of the narrow gauge has been enforced by the necessity for sharp curves, the conjecture is not quite in accordance with the facts of the case here, as we have hitherto been able to avoid curves of less than 11 chains. With us it has been a question of providing a Railway communication at a comparatively small cost in a country of large extent, with little traffic and limited resources; and although the greater facility of traversing sharp curves is a decided and no unimportant advantage to be gained by the use of the small gauge, this consideration has not enforced its adoption here. It has been in this case the choice between a cheap and efficient Railway or none. With what success these lines have been carried out we shall see. I will now give the cost of these separate Railways which I built at the same time under equal circumstances, and with the same view as to economy and efficiency. The one line, the Kongsvinger line, 4ft. 8½in. gauge with a length of 56 miles, has cost £6350 per mile, including stations and rolling stock, but no workshops. The Hamar-Elverum line of 3ft. 6in. gauge, and twenty-four miles only, has cost £3142 per mile, including stations, rolling stock, and small workshops. The third line, the Throndjem-Storen Railway, also a 3ft. 6in. gauge, and thirty-one and a half miles, has cost £5300 per mile, including everything. At the present time there are fifty-six miles more (the Dramman-Randsfjord Railway, of the same narrow gauge) under construction, the half of which is temporarily opened for traffic. This line is calculated at £4563 per mile, and for this sum I have no doubt it will be completed. On the two last-named lines the works are comparatively very heavy; the country which we have had to go through has been difficult to deal with, and necessitated many extensive works, such as cuttings (to a great extent in hard rock), frequent bridges and viaducts, some of timber and some of iron, several exceeding 70 feet in height and of considerable length. Besides these, there are extensive and comparatively costly stone-works along the declivities by the side of the rivers and hills.

"The regular trains are run here at 14 miles an hour, including stoppages, or 16 to 20 miles between the stations, the very same speed at which the mixed trains run on the 4ft. 8½in. gauge here. As to the safety of fast running, engines and carriages appear to run as safely and steadily at 30 miles an hour on the 3ft. 6in. gauge as they do on the one of 4ft. 8½in. And I have run the very engine illustrated in your journal of the 21st December last, at upwards of 40 miles an hour, with as much feeling of ease and security as I have felt when running any engine on the broader gauge. The engine as well as the rest of the rolling stock are constructed with an angle of stability fully as great as in rolling stock for an ordinary gauge. This, with a sufficient minimum load on the axle, being the principal condition for stability, leaves the gauge as a factor of practically small importance in limiting the speed. The working stock, when substantially and judiciously constructed, is as durable in one case as in the other. In stating these facts it is not my intention to advocate as high a speed on these lines, with light engines of only 3ft. to 3ft. 9in. driving wheels, as on lines of a broader guage. They are designed for high speed, but to suit circumstances where this is of a secondary consideration.

"When the difficulties in the construction of an efficient rolling stock for this gauge have been satisfactorily overcome, the one gauge being as empirical as the other, it then becomes in my opinion the duty of the Engineer to decide which gauge is the best adapted to the country. If the 4ft. 8½in. gauge is sufficient for a country with vast traffic and ample resources, the 3ft. 6in. gauge may be all that is required in places less favourably situated. Should, however, that fortunate time arrive (say in the course of 15 or 20 years) when the traffic has developed to such an extent that the line as originally constructed proves insufficient, then I believe that a double line would naturally suggest itself as meeting the requirements of increased traffic in every way better than a single line of wider gauge. The cost of the addition would, based upon calculations made for this purpose, be rather more than 50 per cent. (without much variation) of the original cost of the line proper, stations and rolling stock not included, and the total of this double line would then cost about the same as the single 4ft. 8½in. would originally have cost. I can therefore not see the necessity or justice of having the gauge wider to suit increasing demands in the one case rather than in the other, as long as there is the same facility of adding proportionally to the working power. There is certainly a greater difference in the producing capabilities or the traffic of the various countries than there is here in the gauges. What may be fit for one country is therefore not in place in another; and it therefore is necessary here, as elsewhere, to adapt the means to the end. The amount of interest on the difference in the original outlay between the two lines would consequently have been lost during the assumed period, besides the excess of expense of keeping up the wider line.

"In proof of the slight difference in the cost of the two systems, there has been adduced the amount of earthwork in a bank of 50 feet high, the formation width of which has been set down at 14 feet in the one case and 12 feet in the other. This I cannot consider fair. The formation width for the line of 4ft. 8½in. gauge is generally from 15 to 18 feet, say 16½ feet on an average (it is here 18 feet). And for the 3ft. 6in. gauge it is here 12ft. 6in. (The reason why the latter is reduced so much is obvious). The average heights of the banks and cuttings on the narrow gauge is less than on the broad, owing to the greater facility of adaptation to the country. With us the height is 10 feet, whereas had the broader gauge been adopted it would have been 12 to 14 feet, say 13 feet. This would make, with the same slope as in your example, the proportion as 225 to 38,317, or nearly as 4 to 7, instead of 31 to 32, as stated. You have, however, used the slope 1 to 1, which would make my figures less favourable than the above.

"I find that I have already gone more at length into this discussion than was my intention, and am prepared for doubts being entertained as to the correctness of the conclusions which I arrived at from the facts here set forth. Of many to whom the subject may be of real importance, few will probably be able personally to study the subject on the spot in India and Queensland; but, with the present easy communication between England and this Country, anyone willing to devote nine or ten days to the purpose, may conveniently see and judge for himself; and I can assure all such visitors that they will meet with every facility for obtaining all the information they may desire.

I am, &c.,

(Signed) C. PIHL.

Christiana, February 25th, 1867."

JAMES BARNARD,
GOVERNMENT PRINTER, TASMANIA.