1880.
NEW ZEALAND.

ENGLISH AND AMERICAN LOCOMOTIVES

(FURTHER PAPERS RESPECTING).

[In continuation of E.-4, Sess. II., 1879.]

Presented to both Houses of the General Assembly by Command of His Excellency.

MEMORANDUM for the Hon. the MINISTER for PUBLIC WORKS.

IN January last year some official correspondence was put before me in the course of the ordinary routine, with a view of eliciting an opinion as to whether it was cheaper to import railway rolling-stock from America than from England. This correspondence comprised an extract of a letter from Mr. W. W. Evans, of New York, the agent who has acted for the New Zealand Government in procuring some American stock; and a letter from Mr. R. M. Brereton to the Agent-General of New Zealand in London.

The letters and my remarks thereon were afterwards, unknown to me, published as a Parliamentary Paper. I think, before the letters were published, the writers should have been consulted, as one of them at least (Mr. Evans's) was not intended for publication.

Mr. Evans replies to my remarks, without a full acquaintance with the subject on which I wrote, in a pamphlet which I append.

The writer discusses the cost of American railways. He condemns the use of crank-axles, grease-boxes, inside connections, heavy conings to wheels, double-headed rails, &c.; he writes about bogie cars, American bridges, and a number of other matters which were not referred to in my memorandum.

Among all this foreign matter, my former remarks are obscured. The purport of the two letters was to the effect that America could supply engines cheaper in first cost, and in every way better, than England. My remarks were to the effect that the Americans could not compete with English in cheapness, and that I did not concur in the universal superiority claimed for American-built locomotives. My brief note was thus concluded:—

"These remarks are not intended to depreciate the merits of Mr. Evans's engines, of which there are now eight working at Christchurch. . . . . It is, however, desirable that unqualified statements of the universal efficiency and superiority of American-built locomotives should not be circulated without comment, as they are apt to mislead. The class of locomotives required on a line will always have to be determined by the features of the line, the kind of traffic, and the rate of speed demanded."

The writer thinks that I have misstated the cost of the locomotives, the prices of which I compared erected under similar conditions in New Zealand. Without a proper explanation appended he might readily arrive at such a conclusion.

The prices could not be compared in widely-differing states of the market, without making a proper allowance for the variation. This allowance was made in my comparison, and there is no error or misstatement, as the writer supposes. The figures gave the relative cost of the locomotives. The general inference drawn from the comparison is more than confirmed by subsequent purchases made in England and America. In the case of the particular prices selected from among those I gave, which the writer refers to, the English engine was ordered in 1873, and the American in 1877. The difference in the state of the market was this: that under the former state the invoice price of the English engine, delivered f.o.b. in London, was £2,125; while in the latter state it was £1,515. These are actual contract prices. The American engines also were landed and erected under favourable conditions and facilities which did not exist when the English engines were imported. Under these circumstances, a bare statement of the sums paid on account of the respective engines at the different dates would have been as misleading as the error I sought to correct, and had I made such a statement I should merely have reiterated Mr. Brereton's error, which was that he took the average cost of locomotives on English lines for a number of years preceding, and compared with the price at which he stated American locomotives could be delivered in the current state of the market.

The cost of the locomotives when the market was high, to which the writer takes particular exception, was compared thus, erected in New Zealand: American, £2,800; English, £2,700 Purchases made in America and England during the year 1878 (see full particulars further on) give the actual cost of the same types, delivered in port in New Zealand, but excluding erection and receiving—American, £1,986; English, £1,683. Or, giving an estimated price under present conditions for landing and erecting, and contingent expenses, the prices will be—American, £2,080; English, £1,780.

It will be evident that the comparison made in my memorandum of 1879 was too favourable to the American stock. Being afraid of overstating the case, the allowances made were too moderate.

The reasons that no explanation was given in my memorandum were, that the memorandum was written for departmental record only; the data from which I wrote were departmental, though not stated on the particular papers on which my remarks were written; and my remarks were published without my knowledge.

I now give a statement of the more recent importations from England and America; and, so that no incidental local charges may affect the comparison, the actual net cost per locomotive, as nearly as it can be made out, is given alongside in port in New Zealand, excluding any local charges for receiving, erecting, or otherwise:—

Makers.	Number of Engines ordered.	Cylinder.		Coupled Wheels.			Cost per Engine.	Tractive Power for each effective Pound of Steam Pressure.	Cost per Unit of Tractive Power.	Date of Order.
		Stroke.	Diameter.	Number.	Diameter.	Wheel-base.				
		Inches.	Inches.		Inches.	Ft. in.	£	lb.	£ s. d.	
(1.) Rogers	6	20	12	4	48	6 0	1,986	60·	33 6 0	Jan, 1878.
(2.) Burnham, Parry, Williams, and Company	6	18	15	8	36	11 4	2,099	112·5	18 13 0	Jan., 1879.
(3.) Dubs and Company ...	4	20	14	6	42	10 0	1,683	93·3	18 0 0	June, 1878.

(1) *American* has leading and trailing bogies, 8-wheel tender, steel firebox, iron tubes, iron axles, cast-iron engine wheels with steel tires. The tender had cast-iron chilled wheels, which proved objectionable, and they were removed and replaced by wrought-iron steel-tired wheels of English make.

(2) *American* has leading bogie, 8-wheel tender, steel firebox, iron tubes, iron axles, cast-iron wheels, and steel tires.

(3) *English* has leading Bissel bogie, 6-wheel tender, copper firebox, brass tubes, Bessemer-steel axles, wrought-iron wheels, and steel tires.

These particulars, carefully compiled from official documents, conclusively bear out my former statements. (1) and (3) are the same types of engine of which I compared the cost under previous orders and different conditions.

The English goods, although it has larger driving-wheels than the American goods, proves to be much cheaper. Thus, while the relative cylinder-power of (2) to (3) is as 40 : 39, the relative cost is as 40 : 32.

The invoice prices, exclusive of all other charges, are, for (1), (2), and (3) respectively, £1,752, £1,844, £1,450.

The letters of Messrs. Evans and Brereton contained the following statements:—

"English Railways.	Miles.	American Railways.	Miles.
London and North-Western	15,415	Boston and Albany	24,500
Midland	18,808	Erie	27,550
North-Eastern	17,290	New York Central	26,933
Great-Western	18,320	Pittsburg, Fort Mayne, and Chicago ...	31,737
	4)69,833		4)110,720
Average of all	17,458	Average of all	27,680

"The above gives an average of 10,222 miles for the American engines more than for the English. This is decimally 58 per cent. greater duty, and it was done on inferior tracks, in a more severe climate, over steeper gradients and sharper curves, and with heavier loads. It must be admitted, in making this statement, that the English engines no doubt showed a greater average speed than the American; but, with this admitted, they should show greater average mileage in the year."

Again,—

"The English engine is a very heavy affair, and, in running, it not only wears and tears itself very rapidly, but also the roadway, and it greatly, by its unsteadiness and jar, fatigues the drivers and firemen."

Again,—

"The American engines for the Colony of Victoria, and for the New Zealand Government railways, were ordered through Mr. W. W. Evans, Mem. Inst. C.E., who has an office in New York, at 66½, Pine Street. They were built and shipped under his direction entirely. The best American narrow-gauge engines cost, delivered f.o.b. in New York, as follows:—

"1st class passenger (C)	£1,500 per engine.
1st class goods (D)	£1,600 per engine.
1st class goods extra (E)	£1,700 per engine."

Again,—

"Now, if the best American engines can be laid down in India and in our colonies as cheap or cheaper than English engines, and that they will run easier and with greater steadiness, involve less expense in repairs and renewals, and do less damage to the permanent way, it is surely worth while for consulting engineers, directors, and agents to consider the economy their introduction must occasion."

Again,—

"As regards train-mileage, the following comparative statement, showing working results in English, American, and Indian railroads for the year 1876–77, will prove interesting and instructive:—

	No. of Engines.	Miles operated.	Train-miles per Engine.
"ENGLISH—			
Great Western	1,478	2,274	17,397
Great Eastern	505	907	20,600
Midland	1,326	1,588	18,219
London and North-Western ...	2,058	2,158	15,800
	5,367	6,927	4)72,016
		Average of all ...	18,004
AMERICAN—			
Pennsylvania	515	1,071	32,627
New York Central	602	1,000	30,870
Michigan Central	219	804	30,812
Erie	468	956	26,900
	1,804	3,831	4)121,209
		Average of all ...	30,302
INDIAN—			
East Indian	450	1,505	14,737
Great Indian Peninsular	331	1,288	17,000
Madras	100	858	23,334
Bombay and Baroda	64	417	19,149
	945	4,067	4)74,220
		Average of all ...	18,555

"The above shows 12,298 more train-miles per engine for American roads than for English, and 11,747 than for Indian roads. The following statement shows the average cost of locomotives on four of the English roads, and the average cost of American engines:—

"ENGLISH.		AMERICAN.	
Midland	£2,648	1st class passenger engine (C)	£1,720
Great Eastern	2,271	1st class goods engine (D)	1,800
Great Western	1,767	1st class goods engine, extra power (E) ...	2,300
London and North-Western	1,617		
	4)8,303		3)5,820
Per engine	£2,076	Per engine	£1,940"

I characterized these data as "vague generalizations." I am not disposed to withdraw that remark.

It may be observed that, although a high average train-mileage may indicate a good state of mechanical excellence in the locomotives, a low train-mileage does not necessarily indicate a bad one. The length of the services and the nature of the traffic, combined with many other causes, go to determine the train-mileage performed by the engines on each line.

The following are the remarks of Mr. R. Price Williams, Mem. Inst. C.E., in speaking of Mr. Harrison's paper on Railway Statistics and Expenditure, read before the Institution of Civil Engineers, London. He instanced "two cases that occurred on railways dealt with in the paper which differed as much in every way, as regarded the nature and extent of their traffic, as they did in their relative cost per train-mile—namely, the London and South-Western and the North London Railways. In the case of the latter, its enormous passenger traffic, which was of what was called an omnibus character, and its very heavy mineral traffic, required the unusually large number of three engines per mile, and a resulting low average of 18,400 train-miles per engine per annum. On the other hand, the London and South-Western, with a large mileage of single line and light traffic at its remote end, was worked with less than half an engine per mile, but with the unusually high average, during the past six years, of above 25,000 miles per engine per annum."

In adducing these remarks I am merely stating facts well known to every railway manager.

The writer says, "Mr. Maxwell says that the Fairlie engines on the Great South-Western of Ireland showed an average of 25,000 miles a year for three years. Now, as I am sure that is what a Fairlie engine never did, I am led to believe this is another error in Mr. Maxwell's figures." The writer will find the statement referred to in *Engineering*.

The following is an extract from Vol. XXXVII. of the Minutes of the Institute of Civil Engineers, London, by Mr. A. McDonnell, which gives the year's run with two single Fairlies, with 15 in. cylinders and 5 ft. 6 in. wheels:—

No. 33: Miles run, 30,977; coal used, 19·8 lb. per mile; wages and repairs, 0·19d. per mile; materials for repairs, 0·4d. per mile; average load, 6-wheel carriages, 6·1 tons.

No. 34: Miles run, 22,738; coal used, 21 lb. per mile; wages and repairs, 0·5d. per mile; materials for repairs, 1·08d. per mile; average load, 6-wheel carriages, 7·9 tons.

The writer asks concerning me, "Surely he cannot mean that a goods engine running 10 miles an hour makes as great a mileage as a passenger engine that runs 40." This will depend on how many hours each runs (the figures are Mr. Evans's).

The writer of the pamphlet says it is new to him that there are different ways of computing train-mileage.

The report of the Railroad Commissioners of the Commonwealth of Massachusetts in 1875 states that the following question was put to, and answers received from, different companies:—

Question: "At what daily mileage were gravel trains and engines engaged in switching computed in your train-mileage?"

Answers:

Boston and Albany Railway Company: "Gravel, actual. Switching, 5 miles an hour."

Boston and Lowell Railway Company: "Gravel, actual. Switching, 6 miles an hour."

Boston and Maine Railway Company: "No daily mileage, but in gross for gravel trains. Switching is not kept."

Boston and Providence: "One hundred and sixty-three miles."

Connecticut River Railway Company: "Actual mileage, road repairs and wood trains. Switching engine averaged at 35 miles per day."

Eastern Railway Company: "Eighty-four miles."

Fitchburgh Railroad Company: "Switching, 50 miles a day. Wood, gravel, and snow, actual distances run."

And so on, showing great variations. The writer of the pamphlet is thus unaware of the practice in his own country in this respect. It is to be regretted that he should have been ignorant of the significance of the train-mileage figures which he quotes so largely. At the end I append a statement of the train-mileage performance of engines on a large number of American lines, compiled from American official returns, which shows an average very far below that claimed by the writer. The lowest average is only 14,855 train-miles per engine per annum, and the highest only 24,790.

In New Zealand, the rule laid down is this: Train-mileage is the station-to-station distance of passenger and goods trains, *plus* the distance one way of engines assisting trains. No allowance is permitted for shunting or for ballast trains.

We have thus before us one of the causes why the Americans could show much better train-mileage than New Zealand.

Here are the remarks of the same Commissioners on the subject of train-mileage: "The accuracy of any result arrived at through the application of this test necessarily depends, in the first place, on the correctness with which the mileage account is kept, and upon what in each case enters into it. That, again, is decided by arbitrary rules: some corporations make the computation in one way, some in another." Then follow comments on the cases previously quoted; and the report continues, "In the first place, therefore, there is no uniformity in the mileage account, upon which the value of the test depends."

What value, then, is to be placed on the quotations of the performances of American engines in train-mileage, when these are the opinions of American Commissioners, carefully arrived at after a minute examination into the working of a large system of American railways? My former remark, to which the writer takes exception, will apply with greater force, backed by this evidence—"To compare the train-mileage of two countries in so crude a manner is therefore manifestly erratic."

I shall again draw on the Commissioners' remarks on "Railroad Accounts and Returns" of the Massachusetts corporations. They speak thus:—

"The railroad returns are, and must continue to be, essentially unreliable, if not even deceptive, until a radical reform in the methods of railway bookkeeping is effected. . . . ."

Of the returns they say,—

"They are collected by authority of the law and compiled by public officials; they are prepared under oath and upon a uniform schedule of interrogatories, the answers to which are carefully tabulated. . . . . Under all these conditions the returns go out to the public with a species of indorsement of their truthfulness and accuracy on the part of the commonwealth. They thus enjoy an authority which in no way belongs to them. In the popular mind it is naturally supposed that, as the results are uniform, the methods through which they are arrived at are likewise uniform, *and it requires a very considerable familiarity with the railroad accounts to see that this is not the case.*"

The italics are my own. Having given a very considerable amount of attention to railway accounts and working, and having compiled the system of accounts in use on the New Zealand railways, I can, in a general way, most thoroughly indorse the latter remarks of the American Commissioners. For instance, the cost per ton-mile of haulage expenses can only be properly appreciated by an expert. An engine drawing 1,200 tons on a level straight line will only draw 80 tons on a straight 1 in 40 grades with the same expenditure of power, and the same cost of fuel and wages. Hence the cost of haulage per ton-mile on the Canterbury main lines should not be compared with that on the Wellington line with 1 in 35 and 40 grades, or with that of the Auckland lines with 1 in 40 grades. To a layman who observes the cost per ton-mile in

Auckland to be higher than in Canterbury, it might seem that bad management or poor stock was the cause; but the higher rate in Auckland might really turn out on close examination to be a cheaper result than the low rate in Canterbury, bearing in mind the different conditions due to gravity. The reason of this is: that the term "ton-mile," meaning the haulage of one ton through one mile horizontal, conveys no adequate information about the *work done* by the locomotive. In the case before quoted the work done in hauling one ton a mile, *cæteris paribus*, is 15 times greater on the 1 in 40 grade than on the level.

I now append particulars of nine months' performance of two types of American and English locomotives running on the favourable lines of the South Island during 1878, procured when I was writing my previous memorandum:—

New Zealand Railways.—Locomotive running Nine Months, Christchurch District.

——	Cylinder.	Diameter of Driving-wheel.	Train-miles.	Total Cost.	Cost per Train-mile.
	in. in.	in.		£ s. d.	d.
English	14 x 20	42	23,380	927 16 10	9·52
Do.	...	42	23,511	938 0 3	9·57
Do.	...	42	21,378	969 17 5	10·88
American	12 x 20	48	22,867	727 11 5	7·63
Do.	...	48	22,350	716 8 0	7·69

These engines were working in the Christchurch district, under the same Locomotive Engineer (Mr. A. D. Smith) to whom I was indebted for these figures. The engines are those of which I had previously compared the first cost. Having regard to the relative cylinder-power, the English engines appear to have been running the cheapest. The American engines were running faster trains than the others during two months and a half of the period; but, while the American engines were new, the English had been running for several years.

There is one misquotation in the pamphlet which, although it is personal and does not affect the issues, I draw attention to. The writer says,—

"Mr. Maxwell says that this engine subject is taken up as if it were new, and not before discussed. I beg to differ from the gentleman. It is well known to every railway engineer and investigator as an old subject, written on and discussed in various ways during the past forty years," &c., &c.

Here is the remark which I applied to Messrs. Evans's and Brereton's letters: "The subject has been taken up as though it were new and previously undiscussed: it has, however, formed a subject of minute examination by some of the best engineers in both countries for years past."

Sufficient has now been said to show that my previous memorandum was thoroughly justifiable.

Time does not permit criticism of the many figures the writer gives; but I take one case to examine. The writer takes four engines—two Fairlies and two Rogers—and compares the "foot-pounds of work done per hour per ton of weight on the driving-wheels alone, exclusive of engine." He obtains about 9,000,000 lb. for each Fairlie, and about 41,000,000 lb. and 25,000,000 lb. respectively for the Rogers. He gives no data, and for all purposes, therefore, of comparing the merits of the engines, his figures are useless. The grades, speeds, weights, and numerous other data are necessary to enable any one to compare: without these the supposed comparison has no meaning to the reader.

The principle of excluding engine-weight is also misleading in comparing the merits of the engines, unless all data are given, because widely-differing results may be shown with the same engine by it.

Following are some particulars of the cost of recent importations of American and English carriage-stock.

The American carriages have two 4-wheel bogies. The English carriages have Cleminson's flexible wheel-base. The cost is the actual net price alongside in port in New Zealand, excluding all local colonial charges for receiving or erecting, which, in the case of the American stock, chanced to be somewhat heavy. Cleminson's carriages have only been imported into the North Island.

——	Class.	Number of Wheels.	Diameter of Wheels.	Length inside.	Breadth.	Cost.	Cost per foot run, inside dimensions.
				Ft. in.	Ft. in.	£	£ s. d.
American ...	1st	8	30	37 0	7 6	685	18 10 0
Do. ...	2nd	8	30	37 0	7 6	546	14 15 0
English ...	1st	6	30	25 0	7 0	446	17 13 0
Do. ...	2nd	6	30	25 0	7 0	347	13 18 0

The prices on the whole show in favour of the English stock, notwithstanding that its shorter length would make it relatively more costly. The American 1st class is more luxurious, provides for only thirty-five seats; English 1st class is of simpler construction and allows of seating thirty-two passengers.

The bogie carriages are unsurpassed for steadiness in running, and consequently for personal comfort, but are, as is seen, more expensive than the lighter stock.

The 6-wheeled stock, being smaller and lighter, is more suitable in general for light traffic, such as prevails on many of the New Zealand railways, as it affords means of running lighter trains by the greater facility it gives for adapting the size of train to the number of passengers carried. A proportion of bogie carriages would, however, be found useful and advantageous. I believe they would prove more economical if they were 10 feet longer than those imported. For economy in cost the carriages constructed with Cleminson's flexible wheel-base show well; they run with great smoothness and freedom from oscillation, and the wheels accommodate themselves to the 5-chain curves with facility.

It is desirable to dispel the impression that is evidently on the writer's mind about the conditions of engineering in New Zealand. His remarks tend to implicate not only me, but others, in all sorts of objectionable practices which he enumerates, while he is apparently ignorant of the practice pursued, and certainly is so of my opinions. Under the public works policy, instituted in 1870, over 1,000 miles of railway were executed under the superintendence of Mr. John Carruthers, Mem. Inst. C.E., as Engineer-in-Chief, whose experience in the United States, Russia, India, Egypt, and Mauritius, was brought to bear. Associated with him were Mr. John Blackett, Mem. Inst. C.E., Assistant-Engineer-in-Chief, in the colony, and Messrs. Hemans and Bruce, as consulting engineers in London. The lines were carried out and equipped at an average cost of a little over £7,000 a mile.

The mountainous features of both Islands, and more especially the Northern, rendered unavoidable steep grades and very sharp curves. Although there are some hundreds of miles of comparatively easy lines in the South, yet the major portion of the New Zealand railways may be said to abound with grades not flatter than 1 in 50 and curves of 10 chains radius, and a very large proportion has grades ranging from 1 in 35 to 1 in 50, with 5-chain curves. The permanent way generally is of 40-lb. and 52-lb. rails of Vignole's pattern, and the gauge 3 ft. 6 in. With such physical features, the use of stock with flexible wheel-base and light wheel-loads was imperative; and stock possessing the requisite features for the physical conditions of the lines and the very light traffic was introduced with due regard to economy. All the stock has central buffers. There are among others two types of English engine with Bissell bogies, one having 6 wheels coupled, with a 10-ft. base, and the other having 4 wheels coupled, with a 5-ft. base, both well adapted for the lines and traffic they are designed to work. There is also a 6-wheel coupled engine, with a 10 ft. 6 in. base—a type very largely in use on lengths of lines where the curves are not sharp. Some double Fairlies are in use on the worst lines, and some single Fairlies, which were procured on the advice of the late Engineer-in-Chief, Mr. Carruthers, and which perhaps are the most efficient and useful engines on the steep grades and 5-chain curves which we have. The single Fairlie is carried on one 6-wheel bogie and one 4-wheel bogie. The former has a base of 6 ft. 9 in., and the latter one of 4 ft. 6 in. All the goods stock is 4-wheeled: the traffic is too light to warrant introducing 8-wheeled bogie stock. The carriage stock is 4-wheeled and 6-wheeled; the latter has a flexible base. Recently Cleminson's flexible base has been introduced with marked success.

There are no grease-boxes to the New Zealand stock. Crank-axles, double-headed rails, and inside connections are practically unknown.

In the face of this, it is difficult to understand why such a long pamphlet has been written. Mr. Evans unnecessarily undertakes to instruct me in the opinions of the school of English engineers, in which I have been educated.

It would be ill-judged to omit to acknowledge the services rendered by the American engineers in the application of the bogie, and in many other improvements in the construction of railway rolling-stock which they have advocated and introduced. It would be manifestly impossible to work such railways as there are in New Zealand without adopting mechanical features which also characterize the American stock to a very large extent. But while acknowledging the merits attaching to the American engineers and manufacturers, I must as yet maintain the opinion which I previously expressed, that we can obtain all we require more cheaply from England than from America. Nor do I concur in the claim made for the universal superiority of American-built engines. I do not desire to be the special pleader for obsolete practices, as the writer seems to infer. There is no reason that I am aware of why the respective countries should not produce equally good results mechanically and economically in their locomotive performances.

Appended are some data respecting New Zealand practice which will bear out my statements.

As I have been rather acrimoniously attacked in the performance of my duty by the writer, who has not understood my figures, I ask the favour of having this reply made a public document, and, with it, Mr. Evans's pamphlet.

J. P. Maxwell,
Assoc. M. Inst. C.E.

Wellington, 5th May, 1880.

NEW ZEALAND RAILWAYS.

PARTICULARS of the Cost of Haulage per Ton-mile (extracted from the Returns of Mr. A. D. Smith, Locomotive Engineer, Christchurch District), for the Nine Months ending 31st March, 1880.

Departmental Class.	Cylinders.	Coupled Wheels. No.	Coupled Wheels. Diameter. Inches.	Truck.	Mean Tonnage per Mile.	Estimate Speed, Miles per Hour.	Cost in Pence of Haulage per Ton-mile. Repairs, Stores, and other Expenses.	Driver, Stoker, and Cleaner's Wages.	Total.	No of Engines.	Actual Engine-mileage for Nine Months.	Average Days in Steam.	Remarks.
F	10½ x 18	6	36	None ...	57¾	20	0·104	0·080	0·184	8	166,349	188	English. Heavy branch and light main line mixed traffic.
O	10½ x 18	6	36	None ...	58¼	20	0·115	0·080	0·195	3	60,711	191	Do. Heavy branch and light main line mixed traffic.
D	9½ x 18	4	36	2-wheel ...	50½	17	0·083	0·080	0·163	6	125,314	211	Do. Heavy branch work.
G	10½ x 18	4	36	4-wheel ...	55⅓	18	0·114	0·060	0·174	4	77,979	177	Do. Heavy branch and light main line mixed traffic.
J	14 x 20	6	42	2-wheel ...	121½	18	0·072	0·030	0·102	10	173,514	173	Do. Heavy mixed and goods traffic.
K	12 x 20	4	48	Two 2-wheel ...	58¾	27	0·082	0·050	0·132	5	139,397	206	American. Light mixed and express traffic.
M	13 x 20	6	42	None ...	115½	17	0·075	0·050	0·125	3	55,356	214	English. Principally heavy goods.

The main line in the Christchurch District has about 190 miles of straight lines and very flat grades. There are a few grades 1 in 100, but generally the lines are much flatter or level. It also has about 35 miles of line on which the prevailing grade is 1 in 50, and there are some 15-chain curves. The branch lines generally have steeper grades than the main line. There are nine branches with an aggregate length of about 169 miles. The working involves numerous short services. The particulars of the grades run over have not been recorded in each case, such being impracticable, so that no approximate estimate of the work done can be deduced. The engine-mileage includes ballasting and shunting. Sufficient data were not available to give the results of running the American engines of the consolidation type in Christchurch.

PARTICULARS of the Cost of Haulage per Ton-mile (extracted from the Returns of Mr. A. V. Macdonald, General Manager, Auckland Section), Four Months' Average.

Departmental Class.	Cylinder.	Coupled Wheels. No.	Coupled Wheels. Diameter.	Truck.	Total Engine-mileage.	Total Train-mileage.	Ton-miles.	Tons per Mile.	Cost in Pence of Haulage per Ton-mile. Stores.	Wages.	Total.	Remarks.
F	10½ x 18	6	36	None	8,509	7,229	473,738	65	·087	·087	·174	English.
					4,471	3,756	234,949	62	·060	·099	·159	Do.
					10,463	8,671	572,150	66	·048	·087	·135	Do.
B	9 x 16	8	36	Double Fairlie ...	9,744	8,652	652,732	75	·065	·072	·137	Do.
I	10½ x 18	4	36	2-wheeled ...	9,382	6,850	407,123	59	·052	·114	·166	Do.
					7,959	5,876	350,826	60	·067	·128	·195	Do.
					7,387	7,008	470,703	67	·047	·091	·138	Do.
R	12¼ x 16	6	36	Single Fairlie ...	6,220	5,766	431,379	75	·077	·069	·146	Do.
					7,518	6,751	467,943	69	·073	·076	·149	Do.

The lines on the Auckland Section have numerous grades ranging from 1 in 40, and flatter, with sharpest curves 6 chains. The ton-mileage is based on the train-mileage, and thus is shown at a disadvantage compared with the Christchurch return, which is based on the engine-mileage.

EXTRACTS compiled from SEVENTH ANNUAL REPORT of BOARD of RAILROAD COMMISSIONERS, Commonwealth of Massachusetts.

Railroad Reports, Year ending 30th September, 1875.

Name of Company.	No. of Engines.	Total Train-mileage, including Gravel Trains and Shunting.	Average Train-mileage per Engine per Annum.	Speed in Miles per Hour.			
				Passenger Express.	Passenger Accommodation.	Freight Express.	Freight Accommodation.
Boston and Albany	239	4,909,216	20,541	33	25	12	...
Boston and Lowell	42	912,424	21,724	30	25	18	12
Boston and Maine	73	1,576,575	21,597	30	24	...	12
Boston and Providence	42	800,269	19,054	38	22	22	10
Eastern	95	2,082,732	21,923	28	20	15	10
Fitchburg	54	997,093	18,465	26	22	10	$8\frac{3}{4}$
New York and New England	29	660,056	22,761	25	20	15	10
Old Colony	63	1,387,481	22,024	33	23	16	10
Average	637	13,325,846	20,920	...	...	...	...
Cheshire	31	633,277	20,428	25	22	12	10
Connecticut River	18	329,552	18,308	29	24	15	8
New Haven and Northampton	20	371,561	18,578	28	25	12	12
New York, New Haven, and Hartford ...	92	2,004,062	21,783	30–35	28	...	15
Norwich and Worcester	21	371,284	17,680	30	22–25	17	15
Providence and Worcester	29	546,720	18,852	28	20	16	12
Springfield, Athol, and North-Eastern ...	4	99,158	24,790	25	20	...	12
Worcester and Nashua	21	311,953	14,855	30	23	15	10
Average	236	4,667,567	19,778	...	...	...	...

On some recent trials of the single Fairlie engines by Mr. A. V. Macdonald, General Manager of the Auckland Section, the following result was attained on 1 in 40 ascending grade, combined with 6-chain curves, dead start: Weight of engine in steam, 27 tons; state of rails, wet; cylinders, $12\frac{1}{2}$ in. x 16 in.; 6-coupled drivers 36 inches diameter; working boiler pressure, 140 lb.; load in nine vehicles, 81 tons 12 cwt.; average speed, 10 miles an hour. Adopting the American method of computation, with resistance 12 lb. per ton for the engine, and 5 lb. a ton for the vehicles, both on the level and straight, and $\frac{1}{2}$ lb. per ton for each degree of curvature, the total resistances are found to work out to 8,291 lb. for the curved portion of the line, which would require an effective steam pressure of 124·3 lb. in the cylinders to overcome. It is probable, however, that these resistances are somewhat high for the New Zealand single buffer stock. Time does not admit of my recording more extended experiments with these engines, which have been made, but at some future time they will be put on record.

Mr. G. Ashcroft, General Manager of the Wellington section, informs me that, in testing one of these single Fairlie engines, he took a load of 74 tons 7 cwt., in nine vehicles, up 112 chains of 1 in 35 grade combined with 5 chains reverse curves, at a very slow speed, with the object of determining the utmost capacity of the engine. The steam was above the normal working pressure of 140 lb. at times, and I must regard the feat as exceptional, and not one to be obtained under ordinary working conditions. The load was carefully ascertained.

The preceding data show that the American engines in New Zealand do not give results entitling them to pre-eminence in economical working, though they exhibit very good results. The much-abused Fairlie engines show results superior to the American in economical working on analysing the returns. The data obtained from the American Commissioner's reports shows that at any rate there are very large and important sections of railways in the United States which give results in locomotive working altogether different from what is shown by the pamphlet, the writer of which would lead us to infer that the somewhat inflated figures he quotes represent the ordinary American practice.

J. P. M.

APPENDIX.

A LETTER by W. W. EVANS, being a Commentary on Mr. MAXWELL'S Criticisms.

SIR,— New York, 14th February, 1880.

I have the honor to lay before you a few comments on parts of a parliamentary document sent to me from New Zealand headed *English and American Locomotives.*

This document contains a long and able letter by Mr. R. M. Brereton, late Engineer-in-Chief of the Great India Peninsula Railway, a letter written by myself to Mr. Higinbotham, Engineer-in-Chief of the Railways of Victoria, Australia, and not intended for publication; a criticism on the above letters by Mr. J. P. Maxwell, of New Zealand; and some opinions on engines by Messrs. Neilson and Co., of Glasgow, and the Vulcan Foundry of Lancashire. As the letter of Mr. Maxwell contains some errors of fact as well as opinion, I beg permission to offer, in as brief a manner as possible, a few comments on his criticisms.

To combat ignorance and prejudice is a very thankless and unsatisfactory duty to perform, as it appears to be an inherent principle in the brain of man "to try to believe what he wishes to be true." Mr. Maxwell undertook a duty that he was sadly incompetent to perform, simply because he had never seen an American locomotive and knew nothing about them, and being a civil engineer he could not be expected to know much about locomotives of any kind. He has, however, written a long letter, stated some things that are not based on facts, and jotted down a considerable amount of special pleading and fallacious argument. Most American civil engineers would "come to grief" if they attempted to write on English locomotives, for the simple reason that they know nothing about them. Mr. Brereton has written a long and very able letter in connection with railway economy, and deserves credit instead of severe criticism. He has given piles of facts and valuable data, and expressed opinions that any unprejudiced mind was sure to arrive at with such evidence as he had. He was well able to judge correctly on the subject he wrote on, as he had many years of experience in connection with railways, first in England, then in India as chief on one of the most important lines of railway in the world, then for some years in the United States, and now in England again. Surely a man with such experience should carry some weight in his train when he expresses an opinion, and particularly when it is understood that he is an educated English gentleman, living in England, and not in any way connected with any American enterprise or industry. He simply wished, without fee or reward, to give to railway progress a few facts from his storehouse of experience and knowledge, the same as Fox, McDonnell, Colburn, and others had done before him in the elaborate and clever papers they wrote and read before the Institution of Civil Engineers of England, and for which they were so highly complimented.

I have no knowledge of how my letter to Mr. Higinbotham came to get into print. It was a hurriedly-written private letter, written to prove one single point—namely, that American engines were not short-lived affairs, and, if that letter is not a full and convincing proof of that fact, then I submit that figures are deceptive, and that there is no use in referring to them in discussion or argument.

It was asserted by an English writer on political economy that any man who could make two spears of grass grow where only one had grown before was doing a benefit to all mankind. In the railway world it has been conceded that the true measure of railway economy is the cost of carrying a ton a mile, and that any one who can, by any device or system, produce this result, is adding something to the progress of the age in which he lives. The whole matter of railway progress and economy is wrapped up in this one item of cost of carrying a ton of goods a mile and a passenger a mile. It has often been asserted by "croakers" afflicted with weak thinking organs that the superiority of the English railway system is proved by the fact that the ratio of expenses to receipts in England is less than 50 per cent., while in America it is more than 50 per cent. Any railway investigator can readily see that, in a country where labour and materials are high priced, and where the railway tariff of charges is low as in America, the ratio of expenses to receipts must be higher than in England, where labour and materials are low priced and the tariff of charges high.

We claim in America that we have solved the problem of cost of carrying on railways a ton of goods a mile more finely and obtained more satisfactory results than has ever been obtained in any other country in the world. I will give the figures of cost of carrying a ton a mile for a series of years on the Pennsylvania Railway, and if any one can match them with better figures on any railway in England or Europe I will be delighted to see them:—

PENNSYLVANIA RAILWAY. GOODS TRAFFIC COST IN CENTS PER TON PER MILE.

Years	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Cost	1·82	1·54	1·25	1·20	1·00	0·87	0·886	0·857	0·719	0·616	0·582	0·552	0·483

It must be recollected that the through traffic of this railway is all carried over the Alleghany Mountains, on gradients of 1 in 55, and many curves of less than 1,000 feet radius.

The fallacy of the argument in reference to the ratio of expenses to receipts proving anything is shown when I state the facts that, in 1859, the expenses of the Grand Trunk Railway of Canada were 2 per cent. more than the entire receipts, and that in the same year the ratio of expenses to receipts on the Panama Railway were only 23 per cent., and that the same for 22 years, from the year it was finished to the last year I got the statistics, 1873, the average was $32\frac{4}{10}$ per cent., and this, too, with enormous expenses for labour and materials; but the tariff of charges was still more enormous.

Mr. Maxwell commences his letter by saying that there is but little information in Mr. Brereton's or Mr. Evans's letters that conveys any practical intelligence to a professional man, that they contain vague generalizations that are calculated to mislead an unprofessional man, and that the subject is taken up as if it was new. I submit that papers that are full of facts and few of opinions are of service to all professional men, and cannot mislead any unprofessional man who is a reasoning creature and has a brain above that of a "non-compos."

Mr. Maxwell complains that we do not give all the data of each engine, train, and road. Such data would swell an ordinary letter to the size of a book. As Mr. Maxwell calls for some more explicit data, I will give some in another part of this letter, as I am desirous to give the truth, simple and full.

Mr. Robert Stephenson once said to me at his own table in London, when I was offering some theory at a point in discussion, "Don't give us theory; give us facts: we have got past the age of theory." I admitted the strength of his argument, and have vividly recollected his bringing me up with a "round-turn" ever since. I will give Mr. Maxwell some facts to ponder over, but first let me correct some of his mistakes that are calculated to mislead the *professional man*, as well as the unprofessional man.

Mr. Maxwell says that the American engines cost £2,800 each. These engines cost on board ship, with tender, $8,500 each; equal to £1,717. With insurance, freight, commissions, and a liberal allowance for cost of landing and erecting in New Zealand added, I make these engines to cost £1,998 each. I sold the bills on London to pay for them, and got one pound sterling for each $4.94½. I also engaged the freight, so I am giving facts that are within my knowledge. There is a very wide difference between £2,800 and £1,998. How Mr. Maxwell came to make this big error, I leave to him to explain; but, having made such an error, I should like to ask if there is not a possibility of his having made an error in the other direction when he put down the engine he used in his comparison as costing *about* £2,700. I wonder what limit in sterling figures Mr. Maxwell gives to the word "about." It appears to be about £802, or say 40 per cent. of the whole, in the case of the American engines. Mr. Maxwell makes reference to an American engine on the Iquique Railway, in Peru, and calls it the "Evans' engine," saying it was too costly to work, and that the road was worked by Fairlie engines. I beg to say, in answer, that I never had anything to do with the engine he calls the "Evans' engine." I did not design, order, inspect, or receive it. I would here add that, in that particular case, it mattered not if the engine was good or poor, it was doomed before it left here. Mr. Fairlie had won the affections of the "Brothers Montero," the owners of the Iquique Railway, and by some "hocus-pocus" had made them believe that the engine he called his was something wonderful, and destined to regenerate the railway world. The Monteros were "innocents," and allowed their money-bags to flow freely into the pockets of Fairlie. Their faith was supreme, but their money-bags had a bottom. Fairlie put his faithful henchman, a Mr. Clemenson, on the road as locomotive superintendent, and from that day until the Monteros were nearly ruined and had to transfer their interests to an English company there was nothing believed in, "cracked-up," or allowed on that railway but the so-called "Fairlie engine." Before Mr. Fairlie and his man Clemenson were known on that railway, the Monteros, thinking that one railway was the same as any other railway, and an engine an engine—the same as one goose is like another goose—bought, as they would barrows or bars, two ready-made locomotives of Stephenson and Co. Finding they could not run their sharp curves, as they were useless they then bought two "Mogul engines" I had built for mountain railways in Peru. For one whole year, and up to the advent of Fairlie and Clemenson, these two engines did the entire work of that railway, and almost without repairs, for they had no shops or tools. Mr. Clemenson soon remedied this state of affairs. There was not much time lost in burning the flues of these engines, and then they were run out by the sea-side to allow the spray of salt-water to finish the job. I must do Mr. Clemenson the justice to say that, before he was kindly relieved of all authority on that railway, he had not only ruined all the American engines, but all the so-called Fairlie engines also. A merchant in Lima said the Fairlie engines were the best he ever heard of, because they ruined the rails, they ruined themselves, and the more they got the more they wanted, and the more they ordered the more his commissions were.

Mr. Maxwell is in error in saying that the Iquique Railway is worked by Fairlie engines. When that railway passed into the hands of some English merchants there was hardly a Fairlie engine on the road fit to run. The new company ordered a new set of engines of another type.

An eminent German railway manager says he has no engines on his lines that cost as little for repairs as the Fairlies, for he takes good care never to use them. When I found that there was such a hue-and-cry set up against the American engines on the Iquique Railway in Peru, and such a blast of "music in the air" about the wonderful performance of the Fairlie engines on that railway, I made an offer to Mr. Fairlie, through the editor of *Engineering*, that I would give him the price of a Fairlie engine if he could produce authentic data that any one of his engines on that road ever did, on any single occasion, as much duty in proportion to weight on driving-wheels as the American engines had done as a regular duty on that railway every day for a year. This offer was never accepted.

In 1870 Mr. Fairlie had some experimental trials of his engines in England in the presence of some foreign Counts and other noble railway experts. They declared the results to be wonderful, and were more than anxious to sign the strongest certificate that could be drawn. The data of these trials was sent to me. Wishing to see how it compared as to duty performed at two Government trials (one in Peru and one in Chili, South America) with engines under my direction (the trials being under the eyes and certified to by clever and experienced English engineers), I reduced the data of all down to one common basis of comparison—namely, foot-pounds of work done per hour per ton of weight on driving wheels, in moving train along, exclusive of engine. The results were as follow: Fairlie engine "Little Wonder," Festiniog Railway, gauge 1 ft. 11½ in., equal to 9,024,739 foot-pounds; Fairlie engine "Progress," Mid-Wales Railway gauge, 4 ft. 8½ in., equal to 9,272,339 foot-pounds; Rogers's American engine "San Bernardo," Southern Railway of Chili gauge, 5 ft. 6 in., equal to 41,587,020 foot-pounds; Rogers's American engine "Conquistador," Arequipa Railway of Peru gauge, 4 ft. 8½ in., equal to 25,377,544 foot-pounds. A full table of these comparisons was published in *Engineering*, 11th November, 1870.

I will send you a copy of these comparisons and also a pamphlet in reference to this much-lauded Fairlie engine. Mr. Fairlie has never been desirous to put his engines on any railway unless he could "saddle" his locomotive superintendent also on the railway. Mr. Meiggs, the railway contractor of Peru, gave Mr. Fairlie an order for one of his engines, after much solicitation, merely to test it. Mr. Fairlie wished Mr. Meiggs to build his Trans-Andean Railways with "breathing-places" for his engines. Our engines have now worked those railways for years without lung-complaints, these railways having gradients for many miles of 1 in 25, and sharp curves for nearly the entire distance up to the summits. One railway has over 70 miles that is over 14,000 feet above the sea-level. Mr. Fairlie, in writing to Mr. Meiggs, says, "There is no engine of the ordinary type built in England of the description you give, as far as I can understand it, capable of doing anything like the duty you report having done—namely, 135 tons, exclusive of engine, over a grade of 1 in 25, at a speed of 11¾ miles an hour. It would puzzle *even* a Fairlie engine to do such a duty. There must be some peculiarity in the climate or the gradient, or in *something or other*, which enables you to get such enormous duty out of your engines compared with what we can get here."*

Mr. Fairlie had *carte blanche* to build one of his engines and send it to Mr. Meiggs, in Peru; but he never did it, there was *something or other* in the way. Mr. Maxwell says that Fairlie engines on the Great Southern Railway of Ireland showed an average of 25,000 miles a year for three years. Now, as I am sure that this is what a Fairlie engine never did, I am led to believe that this is another error of figures in Mr. Maxwell's letter; and particularly as the Fairlie engines on the Mexican Railway, under the direction of one of Mr. Fairlie's own men, showed no such mileage. In 1874 the manager of that railway made out a statement in detail of the performances of the Fairlie and Baldwin engines, running from Vera Cruz to Boca-del-Monte. This table can be seen in full in the report of Augustus Morris (Commissioner to the Centennial) to the Government of New South Wales. This table, reduced, gives the following figures:—

Fairlie engines, miles per annum	14,371
Baldwin " " "	28,673
Fairlie engines, running and repair expenses per mile	79·32c.
Baldwin " " " " "	37·66c.

The above is for the only two Baldwin engines on that railway, and for the six best and newest of the seventeen Fairlie engines they had in December, 1874.

Mr. Maxwell says that the average mileage of the engines of the London and South-Western Railway is 25,000 miles. Now, although this railway does give the largest average of any railway in England, I cannot find a single year in which it gives as high as 25,000; but I do find this very railway figuring in the list of the twenty railways in England giving an average of 18,336 miles; again, in the list of twenty-two in England giving an average of 17,934; and again in the list of twenty engines given by McDonnell as averaging 17,625, all as mentioned in my letter to Mr. Higinbotham. I would ask Mr. Maxwell if he thinks it fair, in a discussion of this kind, to pick out the railway that gives the largest average and parade its figures as a set-off to the averages of twenty railways.

Mr. Maxwell says that Mr. Brereton and Mr. Evans claim a larger mileage for American engines than is shown by English engines, without a single qualification. This is a singular assertion. We give the mileage as printed in English papers, which I took the trouble to confirm by official figures, and then we state that this mileage is made in America on roads subjected to a more severe climate, gradients, curves, tracks, and loads. If that is not qualifying the mileage statements, then I am at a loss to know what kind of qualification Mr. Maxwell desires.

Some twenty years ago the *Engineer* published a statement of an engine performance in the United States, and then commented on it as follows: "The above engine performance, together with other similar data published in former issues of this paper, shows that from 20 to 25 per cent. greater duty is obtained from the locomotive in America than we can get here, and that, too, over what we know to be notoriously inferior tracks to ours. What can be the reason?" The Editor of *Engineering* once wrote to me in the same strain, and asked me to write him on the subject and explain the causes.

Mr. Maxwell says there are many ways of computing train-mileage. This is news to me. It must be a most objectionable record that has entered on it more or less miles than the engine actually run and hauled a train.

Mr. Maxwell says it is questionable if low speed is a drawback in obtaining a larger train-mileage. This is another singular assertion. Surely he cannot mean that a goods engine running 10 miles an hour makes as great a mileage as a passenger engine that runs 40 miles an hour.

Mr. Maxwell alludes to Mr. Brereton's remark that some engine economy may be obtained by running with two crews to an engine, and infers from this that the greater average train-mileage of American engines is obtained in this way. I would state that this matter of double crews on engines is of very recent date, and is now practised only on some trunk-lines for their heavy-goods trains. The mileage made by American engines, and referred to in Mr. Brereton's and my letters, was not, in any case, made by engines having two crews.

The practical inference to be drawn by *professional* thinkers, when told that one system of railway equipment results in engines making an average of 15,000 miles a year with loads of 200 tons, while another system, on similar lines, or more difficult, with equal loads, gives an average of 30,000 miles a year, is that the road with the 30,000-mile engine can whip out the other in the ratio of 2 to 1.

When I got an official report of the workings of the Fairlie engines on the Mexican Railway and laid it before the Baldwin Locomotive Works Company they said, "With such data the proof is clear that we could, with nine of our Consolidation engines on that railway, do all the work done by the seventeen Fairlie engines." Here comes in a point that is easily understood by the *unprofessional* mind. The nine Baldwin engines would cost in Mexico £26,000, while the seventeen Fairlies would cost £66,000, to say nothing of their greater cost for repairs, fuel, and destruction of track.

Mr. Maxwell says that this engine subject is taken up as if it was new and not before discussed. I beg to differ with the gentleman. It is well known to every railway engineer and investigator as an old subject, written on and discussed in various ways during the past forty years by some of the best and most lucid-thinking and writing engineers of England. In 1843 John Weale published a book entitled "Ensamples of Railway Making," in which he draws a comparison between the cost of an American railway and an English railway, showing that, while one cost £3,600 per mile, the other cost £30,000 per mile. Mr. David Stephenson wrote a book called "Civil Engineering in North America," in 1838, and jotted down many interesting and instructive things. Mr. Isaac, Mr. Pasavant, Captain Douglas Galton, R.E., Sir Charles Hartley, Mr. Neilson, Sir H. W. Tyler, and a number of other clever English engineers have written most instructive papers on the railway system of America, and pointed out in forcible terms the merits of many things and ways as practised here to their professional brethren in England, and urged their adoption; but they may as well have saved their pens, paper, and patience, for their recommendations were as so much water poured on the sand. I intend to refer again to

* The engines referred to had three pair drivers coupled. Weight on coupled wheels, 25·9 tons; diameter of wheels, 49 in.; cylinders, 18 in. x 24 in.

what some of these gentlemen said, thought, and urged; but the soil on which they sowed their seed of belief and faith never produced any good fruit. Some twenty-seven years since I undertook to sow some American locomotive seed of this kind in England, but was promptly met with the assertion that we in America were all wrong and they were all right. If that was really so, why did they in Canada alter all their first English locomotives to American patterns, and then order a vast number more from the United States, paying a large duty on every one they received, and have continued their orders ever since. Why have other English colonies, Victoria, New South Wales, Queensland, South Australia, New Zealand, &c., sent to America for locomotives. Surely no Englishman in his senses would send to America for engines unless he had some pretty positive proof that he was going to get something superior in utility and economy to what he could get at Home. I have never heard of any American manufacturer soliciting their orders. I have received and executed some of them, but I have never solicited them or expected them. I felt that there was no use in any American builder asking for orders, as they stood no chance of getting any. This was the case when a Canadian company asked for proposals for the Great International Bridge over the Niagara River. No American firm proposed. Finding there was no American proposal put in, the Canadians sent to Clarke, Reeves, and Co., asking for a proposal. They put in one, and got the work, not through any favour, but because their bid was much the lowest. This bridge is a master-piece of engineering. At the time it was built it had in it the largest "Draw"—360 feet—ever put in a bridge. It stood all the severest tests, some of them under the eyes of Captain Sir Henry W. Tyler, R.E. (It has carried a very heavy traffic for years.) Since then this firm of bridge-builders have built all the long-span bridges for all the railways in Canada, simply because they can do the work cheaper than others, and pay a heavy duty besides.

Mr. Maxwell draws a comparison between two engines, showing cost and tractive power (I have shown that he makes a huge error in quoting cost). He says the tractive force of American to English, of the two he compares, is as 60 to 93. This is the calculated or theoretical force, but what is the relative powers of these two engines when at work? Which can utilize the greatest percentage of its power—which consumes the largest percentage in frictions—which can traverse the curves the easiest—which is the steadiest engine in running—which is the easiest on the track—which requires the least repairs? All these are elements that the practical *professional man* will ask for. I cannot give them, but Mr. Maxwell, being on the spot, could and should have got and given all this data. It would, if favourable, have strengthened his argument, and it would, if unfavourable, as it was very likely to be, have knocked his argument all to "flinders." As I have not the New Zealand data of work, &c., actually done, I beg to mention some data of engine trials on a Government railway built under my direction in Chili, South America, in 1859. This railway, running from Santiago, the capital, to the south, had easy gradients and curves. Two engines were ordered from England and two from the United States, one goods and one passenger from each country, with the understanding that they were to compete with each other. Before the trials took place the Minister asked Mr. Bailes, the English engineer of the Valparaiso Railway, to calculate, from dimensions an weights, the theoretical powers of these engines; that is, what they ought to do.

Mr. Bailes was the cleverest mechanical engineer that had ever been on the west coast; he made a correct and accurate calculation of the powers of each engine, and compared them relatively. He showed that the English engines had theoretically the advantage in cylinder, tractive power, and in power due to adhesion of over 12 per cent. He shows the relative heating surfaces, and then winds up his report to the Government with the following passage: "Thus we see that, in addition to the superiority of tractive power of cylinders, and the tractive adhesion to the rails possessed by the English engines, their ability to sustain that power by the generation of steam exceeds by about 50 per cent. that of the American engines."

Now, having got through with the theoretical part, let us look at the practical part—the dimensions and the work done; the part the *professional man* would be likely to ponder over:—

Goods Engines.		—	Passenger Engines.	
English, by Hawthorne.	American, by Rogers.		English, by Hawthorne.	American, by Rogers.
28·60	28·11	Weight in gross tons	27·61	27·78
64081	39160	Weight on driving-wheels in pounds	46122	39576
6	4	Number of driving-wheels	4	4
54	54	Diameter of driving-wheels in inches	62	66
16½ x 24	16 x 24	Dimensions of cylinders in inches	15 x 22	14 x 24
1188	912	Fire surfaces	1204	783
586 v 335	587	Gross tonnage (cars v. loads)	288	291
35 v	35	Number of 8-wheeled cars in train	15	15
88. m's.	41. m's.	Time to summit, 11⅜ miles...	37½ m's	26½ m's
$20,001	$19,249	Cost of engines erected in Santiago	$19,881	$19,129
$7,247	$2,701	Cost of extras in Santiago	$6,782	$2,801
		Maximum gradient, 1 in 168		
		Minimum radius of curves in feet, 6,562		
		Limit of steam-pressure agreed upon, 115 lb.		
		All had copper fire-boxes and brass flues.		
		Cost of carrying each of these engines over the mountains from Valparaiso to Santiago, over common road, was about $5,000.		

The English goods engine having failed to carry the 35 cars with 586 tons beyond the third mile, was backed to station and tried with 130 pounds; failed a second time; was backed to station and tried with 20 cars, having 335 tons; got stalled twice, and got to the summit in 88 minutes.

The cars were all long, 8-wheeled, and each loaded with 10 tons of railway bar iron. The four days of trial were fair, with light winds, the rails dry and in good condition. Mr. Bailes, the mechanical engineer before-named, was on the footboard of each engine during the trials. The officers of the road—secretary, locomotive superintendent, stationmaster and foreman—were all Englishmen. The only Americans were the two that drove the two American engines, and they had English firemen. I must in justice say that the two English engines were about as badly designed, as badly balanced, and as stiff and clumsy affairs as I ever saw. They were what "Zerah Colburn" graphically called four- and six-legged beasts.

I will send to New Zealand a detailed account of these trials, so that Mr. Maxwell and other *professional men* may have something to judge by. The *Engineer*, in referring to these trials and giving much of the data, went into a laboured argument to prove that the duty recorded as being done by the American goods engine must be false, as no engine of its dimensions had ever, or could ever, perform such duty. I need only say, in reference to this, that Mr. Bailes was there with his eyes open, and that his notes agred with mine exactly.

It may be interesting to some *professional minds* to know that, in the trials of passenger engines, with trains behind them of *five times* the average weight of express trains of the London and North-Western Railway (*see* Ed. Wood's Private Reports), the American engine run some of the miles in 75 seconds, while the quickest mile of its competitor was 105 seconds.

Mr. Maxwell refers to Mr. Zerah Colburn as "an American engineer of *considerable eminence, and a most able writer*," and quoted from his Paper, No. 1230, on American Locomotives, read before the Institution of Civil Engineers, to show that steep gradients in the States were rare.

If Mr. Maxwell had looked down the page from which he got his quotation he would have seen that Mr. Colburn says the engineers in the States were the first to adopt long inclines of 1 in 45 and 1 in 90, and then goes on to give instances of engines working on gradients of 1 in 28·7, 1 in 16·5, 1 in 10, 1 in 18, 1 in 27, and 1 in 14, as far back as 1836. Surely, these might be called exceptionally steep gradients; but, after all, what has steep gradients to do with the designs or peculiarities of an engine? Why, nothing, except where steep gradients are found there also are found sharp curves; they are the "stumbling-blocks" in the way of the locomotive engineer; they are the features that have called for so many devices and ingenious inventions known and used by the engine-builders of the States, and it is because we have so many sharp curves that these inventions spring into existence here more than in any other country.

I supposed that everybody knew that steep gradients and sharp curves were very common railway features on all the mountain railways in the States. Gradients of 1 in 40 and 1 in 50, and curves of 400 and 500 feet radius, are to be found all over the States; and I have this very afternoon ridden over curves of 90 feet radius in the elevated steam railways of this city.

This Mr. Colburn was the editor of *Engineering*, and was considered in England the cleverest writer on mechanical matters of his day. When he was asked to write the paper above alluded to, he asked me to give him some data. I wrote him a long document, and gave him piles of data; but he did not introduce it in his paper. He contented himself with saying that "the difference between American and English engines was more a matter of costume and toilette than of vital principles of construction." No man living knew better than Mr. Colburn that the main differences were far from being merely a matter of toilette. I had told him that he would not dare to put in his paper the data I gave him, as his "bread and butter" were at that time dependent on his keeping on good terms with all his English patrons. Let us look through this paper of Mr. Colburn's and see if we can find anything worthy of reflection by a *professional man.*

Mr. Colburn says he was employed by the General Manager of the Erie Railway to run an experimental train over the entire line of that railway (a distance of 900 miles, going and returning), to determine the relative engine-power required on each division. This was in 1855. I hope Mr. Maxwell will not consider this so far back in the "dark ages" of railway work as to be of no use to a *professional man.*

The record, as Mr. Colburn gives it, is as follows: The engine had 4 coupled wheels of 5 feet diameter and a bogie. Weight in working time, 29·50 tons; 17·90 tons on driving wheels; outside cylinders, 17 × 24 inches; valves set to blow off at 130 pounds; fire surfaces, 10·38 square feet; the tender loaded weighed 18·50 tons. The train consisted of 100 American 8-wheeled wagons loaded with deals; weight of each wagon loaded, 15·40 tons; weight of total train, 1,572 tons; each wagon was on two bogies, having 4 cast chilled wheels of 30 inches diameter in each bogie; journals of axles inside, 3·88 inches diameter and 8 inches long, running in oil-tight boxes.

This train was a few feet more than half a mile long. It was run on a gradient of 1 in 880, for 4 miles, at a speed of 5 miles an hour, a stop being made in the gradient, and the train started again with no aid from momentum. This same train was run for 5 miles on a dead level over curves of 957 feet radius at 9·70 miles an hour. The train being reduced to 30 8-wheeled wagons, 514 tons in all, mounted a gradient of 1 in 117·50 at a speed of 10·25 miles an hour. Allowing for resistances due to gravity, and also to concussions and frictions of engine and train, the coefficient of adhesion must have been one-third of the weight on driving wheels. These results were obtained under the disadvantages of 6-feet gauge, small wheels, and large inside journals. Now, if Mr. Maxwell will produce equal results in proportion to weight on driving wheels as the foregoing, made by any English or European engine he ever saw or heard of, at that time or any time since, I pledge myself to give 100 guineas to any charity he may name. Mr. Colburn says in his paper that wrought-iron wheels, at first exclusively used on the Grand Trunk Railway in Canada, have been wholly abandoned, and cast-iron substituted; that they are much cheaper, more durable, and equally safe, and that the safety and economy of cast-chilled wheels entitle them to the best consideration of English engineers. Again, he says that Sir Edward Watkin, when in Canada as Controller of the Grand Trunk Railway, in the winter of 1861–62, had all the 6-wheeled tenders changed to double bogies, and to this change was attributed a great diminution in the breakage of rails during that unusually severe period; and yet, in the face of such evidence and piles more of the same kind that can be produced, the Messrs. Neilson and Co., the most liberal, clever, and progressive engine builders in the United Kingdom, after having said in their letter to Messrs. Hemans, Falkiner, and Tancred that the American type of engine is better adapted for railways as now constructed than the engine used in England, go on to tell us that it is needless for them to attempt to persuade their locomotive superintendent to adopt *even* a modification of the American type, as there would be a vast amount of prejudice to overcome. This is the most open but damaging confession that I have heard of yet. I had heard of the tyranny of the men in the shops (for a short time since the men in one of the largest shops in England refused to let a "quartering machine"—an American tool for the cheapening and doing work more quickly and accurately—come in the shops), but I had never heard before of a clever firm of leading engineers bowing down meekly to the imperial edicts of their superintendent.

Sticking to routine, sticking to old and antiquated ways of doing things, while a good portion of the world are enjoying the economy and beneficial results of improvements, is more than I can understand. Using crank-axles and inside connections, keying wheels on axles, using grease-boxes instead of oil-tight boxes, putting a heavy cone on the "tread" of wheels, using double-headed rails in cast-iron chairs, and a lot more of absurdities, which have been proved to be errors and discarded by Americans long years ago, looks as if the railway engineers in England were satisfied with what they had, and content to rest on their laurels for ever and ever more in a Chinese-like conservatism. In 1852 Mr. McConnell had a set of 6 American oil-tight axle-boxes tried on tender of engine No. 182 of the London and North-Western Railway. A set of English grease-boxes were tried at the same time on a similar tender. The engines were put to do the most trying work—running express trains at the highest speed, and ballasting. And, after running 6,000 miles in four months, they were examined. No oil had been added to the American boxes since the first day. The report (*see* Proceedings of Institution of Mechanical Engineers at Birmingham, 27th October, 1852), says, "The journals and brakes of the tender No. 182 are, at the end of four months, as perfect as when new. There was enough oil in the boxes to run 3,000 to 4,000 miles more. A great advantage is found that the great wear, endways, does not take place on the brasses as in the ordinary boxes using grease or tallow. The difference in saving of castings by the use of the American boxes is 176 pounds in a set of six. The American boxes cost for oil, waste, and leather, 1½d. a day; while the other set cost 9d. a day, or a saving for the former of 7½d. a day on a set of 6 boxes. This is all independent of saving in friction, labour in constant attendance on grease-boxes, delays at stations occasioned by hot journals, &c.; and yet, to this day, after these boxes were tried and vouched for by such a man as Mr. McConnell, they have never been adopted in England. Comment on this and similar matters in railway economy is not necessary. Such action is to me abominable, and it is a shame that railway interests should be sacrificed merely through a prejudice against the adoption of anything that was called American, even when it was really not American in its origin, as in the case of the bogie, for this swivelling truck took its name from a two-wheeled vehicle used in the streets of Newcastle. And Mr. Robert Stephenson told me that he proposed that device of the bogie to Mr. Robert L. Stevens, when he was building the Camden and Amboy Railway, in 1830, as a proper means for traversing curves. A gentleman in London told me, not a great while since, that they had tried, on the Metropolitan Railway, every manner of device to facilitate running their long cars around the curves, so as to get rid of using the bogie, simply because it was known as the American system. Here is prejudice for you—clean, clear, and unadulterated; unmitigated and unfathomable.

It has been maintained many times in England that great speed cannot be had with the bogie without great danger of accident, and yet these very obstructors on the track of railway economy must be most abominably ignorant if they have never seen or heard of great speed having been run many times on roads in the United States, Canada, and Russia with trains using bogies, and over tracks where the four-wheeled English cars would be sure to leave the road. Now, if the bogie carriages can be run with safety and certainty over our so-called "miserable tracks," is there any mechanical or scientific reason why they cannot be run with the same safety, certainty, and economy over the much-lauded perfect tracks of all England? The fast train that was run from New York to San Francisco in June, 1876, presented some features that were worthy of notice by the *professional man.* This train was made up of 3 long, heavy cars, each resting on two bogies, having cast-chilled wheels. The same cars were run through the *whole distance* of 3,317 miles, the time being 83 hours 27 minutes, including stops. This is very close to forty miles an hour, and has never been approached by any other railway run ever made. The run from New York to Pittsburgh was made (in the night chiefly) for the whole distance of 439½ miles *without a stop,* and at an average speed of 43½ miles an hour. In this distance the train passed over the Alleghany Mountains, attaining an elevation of 2,154 feet above the tide, over a tortuous track having many sharp curves under 1,000 feet radius, and gradients up the mountain side of 1 in 55. This division was run at a speed of 42 miles an hour. The engine, No. 573, that runs this route was one of the ordinary engines of the Pennsylvania Railway. It had 4 coupled wheels of 60 inches diameter, with cylinders of 17 in. x 24 in.; total weight, 33·17 tons.

On some of the level lands east and west of the Mississippi River this train was run at a speed of 65 miles an hour. Arriving on the Central Pacific Railway, this train was run the whole length of that road, 881 miles, by one engine, No. 149, built in 1866: cylinders, 16in. x 24in., driving-wheels, 60 inches diameter, running time, 21 hours 30 minutes—41 miles an hour. In this run the train had to pass over the Sierra Nevada Mountains, the summit tunnel of which is 7,042 feet above the sea, the route up the side of the mountain being one continued series of sharp curves of 600 feet radius, and steep gradients of 1 in 45. There are on this railway 1,150 curves, total curvature being equal to 125 entire circles. The brake shoes on the train, on arriving at these mountains after a run of 3,000 miles, were so much worn that they had to attach two more cars to secure more brake-power; the engine, showing no signs of distress after this remarkable run, was at once returned to duty on the road.

A large portion of the whole route from Pittsburg to San Francisco is a single-track railway. This train had to pass over four mountain ranges, one summit being over 8,100 feet above tide. The *running time* was at a rate exceeding 43 miles an hour for the whole distance of 3,317 miles, and was completed without an accident of any kind.

Now, what do these figures and this data present to the mind of the *professional man?* What can they present but the fact that such a railway performance stands unmatched and unrivalled by any other railway performance that ever took place in the whole history of railways, and that there is no other place or series of railways in the world where such a thing was possible. It presents other features for reflection, particularly among that class of "croakers" who are continually crying out about the poor, light, rough, flexible American tracks and rolling-stock. It shows one of two things—either that the tracks, cars, engines, officers, employés and management were of the very best possible in every part and department, or that the men who got up and conducted such a railway feat were a foolish, daring, and reckless set.

Among the ignorant, American railway tracks are always put down and described as light, poor, flexible, and rough, and this no doubt is the case in some of the sparsely-populated regions of the West where the business is light and the requirements small; but why writers, except with an intention to deceive, should place the tracks of the great trunk lines of America, and many other lines, in this category, it is difficult *for a professional man* to conceive. The rails are in most cases, the same weight and material as are used in Europe; the ballasting is as good and, in some cases, better than any I ever saw in Europe. (The Pennsylvania railway is ballasted with broken stone throughout, even where they run through beds of fine gravel.) The sleepers are of the same kind of timber and of same dimensions, and more of them are used to a mile; the fastenings are good and reliable, and trains are run with as much security and reliability, and on many occasions with as great speed, as in Europe. Now, where does the poverty of this thing come in? It is a fact that "Jack Frost" does sometimes pitch and toss our tracks, and break things with a facility that is alarming; but he handles the English-built tracks of the Grand Trunk in Canada with still greater ferocity and want of tenderness; and I can bear witness to the fact that, in Russia, he treats with the same marked disrespect and unmannerly conduct the tracks of the Imperial Nicolai Railway, which he puts his adamantine grip on, sometimes just after severe rains have distorted it, and then it has to remain in that condition all winter, while carriages are run over it at forty miles an hour. Mr. Winans told me, in St. Petersburg, in 1866, that he could find no wheels that would stand the severity of that traffic in winter but the cast-chilled wheels, and that he had wheels then on the road of Salisbury iron that had been running fifteen years.

It may not be uninteresting to state that American railways have been so often and so persistently decried that many Americans who never carry any thinking or reflecting apparatus about with them, and who have been told in England that our tracks are so poor, join in the cry and belief that all American railways are but flimsy affairs anyhow; and this, too, after travelling thousands of miles without ever seeing or hearing of an accident. The great mass of people in this world are not willing to be troubled with thinking for themselves, but are ready to pin their faith on the preachings of some one else. Doctor Lardner, in his *Railway Economy*, of 1850, page 400, says, "With an experience of twenty thousand miles of railway travelling in the United States, I have never encountered an accident of any kind, or heard of a fatal or injurious one. The form and structure of the carriages is a source of considerable economy in the working of the lines." Having given an Englishman's opinion of American railways, let us jump over the Atlantic and take an opinion or two on the other side. Some years since, being in London, an English engine-builder, long in charge of one of the most noted works in the States, wrote to me from Edinburgh saying, "I came up here from London last night, and never had such a shaking up in my life." I had been that day down to Portsmouth, and returned so tired out from the shaking I had received that I could join my condolements with the man in Edinburgh.

During much of the past two years I have been travelling over the length and breadth of Europe with two young ladies in my party, and found them often exclaiming, "Oh, I cannot stand this shaking; I cannot read a word. This car is bad; this road is rough."

Did it never occur to any one that a carriage which could not run steady, even on a good track, must be a source of injury to the permanent way and to itself, and that it was playing mischief with the power of the engine? There lies some of the reason why the English engine, on the best of tracks, cannot utilize as large a percentage of its power as is commonly done by American engines on the *poor, light, miserable* tracks of the States.

Another point that deserves notice—among the common sayings in reference to the American railway system—is that American engines are flexible, like a basket, and are pretty good on our *light, rough, poor tracks,* leaving the inference to be drawn that they are not suited to nor would they give good results on the heavy and perfect tracks of English railways. What can be more preposterous—to think that an engine that can do its work well and safely on a rough track is not a reliable engine on a smooth and good track. Is a ship that can

"——walk the waters like a thing of life,
And seem to bid the elements to strife,"

a poor and unreliable craft on a smooth sea? The veriest tyro in mechanical arts can know, and must know, that an engine that can run with ease and safety on a rough track must be a good engine, and a money-saving engine, on a smooth track.

Having said so much about American engines, let us see what Mr. Zerah Colburn, the *engineer of considerable eminence,* says about English engines in an editorial in *Engineering,* 16th October, 1868, vol. vi., page 345. He writes as follows: "LOCOMOTIVE ENGINES.—Although locomotive engineers are plain, practical bodies, they would no sooner listen to any proposal to give it new forms than would the genius of sculpture, or his chosen disciples, to transform the *chef d'œuvre* of the Belvidere Gallery into the traditional tripodal aboriginal of 'Manx.' The locomotive engine is —as the locomotive engineers would, we are sure, say—a heaven-pacing 'Pegasus'—good-looking as, may be he is, nevertheless the greatest beast that paweth the valley, and his pawing is really more than the valley can withstand. In plain English, the locomotive of 1868 is a monster which all good engineers should unite to destroy. He is a stalking-horse of railway bankruptcy, the gaunt steed of railway ruin. It is time he was off to the 'Knackers,' and his carcass sold for what it will fetch in gun metal (precious little) and old iron. There are several counts of the indictment against this beast. But chiefly he will perform his plunging, racing, backing, gibbing, and shying only on an iron railway, and of his sextupedal or octupedal hoofs there is generally one pair on which from ten to fourteen tons of his carcass are supported. With these he will often 'let out' in a manner to grind fire from the rails. (No railway ought ever to be strained with a load of more than four tons to a wheel.) He has grown altogether too big, and he must either have more legs put under him or else be knocked in the head. When the beast has eight, or ten, or twelve legs, as some of them have, in turning a sharp curve the off-wheels are playing mischief with everything on that side. The fact is, very long-bellied horses of the breed we are now dealing with will never ride well in the 'ring.' Dropping mataphor, eight, ten, or twelve-coupled engines, having, therefore, necessarily long wheel bases, tear the 'way' to pieces and themselves too. The system of engine building which requires a permanent-way twice as strong as is necessary for the paying load, including wagons to be drawn, is, on its face, wholly wrong, and nothing but habit and an almost pagan veneration for the outward form of the locomotive as George Stephenson left it can account for the long continuance of a practice so palpably vicious," &c., &c.

The proper counterbalancing of engines was a matter on which Mr. Colburn, on several occasions, under took to preach a reform in the railways of England, but, as far as I know, with little success. The great importance of this matter had been clearly stated by George Stephenson many years ago. D. K. Clarke, in his great work on Locomotives, declares the importance of it, lays down the laws governing it, and describes the rules that should be followed in counterbalancing an engine to make it run steady. Colburn took one of the heavy 4-coupled engines of the South-Western Railway of England, counterbalanced it correctly, then ran it at the rate of 60 miles an hour with perfect steadiness. He then took out his counterbalances and returned it to its former condition. In that state they did not dare to run it at over 20 miles an hour, and at that speed they found the oscillations so violent and the concussions so great that they broke two strong hooks between engine and tender. This engine was called the "Norman." Another of the same set, called the "Canute," was properly counterbalanced, and showed a saving of 4·20 pounds of coal per mile, or 20 per cent. of total consumption. Four of their engines were properly counterbalanced, and showed an average saving of 3 pounds per mile after a total mileage of 108,941. For this data and other similar data see Colburn's great work on Locomotives, page 253. The latter half of this work was accomplished by D. K. Clarke, after Colburn's death, and he became responsible for the contents.

I met a Polish mechanical engineer at the Paris Exhibition who had been much on the railways in the States, and who was interested in locomotives. I found him most enthusiastic as to American engines. What he said to me he afterwards put in writing: it was chiefly as follows: "All our engines on the continent are patterned after the English; they are all unsteady in motion; it is no exaggeration to say that, compared with the American, riding on them is like riding on a car-horse and an Arabian. This unsteadiness of motion diminishes the effective tractive power and increases the wear of the road. European engineers, those especially who visited America during the 'Centennial,' say that European locomotives would soon destroy American road. Do they not thus admit the superiority of the American motor? How strange it is that they do not consider it important to have their locomotives so constructed that they can diminish the wear and tear of their roads, and increase their effective power. I had the intention to take a trip on a locomotive from Paris to Troyes, but I had to give up after some 80 kilometers—not being able to stand the shaking. This never occurred to me in America. I asked the engine-driver how he could stand such severe service; he said, 'the company take care of me when I am ill, or I should be obliged to give it up.' During the Philadelphia Exhibition an Austrian engineer was charged with making a detailed report on American locomotives. He speaks at length about the steadiness with which they run. Some years since, in Vienna, a premium was offered for a design of a locomotive that would run steady at high speed. The locomotive adopted was nothing else but an imitation of an American standard locomotive. The success would be greater if the American locomotive was wholly copied."

So much for the Pole's opinion on steadiness. Let us see what others say. Mr. A. D. Smith, Locomotive Superintendent of State Railways in New Zealand (all 3-feet-6-inch gauge), writing, in October, 1878, about the first American engines erected there, says, "These engines are giving the greatest satisfaction. The engine 'Lincoln' has run, up to 8th October, 22,474 miles (equal to 47,000 miles a year) in 147 days, at an average speed of twenty-five miles an hour."

At this same time the Secretary for Public Works of India writes that, on account of the unsteadiness of the engines (all English) on the State railways in India (all of meter gauge), he has been forced to reduce the speed to fifteen miles an hour.

I wonder if this is not something for a *professional man* to reflect on; if it is not, I should recommend him to study a most exhaustive report published by the Government of Victoria, Australia, on the merits and demerits of the locomotives built at Melbourne. This report shows that these engines had the remarkable ability, when running on *straight lines*, to move the whole track bodily sideways 3 inches, and kink the 80-pound rails in lengths of 5 feet. One of the witnesses, when asked to explain the motion of one of these engines, said, "Well, sir; it looked very much as if one side of the engine was trying to get ahead of the other." This report was drawn by a Commission of Locomotive Superintendents of railways of different colonies of Australia. It grew out of the report of Mr. Higinbotham, Engineer-in-Chief of Victorian Railways, to his Government on American and other railways, in which report he condemned the Melbourne-built engines as poor and inefficient. I will give, in an appendix to this letter, some extracts from this report of Mr Higinbotham on American rolling-stock, first stating that he came to this country, as he admits himself, decidedly prejudiced against things American.

The laboured arguments that from time to time appear in the *Engineer* to show that the American engine is a "myth," and that all that is claimed for it is mere "moonshine," are very amusing, and bring to mind the many editorials in *Engineering* holding up that paper to ridicule, and in no stinted terms measuring out the paucity of talent and knowledge that conducted its destinies. If it had been entitled an "English Trade Circular," devoted to bolstering up crude and fallacious mechanical devices, instead of holding up its head as the exponent of scientific research and mechanical progress, it would have come nearer hitting the mark of truth and accuracy. There was a time when the *Engineer* could afford to soar pretty high in the world of engineering minds. But those were the days when Colburn directed its editorial pen. Alas, for those days, and the early days of *engineering*; they have gone like the baseless fabric of a vision bent upon a wrecking expedition. Colburn, with all his cleverness, and rising like a meteor, flashed for a while, and then sank himself and his paper so deep in the mud of venality and vituperation that it has been no small job for his successors to dig the paper out and set it on the high pedestal it once occupied.

Recently some small papers in the far east, finding that certain Governments in Australia and New Zealand had, in the spirit of progress and economy, ordered rolling-stock from the States, and feeling not only very patriotic but very virtuous, considered it their bounden duty to join in the key-note of the hue-and-cry set for them by the *Engineer* in a crusade against the American railway plant. They are right; I would do the same myself, if I were in their place; but I should, in the first place, try not to get in the position of a tool for any trade circular; and, in the second place, I should try not to make a fool of myself by assertions that any tyro in railway matters must know to be untrue.

It appears to hurt the consciences of some of these worthy editors that British gold borrowed to assist the colonies in railway construction should be sent to America for engines and cars. This is certainly very naughty; but I suppose the Governments that borrow have some good reason to give for the way in which they spend their money, just as certain bankers in Paris, some years since, decided that they would not loan the money required for a new line of steamships unless the promoters agreed to have the engines built in England. This was no doubt naughty also. But the bankers may have had a reason for it. And they were probably not as much in the dark about the reason as Rogers was when appointed poet-laureate and said to a friend—

Once on a time
They promised me reason for my rhyme.
But from that day to this season
I have seen neither rhyme nor reason.

Large sums of money are drawn, no doubt, from the pockets of Englishmen to build railways in New Zealand, and I have no doubt but that they would, if asked about how it should be spent, say, "Go and spend it where you can get the most for the least, only, for Heaven's sake, make sure to give us our interest regularly." The amount of money loaned in this way to New Zealand is but a "speck in the bucket" to the vast sums loaned to railway companies in the United States and Canada, and yet these "Yankees" and Canadians are so unmannerly as to spend it all on this side of the water. The Canadians in this are worse than the "Yankees," for they come down here with British gold in their pockets to buy engines, bridges, &c., knowing that they will have to pay 17½ per cent. duty on their going into Canada, and also knowing that they could get engines and bridges from England without paying any duty. There must be a reason for this, other than mere love for their neighbours.

A few days since I saw a large amount of tramway cars boxed and marked for London. These cars were no doubt paid for in British gold, and were going to the very heart of the British Empire. This was another naughty trick to get rid of good gold in an alien country. There must have been some reason for it.

The Chairman of the North Metropolitan Railway Company, of London, some three or four years since, in his annual report, told his shareholders that their city-made cars had a life of only 4½ years, while the cars made in New York were found to be much superior. He had no doubt discovered that the tramway-cars built by John Stephenson, in New York, had an average life of twenty-five years, and that they were in use in all parts of the world. Surely there must be some reason for these cars lasting so unconscionable a time, seeing how "poor materials" and "execrable" workmanship we use in all our railway "plant."

The Otago *Times* is a firm believer in the preachings of the *Australian Engineering News* (a paper recently started, I am told, in the interests of Fairlie), and speaks of a "clap-trap" editorial of that paper as an "able article that fits our mind conclusively." Any article can be made to fit an ignorant head. That little head of the Otago *Times* says that the bar-frame of the American locomotive was introduced because it was flexible, and that it was done at the expense of strength and stability. Every railway child must know that the very reverse is the case. It was adopted because it was less flexible, stronger, and more stable than any slab frame can ever be made. I intend to touch on this frame point again, and give some clever English engineers' opinions on it.

Bogies under tenders are another contrivance that does not suit the Otago mind. It says that brakes cannot be applied to them. Why not? They are on the bogies of every locomotive tender in the States, as well as on the bogies of all cars, and are found efficient and reliable.

Other trumped-up objections are that "poor materials" are used in American locomotives, that they are short-lived, work execrable, &c. I intend to give answers to all these points in an appendix, and chiefly from the pens of clever English writers, *professional men*, whose liberal minds have not been cramped up in the small quarters of those who carp at everything, and particularly American things.

This matter reminds me of what a gentleman from Melbourne told me of the love of abuse by the editors of that city. In referring to the first Governor of Victoria, Mr. La Trobe, he said that man was the best governor they ever had—honest, talented, and energetic. He did wonders for the infant colony, but he was so badgered and abused that he was driven from the colony by a set of howling editors, and is now living on a small pension in London, while some of these same editors are living there in elegance on their ill-gotten gains.

A junior partner in a law firm once asked his senior how he should conduct a case. He answered, "Why, by argument deduced from the merits of the case." "But there are no merits, and no argument to offer," said the junior. "Then," said the senior, "abuse the plaintiff." This appears to be the rule of action—the human nature of those weak brains that are eternally carping at things they cannot understand.

I might here state that the specifications for American engines are not left to the builders, as these writers assert, but are drawn up with much care and in complete detail; also that American engines are not in many cases "mere duplicates of others." The first engines built for New Zealand were different from any built before, and some delay, as well as considerable cost, was occasioned by having to make for them an entire new set of patterns. These are the engines Mr. Maxwell puts down as costing £2,800 each, and which cost really only £1,998.

It is contended that, for the colonies engines and all classes of rolling-stock can be got as good and as cheap in England as in the States; if so, then they ought to be got there. Any colony that would be going out of the limits of itself or its mother-country to get anything, without some good and valid reason, would, in my opinion, be doing an unjust and an unnatural act. It is contended that rolling-stock can be built as good and as cheap in New Zealand as it can be here; if so, it ought to be built there. It is easy enough to try the merits of this policy. I saw it once tried in South America in the matter of cars. It turned out fallacious, as the cars cost just double the cost of those they imported.

I beg to say, in concluding this already too long letter, that it is not written for the purpose of converting any one, nor is it written as a trade circular, or to advance my own personal interests, for I am not seeking or asking for business of any kind, nor do I expect any profit or compensation from any source, except the satisfaction that may result from throwing light on an important subject, with a faint hope that it may assist in removing the blindness of prejudice and the folly of error.

A man that has had the honor to write, by request of the British Government, an opinion on railway economy, and then refuse to receive any compensation, except thanks, from so high and mighty a patron, while others were asking and receiving fees far beyond £10,000 for similar opinions, need not fear that his acts will be misconstrued or attributed to any feeling but that of love for progress, prosperity, and the diffusion of knowledge among men.

I have, &c.,
W. W. Evans,
Member, Institution of Civil Engineers,
Member of American Society of Civil Engineers,
Member of Council, American Geographical Society.

The Hon. Sir Julius Vogel,
Agent-General for New Zealand, London.

P.S.—I must not close this long and no doubt tiresome letter to some to read, without offering my sincere thanks to Mr. Maxwell, to the editor of the *Engineer*, and other editors, for giving me a chance to ventilate this important matter of American railway plant more thoroughly than it would otherwise have been done.

THE TESTIMONY.

An Appendix, giving the opinions of several clever and well-known English engineers on the merits and peculiarities of American locomotives and railway plant.

As some of these extracts are taken from the proceedings of the Institution of Civil Engineers of England, and as those publications are not to be purchased, nor are open to the public, they may meet the eyes of some who would not see them otherwise, and will, I am sure, be read with interest by all who desire to see railway progress, and who study railway economy.

Extracts from the Report of Thomas Higinbotham, Engineer-in-Chief of Victorian Railways, to Parliament on the Railways of the United States in 1875.

Page 4. "I rode on the engine crossing the Sierra Nevada Mountains; the speed on falling gradients was very great, but the drivers appeared to have perfect confidence in their engines. I had opportunities of speaking to several drivers—Englishmen—who had driven engines in England; they all preferred the American to the English engines."

Page 12. "At Toronto, Canada, there are two railways of 3-feet-6-inch gauge—the Nipissing, 88 miles long, and the Toronto, Grey, and Bruce, 190 miles long. These two lines were stocked at first with engines and carriages and wagons built in England, which proved complete failures, and have been replaced by American engines and carriages; these are found to work well. The rigid wheel base of the English rolling-stock, the small wheels, and the radial axle boxes had been tried and condemned. The original rolling-stock was of light construction. An accident happened on the Nipissing line; a train left the track. I was informed that after the accident nothing was left of the rolling-stock but the wheels. The rolling-stock now used is as strong as that used on a road of 4-feet-8½-inch gauge; it is found to be much more economical than the light stock. The master mechanic (locomotive superintendent), who is an Englishman, told me that he preferred American to English engines and rolling-stock for railways in Canada."

Page 20. "The bogie truck and cast-iron wheels are two of the most important features of American engines and rolling-stock. On the Grank Trunk Railway of Canada, neglecting the experience gained in the States, English engines and rolling-stock were tried, but had to be abandoned and the American type adopted; very recently the same mistake was made on the Narrow Gauge Railway of Canada, and with the same result. The chilled cast-iron wheels stand well; they are safer in severe frosts than those with wrought-iron centres and steel tires, because they are in one piece. It is well known in England that some of the worst accidents have occurred from wheel tires breaking in frosty weather. There has always been a distrust of cast-iron wheels in England, but it is impossible to resist the testimony in favour of the safety of the cast-iron disc wheel which is used in the States. I feel convinced that the best of these wheels are as safe as the best wrought-iron wheels in any climate, and that they are safer than wrought-iron wheels with steel tires in countries subject to severe frosts. I did not go to the States at all prepossessed in favour of American engines; but what I saw there satisfied me that for the light railroads of this country they are better adapted than any others. I am of the opinion that it would be a wise course to obtain engines from the States. The vast system of railways in the States, extending over 70,000 miles, has led to the establishment of great works with the most perfect machinery for the manufacture of locomotives. The competition between these works secures first-class engines at moderate prices. The express trains on the London and North-Western Railway are drawn by engines with two pairs coupled. The practice on this railway has, admittedly, been influenced by that of the United States in this respect, and corresponds with it."

Page 60. "Iron tubes are used in the engine boilers in Switzerland, and are found to be more durable than those made of brass or copper."

Page 66. "All the mistakes in the construction of engines and rolling-stock of the narrow-gauge railways of Canada, which have been corrected at great expense, are being repeated on the metre gauge railways of India."

NOTE.—The above is pretty plain writing for a man that came to the States prejudiced against American railway appliances. But Mr Higinbotham was an educated gentleman in search of the truth, travelled with his eyes open, and had the courage to tell what he saw honestly. The London *Engineer*, in reviewing this report, allowed the following to slip, I suppose by mistake, into its columns: "Now it is true that English engines on English roads very seldom run off, but this results not from the merits of the engine, but from the excellent qualities of the road. And it is worth considering whether an American engine which is capable of running well on a road which sets an English locomotive at defiance might not be found to run more *lightly*, *cheaply*, and with less practical resistance, and less wear and tear of track than an English engine." Surely the *Engineer* can "blow hot" and "blow cold" when it is in a disposition to blow either.—W.W.E.

In the centennial year 1876, Mr Massey Bromley, a highly-educated and experienced English engineer, Works Manager of the Great Eastern Railway of England, came to this country expressly to study locomotives. He brought me letters of introduction. He was soon put in communication with the best men, and had a chance to see the locomotives and practice of many railways. At the end of his 100 days' furlough, he came back to New York and said to me, "I am going home to build American locomotives." I (E) said, "I doubt you very much; I do not believe you will build driving wheels as we do." He (B) said, "Yes, I will; I believe them to be better and much cheaper than our wrought wheels." (E.) "Well, how about the frames; are you going to adopt our frames?" (B). "No, we cannot afford that; your frames are too costly for us." (E). "Well, what type of engine are you going to build? You say your railway company are going into the coal business." (B). "I am going to build engines like your Moguls." (E). "Why not adopt our Consolidation engines? they are the fellows for the coal trade." (B). "Oh! they are too advanced for us; our directors could not understand them. We have not a siding on our lines that could hold the trains they would haul." (E). "But why not lengthen your sidings, and get the full economy of the thing at once." (B). "No, they would not listen to such a thing."—W.W.E.

Extracts from the Report of Mr. J. Boyd Thompson, General Manager of the Northern Railway of Buenos-Ayres, to his Directors in London.

Buenos-Ayres, 27th June, 1867.

"Our present stock of first-class carriages consists of ten English and two American; the last with seats for 64 each and weigh 10 to 11 tons, or 385 pounds per each passenger. The ten English seat 60 each, and weigh 16 tons, or 597 pounds per each passenger, or 212 pounds for each seat more than the American. Three American seat 72 passengers more than two English, and weigh one ton more. During the past ten months the ten English carriages cost $40,816 currency for repairs, whilst during the same period the American have cost nothing for repairs, and are at present in better condition than those made in England, though they have been in constant use since the line was first opened. I may also remark that their chilled iron wheels scarcely show any perceptible wear. The American carriages are, in every respect, better and more comfortable, requiring less than one-half the power to propel them that is necessary for the English. It has also been proved that the English carriages are much more injurious to the permanent-way and works, and likewise, in proportion, injurious to themselves, than those of American make. I beg to conclude these remarks with strongly recommending the American-made carriages and wagons, and from experience of their working on the 'Boca' and this line and their fitness for our traffic. They cost less, are not so expensive to keep in repair, run easier, and cause less wear and tear on the permanent-way."

NOTE.—The accuracy of the above can be verified at the office of the Company in London. It appears to be pretty strong testimony coming from a Scotchman who had never been a day in the United States, and was certainly under no American influence. The $40,816 for repairs was, no doubt, in depreciated currency far below gold value. This report was sent to me from London, in print. I have never seen this Mr. Thompson, or any officer of that railway. Mr. Thompson had no American engines on his railway, so he could not add his testimony on that point. Messrs. Brassey, Whythes, and Wheelwright, contractors for the Central Agentine Railway, sent me an order for all the rolling-stock for that great railway. I had to write them that I could not send the engines if they gave me £10,000 for each, as it was in the midst of our civil war, and all the locomotive works were fully occupied by the Government. Years after this, Mr. Wheelwright wrote me of the engines he had on that railway (over the Pampas, nearly level, and almost entirely straight from Rosario to Cordova, 243 miles), and said, "You would have saved us a mint of money if you could have sent us American engines." I think the English railway world will admit that that firm had pretty "level heads" on their shoulders, and knew what they were about.—W.W.E.

Extracts from an Article on American Locomotives published in "Engineering" *in* 1871; *by A. Brunner, Engineer of Cockerell Works, at Seirang, Belgium.*

"Montreal, 1st January, 1871.

"The American railway engine, as compared with European locomotives, bears upon its face the stamp of much fertile originality (similar to that of American steamboats and bridges), when confronted with transatlantic work of a kindred class. . . . I have examined American locomotives in detail at the manufactory, witnessed their performances on all kinds of track, and I am compelled to confess that what I saw far exceeded my anticipations. . . . One of the peculiarities in American locomotive construction is the framing, which is made of square bar-iron, welded together, slotted, planed all over, and entirely finished. The bar-frames, besides being very rigid in every direction, admit of easy access to the link motion; they form at the same time a good base for attaching the various brackets and guide-plates. The cylinders, which are usually outside, are hung from the top bars of the frames, to insure a firm base for the cylinders; and, to prevent independent strains on the frames, a cast-iron separate bed-plate, or 'saddle,' is inserted between them. . . . As a rule, the various details of the motion and gearing are admirably well proportioned and carried out. . . . The cast-iron wheels form another distinctive feature in American practice. The small, chilled, cast-iron disc wheels of their engine-tender and car trucks answer admirably well, being cheap, strong, and durable at the same time. . . . Much ingenuity is displayed in the manner of setting engine and tender on the wheels: in fact, the problem of making an easy riding engine, offering at the same time the least amount of internal resistance, has been solved by the Americans most successfully. Much might be written on the history of the swivelling truck, the faithful 'trackfeeler' of the American locomotive; it would take a graphic pen to record all the modifications this useful contrivance has already encountered. . . . In outside appearance and finish the American locomotives present much original conception, and not unfrequently real artistic merit. The Yankees seem to place great pride in their engines, and it is indeed a proud sight to see an American engine entering a station, blazing in polished brass, embellished with a rich picture, bells ringing and whistle roaring. We will now proceed to witness the performance of American engines. One of the most striking observations is the ease, not to say 'grace,' with which the comparatively light locomotives do their work—and heavy work, too—over the rough roads of the United States and Canada. The average gross tonnage of passenger trains here is probably double that of English trains; still, with from six to seven passenger cars weighing, loaded, about 20 tons each, a baggage car of same weight, and a Pullman drawing-room or sleeping-car of 30 to 35 tons weight; the engine gets quickly away from the station, and without 'slipping.' Of course there must be some material reason to account for the superior useful effect given by American Engines. . . . The Baldwin Works have turned out not less than 200 locomotives in the year. Locomotive building on this continent has made great progress of late, as verified by the perpect organization of the workshops, and the systematic manner in which the work is turned out. My visit to this great country has made a lively impression on me, which I am sure will be shared by most impartial critics, that, in the specialty of locomotive construction, the Americans are fully equal, if not ahead, of the best European practice."

Extracts from the "London Railway News," *for 16th and 30th November,* 1872, *and 22nd February* 1873.

This paper compared four English and four American railways, putting the Grand Trunk Railway of Canada in among the American, to which we decidedly object.

The *Railway News* says, "Comparison shows that the American engines perform an amount of work altogether unequalled by those on any line in this country; for example, the New York Central, where the traffic is heavier even than on our London and North Western Railway, there are not half the number of engines mile for mile to work it. It must be remembered, in instituting a comparison based on the earnings, that the rates of transportation are lower in America than in England; and therefore to earn as much per mile as an English train the American must carry much heavier loads. With respect to passenger trains, the American mean average is 6s. 5d. per mile, against 4s. 7d. in England, the difference being nearly 40 per cent. The rate of fare is probably about 30 per cent. lower than with us, and this, added to the 40 per cent. of extra earnings, shows that an average train in America must convey about 70 per cent. more passengers than an average English train. The American average, it will be noticed, is considerably reduced by the low average of the Grand Trunk Railway, and we are therefore probably within the mark in putting the difference in favour of the American train at 70 per cent. The New York Central average of 7s. 1d. per passenger train mile is probably the best of any large line, and affords a striking contrast with the Midland Company's average of 3s. 11d. only. After deducting working expenses, what a difference there must be in the net profit per mile run by passenger trains on these two lines. Comparing the earnings taken in connection with the cost of the plant, the earnings of the four English companies is £4,662 per engine. In America, on the other hand, the engines earn, on an average, no less than £7,963 each, and on the Lake Shore line each engine actually earns £8,765 a year, or more than three times its present value. Altogether, it would appear that an American locomotive earns somewhere about 70 per cent. more in a year than an average English one. The very same result, singularly enough, appears when the earnings are taken in relation to the original value of the rolling-stock on the lines. The rolling-stock on an English railway may be said to earn its own cost in a year; but in America it earns its own cost and 65 per cent. additional."

The *Railway News* shows that the earnings of the London and North-Western Railway, in 1871, was £4,856 per mile, that they operated 1,614 miles of railway, and had 1,791 locomotives: that the New York Central Railway had earnings of £5,417 per mile, operated 845 miles of railway, and had 423 locomotives. This data reduced shows that the New York Central earned, per mile of road, £561 more than the London and North-Western, and that it did its work with fifty-hundredths of a locomotive per mile of road, while the London and North-Western Railway occupied the services of one and eleven hundredths of a locomotive per mile of road, to say nothing of the New York Central having more severe gradients, curves, and climate to work in, and doing its work on what are considered to be in England "poor, miserable, light, loose tracks."

NOTE.—As the Grand Trunk Railway of Canada, has been introduced in these comparisons, I beg to pay my compliments to it in this connection of comparative merits of American and English engines. Indians are said to be not satisfied with one "scalp," they must have a dozen or more. As I do not intend to be ever again induced to "enter the lists" in favour of or against anything appertaining to railway rolling-stock, I may as well have my say out and knock down all opponents so they cannot get up again, or at least make a bold attempt in that direction. The Grand Trunk Railway was built by English engineers with English capital. The engineers boasted on more than one occasion that they were going to show the "Yankees" how to build a railway. It was stocked originally with English engines and cars, and has always been managed by Englishmen. When this great line of over 1,400 miles had been brought to the very verge of bankruptcy by excessive expenditure in construction, and by the use of English rolling-stock, they were forced to open their eyes to the merits of American engines and cars, and adopt them, paying at that time 12½ per cent. duty on the American engines going into Canada. In 1859 this railway company had 203 locomotives—50 built in England and altered in Canada to American patterns, 110 built in the United States, and 43 built in their own shops after American patterns. This company also adopted the long American car on two bogies, oil-tight boxes, the cast-iron chilled wheels, and centre buffers, all belonging to the American system. In November, 1874, the Grand Trunk Railway had in use 434 locomotives—328 built in the States, 49 built in Canada, and 57 built in England by Neilson and Company, and "Canada Works," Birkenhead. This change to American rolling-stock was a necessity. Without it this railway would soon have become hopelessly bankrupt, and over one hundred million of dollars of British capital sunk out of sight. The directors and engineers in Canada saw that it was impossible to contend with the "Yankee" trunk lines, for the great and ever-increasing business of the "West," without making great and radical changes in their rolling-stock. They bowed gracefully to the governing circumstances, and ordered the changes to be made. The company in London were not prepared to swallow unresistingly this bitter and expensive remedy. On receiving a report from their mechanical engineer in Canada showing that he was altering the engines sent from England to Yankee ideas of fitness, they ordered him home and sent out another, who said he would soon stop this Yankeefication of the engines. But very soon after his arrival in Canada he became a convert to the necessity of a change. The proximity to Yankee land had its impressive features, so the new locomotive superintendent "pitched in" to complete with all despatch the changes commenced by his predecessor. About this time Mr. Alexander M. Ross, the Engineer-in-Chief of the Grand Trunk Railway, in writing to Mr. George E. Gray, an old assistant of mine (and then Engineer-in-Chief of the New York Central), said, "On the breaking up of the frost in the Spring, we never could keep the English engine on the track, except at a slow speed, which defeated our object."—W.W.E.

Extracts from the "Engineer."

1st October, 1858.—"As opposed to Mr. Tait's opinion of American locomotives, Mr. Robert Stephenson stated, while in America, that the engines of that country were *better* than those of English build; while the same gentleman, to the knowledge of the writer, has reiterated the same opinion within the last ten days: "that American locomotives are at least of a fair quality of workmanship may be presumed from the fact that they are worked to a load averaging 20 per cent. more than that of English engines."

29th October, 1858.—"The peculiarities of the American locomotives, which were last season very fully explained to us by Mr Neilson (locomotive builder of Glasgow), are attracting attention in this country, from the good adaptation of these engines to steep gradients and sharp curves."

Data from a Letter of Mr. Howard Fry, Locomotive Superintendent of Philadelphia and Erie Railway, to Mr. J. F. Robinson, in reference to the Performance of a Baldwin Consolidation Engine—No. 41—*on that Railway, 27th October,* 1877. [This Mr. Fry is an English mechanical engineer of experience and ability, and is held in high esteem by all the railway engineers of the United States.]

"The engine No. 41 had cylinders of 20 in. x 24 in.; four pair driving wheels coupled, 48 in. diameter; weight in working order, 102,000 lbs.; weight on four pair coupled, 88,000 lbs.; total wheel base, 22 ft. 10 in.; rigid wheel base, 9 feet. Train consisted of 100 American 8-wheel cars, 87 loaded with oil, and 13 with grain; weight of, including engine, 2,201 tons of 2,240 lbs. each; length of train, excluding engine and tender, 3,127 feet; distance run, from Sunbury to Dauphin, 45·5 miles; time, 4 hours 21 minutes, or 10½ miles an hour; line, practically level; minimum radius of curvature, 860 feet. This engine made 26 double trips in this month of October, running 2,340 miles, or at the rate of 28,080 miles for the year. One day it hauled 106 cars, and averaged 90·3 cars per trip for each day in the month. This engine has made a car-mileage of 192,009, with a consumption of fuel of 1·8 lbs. per car-mile."

NOTE.—If any one in Europe can match this performance of No. 41 with any engine they have there, I will be much pleased to see them trot it out and give us the figures. Our engines may be "miserable affairs" made of "poor materials," with "execrable workmanship," "loose-jointed," "flexible like a basket," &c.; but they do their work in a most miraculous manner, earn piles of money for the shareholders, seldom ever complain, enjoy good health, win friends, and live to a good old age.—W.W.E.

Extracts from a Letter of Howard Fry, Mechanical Engineer (in charge of Motive Power of Philadelphia and Erie Railway, a branch of Pennsylvania Railway), to W. W. Evans, dated 11th February, 1880.

"There are points of difference between locomotives such as are generally turned out of English and American shops. Generally English engines have frames made of iron plates; these plates, if the engine is a heavy one, are of such size that out of England they are difficult to procure, so that in the colonies the breaking of a frame is a serious matter. In an American engine the frames are usually iron bars. They can be made in any country where bar iron can be bought, and if broken can be welded up as good as new in any shop where a blacksmith's fire can be rigged. Driving wheels in English engines are generally of wrought-iron, and can only be made by smiths specially trained to the work and with suitable appliances, so that if new ones are needed in any country but England it is necessary to import them. But the American wheels are cast, and do not require exceptional skill to mould, so that a superintendent of American engines is under no more necessity to import driving-wheels than axle-boxes. It is generally considered American practice to use steel fire-boxes, and in English practice copper, but many exceptions can be found in both countries. Copper fire-boxes are, I believe, more often put in in America than steel in England. Possibly English steel plates cannot be trusted for this purpose as well as American. The cab in English practice is generally made of iron, and if broken requires a skilled plate-worker to repair; while the American cab, being of wood, can be repaired or a new one built by a native carpenter. There is, too, a marked difference in the provision for comfort of the driver between an English and American cab. The English rarely provide seats, and in arrangement of windows and inside fittings appear to care nothing for the man in whose care the engine is to be. In Canada, where both English and American engines have been used, it has often been found that the company sustained serious loss from the inability of the men to remain on their engines. If stuck in a snow-drift to abandon their engines and let them get frozen on the road is a very serious matter, and when several nights have to be spent in a drift, with the mercury below zero, cushions to lie down on and curtains to keep out the cold, are more than luxuries. The locomotive superintendent in the colonies who buys an American engine finds that he can repair and, if he wishes, reproduce it in his own small shops, and it does not always follow that the superior material and form is worth its extra cost. . . . All this may help to explain why engines are built in America, in spite of high wages and excessive cost of material, cheaper than engines for similar work are built in England, and partially accounts for the popularity of American engines wherever they are tried, as in Canada, for instance, where the railways are all officered by Englishmen, who come to Canada with a strong bias in favour of everything English, but who have in every case adopted finally American types in their locomotive practice. I do not know where there are any English-built engines suitable for comparison with American. I never yet saw an English engine at all suitable for the average colonial or American service. All the English engines in Canada were completely unfit for the work they were designed for, and have so universally been condemned that England has lost the entire trade of this her nearest colony, and of the hundreds of locomotives ordered since the Grand Trunk Railway changed its gauge not one has been obtained from England. Now, this does not prove that English engines are worse than American, or that English firms cannot build engines to run on our lines; it simply shows that English firms have not done so thus far."

NOTE.—The writer of the above letter, Mr. Howard Fry, is an accomplished English mechanical engineer, of long experience in England, Canada, and the United States. He is well known among the engineers of the States as a man of marked ability and extensive knowledge of all things relating to railway machinery. His opinion carries weight with it among all American engineers, and I feel sure it ought to be respected wherever it is known, and I also feel sure that in writing and giving his opinions on railway machinery he is actuated by the same motives that govern me—namely, to be honest, and to do what in him lies to promote "railway progress" and "railway economy" throughout the world, without reference to vain nationalities, or stopping to consider who is knocked down or who is set up.—W.W.E.

Data from Letters of Vice-President Strong, I. A. Burr, Engineer, and G. Hackney, Locomotive Superintendent of Atchison, Topeka, and Santa-Fe Railway, in reference to the Baldwin Consolidation Engine "Uncle Dick," running on the Raton Mountain Division, March, 1879.

"DIMENSIONS, ETC., OF ENGINE.—Cylinders, 20 in. x 26 in.; total wheel base 22 ft. 10 in; rigid wheel base, 9 feet; weight on drivers, four pair coupled, 100,000 pounds; total weight, including 1,000 gallons of water, 115,000 pounds; diameter of driving-wheels, 42 inches; total heating surfaces, 1,377 square feet; gauge of road, 4 ft. 8½ in.; maximum gradient for 2½ miles, 1 in 16·5; minimum curvature, 360 feet radius. This engine has hauled, at 6 miles an hour, nine American cars, with 12 tons on each, over this maximum gradient, or 173 tons exclusive of engine. On 1 in 50 it has hauled 430 tons at 8 miles an hour. On 1 in 33·3 it has hauled 230 tons at 8 miles an hour. (Tons of 2,240 pounds.) The above loads are started from a standstill, without taking the slack of the train, and without slipping the drivers."

Extracts from the Paper of C. D. and F. Fox, No. 1,332, *read before the Institution of Civil Engineers in* 1874, *on Pennsylvania Railway, and the Discussion on same.*

Page 4. "The Messrs. Fox show that the net earnings of this great railway were, for thirteen years, a little over 12 per cent. per annum on the capital, and that from 1853 to 1873 the company have paid an average yearly dividend of 9·9 per cent., and a total in dividends of 234 per cent. in 20 years on the entire capital cost. This wonderful result, we are asked to believe, was accomplished by the use of engines and cars of miserable construction."

Page 8. "This railway has in use several different classes of engines. Much attention is paid to interchangeability in construction. An idea of the uniformity practiced is shown by the fact that, while 112 patterns are required for one engine, only 187 are required for all the seven classes. The trucks have chilled cast-iron wheels. Steel wheels have been tried, but it was found that they would not stand the severe work of guiding the locomotive over the sinuosities of the line. Solid cast wheels, with the running surface chilled, are the safest, especially in cold weather, a truck wheel of this kind rarely breaking, and one such wheel outliving at least three steel wheels. Again, the flanges of chilled wheels are soon made smooth and highly polished by wear; while the flanges of steel wheels soon become rough and torn, and in a short time two thin and sharp for safety. Chilled cast wheels are used for the rolling-stock, steel tires having been tried for the passenger cars, but quickly became dangerous from rapid wear."

Mr. F. W. Webb (Mechanical Engineer of the London and North-Western Railway) said, "He had spent a good deal of time on the Pennsylvania Railway. The locomotive had much smaller driving-wheels. Since his visit to America he was running some of the fastest express trains, including the 'Flying Scotchman,' with locomotives having driving-wheels of 66 inches in diameter."

Mr. T. W. Worsdell (Second Mechanical Engineer on the London and North-Western Railway, who was in service on the Pennsylvania Railway for some years) said, "During his connection with the Pennsylvania Railway the company began the manufacture of steel boilers. He had been engaged in the construction of 120 steel boilers and 250 steel fire-boxes. When the copper-fire boxes were worn out thin crucible steel was substituted. He knew from experience that cast-iron valves lasted longer than the brass valves in common use in England. A valve was seldom broken, although the area was large. The Pennsylvania Railway Company were the first to make driving-wheels with hollow spokes and rim. He had never known one of the hollow-spoke wheels to be broken, except in cases of collision or 'jumping the track.'"

Mr. J. Fernie said, "Contrasting the English complicated wheel with the simple American chilled wheel, he was induced to think the Americans were in advance of this nation. From the humblest wagon to the most sumptuous Pullman car, all were fitted with the simple chilled wheel. In his travels through the United States, what he saw in regard to mechanical-engineering work was of the very best kind. All appeared to aim at perfection, and no expense was spared in arriving at that result. Many revolutions in mechanical engineering had been introduced in this country from America."

Extracts from a Paper, No. 1469, *read before the Institution of Civil Engineers, in January,* 1877, *by Alexander McDonnell, on the Repairs and Renewals of Locomotives.*

Page 20. Mr. McDonnell gives some of the statistics of the Reading Railway of Pennsylvania, furnished to him by the General Manager, Mr. Wootton. As this railway has much the heaviest traffic of any railway in the world, moving over eight millions of tons in a year, besides a heavy passenger traffic, and being forced, by great competition, to a close study of railway economy on all points of expenditure, it may not be uninteresting to the *professional man* to state some of this data given to Mr. McDonnell. The importance of a close study of economy on this railway was made evident by the president, Mr. Gowen, in one of his annual reports, when he said that an additional charge of 1·20th of a cent. per ton per mile in their coal traffic would be equivalent to an additional dividend of 2 per cent. on their entire capital. They had in 1875, on 95 miles of railway, 410 locomotives. The average weight of coal trains, exclusive of engine and tender, 846·4 tons; average load of coal in trains, 666·6 tons; coal used per mile, 121 pounds, equal 0·97 pounds per car per mile; average life of steel fire-boxes, 120,000 miles; average life of copper fire-boxes, 45,000 miles; average life of iron tubes, 138,000 miles: brass tubes under test were found to be so unsatisfactory that they were abandoned.

Mr. McDonnell shows that iron tubes were used on the Great Western Railway of England; that the average life was 180,672 miles run. This makes ten years as the life; taking 17,500 miles as the yearly average of the engines, one engine on this railway ran 447,000 miles without the tubes being taken out.

Sir John Hawkshaw said, "He began the use of iron tubes as far back as 1834. It might be interesting to locomotive men to know that in the United States brass tubes were not now used, nor were copper fire-boxes. All the fire-boxes in the United States were of steel, and the tubes were of iron. From what he had seen and heard in America he thought it worth while for locomotive engineers to consider whether steel fire-boxes and iron tubes would not be cheaper and better than copper fire-boxes and brass tubes. His own opinion was that the change would be an improvement."

Note.—The life of steel and copper fire-boxes on the Reading Railway is given merely to show the difference. The life in either case is short in train miles, but might show by comparison with other roads very differently if car miles were used, as the coal trains of this railway are, for summer traffic, made up with 125 cars in each, and 115 for winter traffic, the coal carried for years averaging over 524 gross tons in each train.

Sir Charles A. Hartley, in his paper, No. 1,413, read before the Institution of Civil Engineers in 1875, on the Public Works of the United States, deals in many complimentary terms with what he saw. He describes the immense business of the Reading Railway, and says that the coal is carried 95 miles for 30 cents per ton, equal to $\frac{1}{6}$ of a penny per ton per mile.

For the benefit of the *professional man*, let us quote a few more scraps from the paper of Mr. Colburn, "the engineer of *considerable eminence*," and the discussion on it at the Institution of Civil Engineers in London.

Mr. Hemans said, "He disapproved of the stereotyped make of English locomotives and rolling-stock, and of the enormous weight placed on one pair of wheels, as great in some instances as 18 tons. These weights were very injurious to the permanent-way."

Mr. W. B. Adams said, "The frictions of the railway carriage were induced by the cone on the wheels; that loaded trains had stuck on inclines of 1 in 75, and single cars had stuck on 1 in 80, the friction being changed from the normal 8 pounds (as generally allowed for in England) to 28 pounds per ton."

Mr. G. Berkley said, "He was surprised to find that the weight of their wrought-iron wheels was greater than that of the cast-iron in the proportion of 6 to 5, while the cost of the English wheel to the American was as 4 to 2½."

Mr. Bridges, of the Grand Trunk Railway, wrote: "Our experience in the cast-iron wheels is that we consider them far superior to any wrought-iron wheels that have ever been imported from England. Several hundreds of cast-iron wheels imported from Glasgow were found to be utterly useless."

Mr. R. P. Hodge said, "He had tried the American oil-tight box on the London and North Western Railway; that a set of four had run 21,800 miles with one pint of oil, which oil was taken from the lower chambers, the dirt precipitated, and put back, when they ran the same distance over again. Whatever may be said of American railways, it should not be forgotten that some of the best railways of that country were constructed at a less cost than was paid for the engineering expenses alone of the Great Western of England."

Mr. W. Atkinson said, "He had visited the States and found the frictional resistances of engine-tender and cars was 4½ lbs. per ton. . . . The cast-iron wheels, the bogie frame, and the large one-compartment cars, had their origin in the extreme rigour of the American climate; the permanent-way was frozen so hard that the English composite wheel was shaken to pieces, and nothing but the cast-iron wheel could resist the rigidity of the road.

Mr. E. A. Cooper said, "He had made experiments with the American oil-tight boxes on the South-Western Railway; that in one case a force of 2 lb. per ton was sufficient to keep a car in motion; that at a speed of 15 miles an hour; the friction was 2·4 lbs. per ton, and at a speed of 25 miles an hour it was 2·8 lbs. per ton. The carriages had been tried in various ways: on a level, on inclines, and with and against the wind; the results had been proved in several ways. The experiments were made with ordinary carriages: one carriage, he was informed, had been run 9,323 miles with one pint of oil; the brasses lost one ounce in running 10,040 miles, and after 106,000 miles they were still in fair order. The friction of 8 lbs. per ton, which was common with ordinary grease-boxes, ought therefore to become a thing of the past."

Captain (now *Sir H. W.*) *Tyler*, *Royal Engineer*, said, "The adoption of the bogie and cast-iron wheels under all the engines, carriages, and wagons in America was an interesting subject of inquiry. It could not be from the sharp curves, for the curves, as far as he had seen on many lines, were not sharper, as a general rule, than they were in England. Certain engines sent to Canada, of the ordinary 6-wheeled coupled pattern of England, would not remain on the rails, even where there were no sharp curves. Those engines were altered; bogies were put under the leading ends, and they had since done good service.

Mr. W. Lloyd said, "He had invariably found great economy in the consumption of fuel in the English engines, and that American engines burned 18 per cent. more fuel than English, as proved by the experiments of Mr. Evans."

Note.—I beg to correct Mr. Lloyd in his remarks. Mr. Lloyd was never connected with any railway on which there was an American engine, nor had he ever any personal knowledge of the economy or want of economy of American engines. And he is in error as regards the 18 per cent. economy spoken of above, for, in the experiments he alludes to, there was, in one case, 19 per cent. economy in favour of the American engine, and, in the other case, 13 per cent. economy due to the English engine; but this would have been made more than *nil* if the consumption of fuel on account of speed had been equated; as the American engine, in this case, took the same train, on the same road, the same distance, at 42 per cent. greater speed.—W.W.E.

Mr. Colburn said, "There was evidence that English engineers and railway managers, on going to Canada to take charge of lines owned in England, had, notwithstanding their natural and habitual preference for English practice, adopted the peculiarities of the railway practice of the United States. These Anglo-Canadian engineers and managers asserted that the bogies drew more easily than carriages with rigidly-rectangular wheel-bases, and that chilled wheels were equally as safe as, and less expensive in maintenance than, wrought-iron wheels."

Mr. J. J. Berckel said, "In Canada the railways had been constructed by English engineers, and they had found it necessary to Americanize the whole of the rolling-strock. He knew for a certainty that the leading wheels of the engines sent out from England had been removed and replaced by bogies. . . . The explanation of the remarkable results of the author's experiments on train resistances must be sought, *he believed*, chiefly in the looseness of American railway construction. A train that ran on rails that yielded readily on its passage met with less resistance than if the rails were rigid."

Note.—This is "an opinion as is an opinion!" We in America never thought of this before. We must go to work and make our new lines more loose and the rails, sleepers, &c., more yielding. "There are millions in it," *if true.* This discovery displays almost as much engineering talent and deep investigation as was shown recently in the columns of the *Otago Times*, or *Australian Engineering News*, or the London *Engineer*, I forget which, when its brain worked out the astounding revelation that the *bar-frame* in the American locomotive was introduced to give it flexibility!

Mr. Berckel went on to say that he had once seen in England an engine, fresh from the erecting shop, that could barely start with 40 lb. of steam-pressure in the boiler, and this he attributes to very accurate fittings. Good Providence protect us from such accurate fittings; if the builder of this engine had gone a little deeper into accuracy he might have made a wonder of mechanism, one whose power to pull a train "no fellow could find out."—W.W.E.

Mr. O. Younghusband said, "The life of the chilled wheel made of Salisbury iron might be safely taken at 150,000 miles. There were some in Canada that had run 160,000 miles, and were still in good order." He then goes on to make some comparisons of cost of English and American wheels, and shows that, if the London and North-Western Railway were to adopt the American wheels, they might save £120,000 a year.

Extract from the Report of Augustus Morris, Commissioner to the Philadelphia Exhibition in 1876, to the Government of New South Wales.

"I am confident that the construction of American locomotives and rolling-stock will enable us more readily to imitate them than the more complicated English patterns. I think I have stated sufficient reasons for concluding that the former have many points of superiority over the latter, and are better suited to colonial requirements. The railways of America are remarkably smooth and easy to travel on; serious accidents from defective construction are rare. Not a single accident occurred during the conveyance of the enormous multitudes of people to and from Philadelphia during the Exhibition which could possibly be charged to the neglect of the officials. The manufacturers have produced a locomotive engine which, for simplicity of structure, for power and economy in working, as well as for cheapness, compares most favourably with those of England or Belgium. I consulted those eminent engineers who were sent by the Russian, the German, the Austrian, and other European Governments to report on American railway plant, and my conclusions are theirs. They gave the preference to the best American locomotives over the English for the requisite qualities."

Extracts from Articles by Mr. T. Passavant, Mechanical Engineer, published in the "Glasgow Practical Mechanics' Journal."

Vol. 2, page 76. Mr. Pasaavant, in a paper on the Construction of Locomotives, gives the dimensions of two, one by Sharp, of Manchester, and one by Norris, of Philadelphia. He then gives the daily duty of these engines (the English engine weighed 21½ tons, the American, 14 tons), and shows that the duty of the English engine, as compared with the American, was as 1¾ to 1, while the power employed was as 3·9-10 to 1. He then goes on to say, "The alterations in the construction of locomotives attain their highest value when outside cylinders are employed. A general opinion exists that outside cylinders will not do for high speed; this may be considered a mere prejudice. I have experimented on outside cylinders up to 55 miles an hour, and found them equally as steady as inside cylinders. The outside-cylinder engine possesses very great advantages both as regards safety and economy."

Vol. 2, page 217. "Such engines as were originally imported from England failed on the American lines; the paying duty bore no just proportion to their absolute power. It was soon seen that to copy English engines would be ruinous to the pecuniary interests of the roads. The inventive spirit of the American was roused to build an engine to suit their roads. Experiments were made, principles were developed now universally adopted, and the engines are enabled to go over arduous, heavy lines with a speed equal to that used in England, and with equally heavy trains. Some of these principles would add considerably to the durability and effective power of an English engine, but the latter, as it now is made, would be of very little use on American roads. The first great alteration was in 1833, in altering one of Stephenson's engines, by putting a bogie in the place of the leading axle. The engine could then pass, with perfect ease and safety, and at its highest speed, through curves on the main track such as in Europe would not be considered safe even in sidings at stations. The next alteration of great importance was the substitution of the straight axle for the crank axle. This, with the truck, completely altered the character of the locomotive. The same genius which thus altered, perceived the necessity for a framing more rigid than the usual one, and an entirely new construction was introduced, possessing great lateral stiffness. Why was this necessary? On outside-cylinder engines being built in England, instead of a stronger a much weaker frame was used. In England engines with inside cylinders have always been constructed with two frames on each side: one only carries, but the second one contributes greatly to the lateral stiffness of the whole. This is not necessary, as proved by many such engines being constructed and successfully worked in the United States with only one frame. On the cylinders being placed outside the engines were found to oscillate much more. To resist this the only way was to stiffen the engine laterally. This was the object of the new American frame. What was done in England to oppose this injurious tendancy? If the causes that produce oscillations had been well understood the slight plate frames would not have been generally introduced for this class of engines in England. For comparison, I will take two engines—No. 1, English, by Sharp; No. 2, American, by McQueen: No. 1 has cylinders, steam-chest, smoke-box, and chimney overhanging the point of support by upwards of three feet. In No. 2 the frame plates are in front themselves, carried by the truck frame, the vertical strain on them being, therefore, less. This support is placed underneath, or very near the centre of, the cylinders. Overhanging weight there is none; the tendency to oscillation is therefore removed. We find, moreover, in No. 1 a rigid leading axle, unavoidably subject to straining in curves, and is one cause of oscillation. In No. 2, we find the truck movable around a centre-pin, the wheels and axles adjusting themselves to the curvature, thus removing a great cause of wear and tear and loss of power. Were the form of the frame-beam the same, with the above points of difference, we should rightly suppose No. 2 a more steady-going engine, but in the construction of these beams itself we find a better proportioning of material for the purpose for which it is designed in No. 2. The frame of No. 1 is of iron, 8 in. x ⅞ in.; its strength to resist a force acting against its sides is 4,044 pounds. The American frame consists of a bar of iron, 2 in. x 4 in.; its strength to resist a force acting against its sides is 13,600 pounds. The surplus strength of the English engine in no way contributes to the lateral stiffness of the structure; in the American engine it does altogether. Which of these two frames is the most scientific and, at the same time, the most practical? Of two engines of equal power, which will produce the greatest useful effect? The one that works most easily and has the least oscillation and strain. Which will have the greater durability, and therefore be more economical? The one that possesses greater steadiness of motion. Another advantage of the American frame is the saving of expense in material and labour of construction. These are the great principles by which American engineers have successfully attempted to give steadiness, stability, and durability to their engines; the above three qualities of a locomotive, or the three virtues, are solely dependent on a well-constructed frame."

Vol. 3, page 23. "I gave my views for rendering an outside-cylinder engine steady. By reasoning I came to certain conclusions, which existed simply as theories. Arriving in the United States, I found such engines had been built that were remarkably steady. It may seem bold to place an engine by one of the most renowned firms in England in juxtaposition with one built at a railway workshop in a town the name of which is scarcely known in England, but a glance at the drawings will convince the most sceptical how the one must be unsteady, containing within its construction the very cause of oscillation—high boiler, insufficient fastening of cylinders, and great overhanging weight; while the other will move along the road as smooth as possible."

Vol. 3, page 242. "To start a railway in opposition to the magnificent Hudson River (where the steamers are fitted with a luxurious elegance which, to the English traveller, was incredible, and when competition had reduced the fare to the lowest standard of profit) was a hazardous undertaking. The Hudson River Railway was opened for traffic in 1849. It is crooked, with many quick and serpentine curves, running along the whole distance; the greater part is protected by a river wall. The actual speed of express trains is 44½ miles an hour; for a great part of the line the speed is above 50 miles an hour. We have praised the American engines and must expect that the sample we bring will be diligently, perhaps invidiously, compared with English engines, and must be prepared with positive proofs of the excellence of the engines. The accompanying drawing of the 'Champlain' represents one of the engines on this railway. . . . She is worthy to be placed by the side of the best English engines, both as to mechanical construction, the duty she has performed, and the elegance of her general design. Her dimensions are: cylinders, 15 in. x 20 in.; four driving wheels, 66 inches diameter; heating surface, 824 square feet; weight of engine, 47,360 lb.; weight on driving wheels, 30,060 lb. The trains average one baggage and five passenger cars, all the cars on two 4-wheeled trucks. The cars have seats for sixty passengers each. During the summer we have often seen this engine with from eight to eleven cars keeping her running time, the cars not merely filled but crowded with passengers. Taking one of their trains, it will weigh 128 tons. This is a heavy train for an engine of that size to propel at 44 miles an hour—on many parts at nearly 60 miles. . . . There are many curves on this road such as will not be found on English roads. The American passenger engine performs more work. There is more work got out of her than is generally obtained from the English passenger engines. . . . The American passenger engine has many solid advantages in its construction—the almost universal use of double drives is one of them. . . .

The above performance of the American engine compares favourably with engines of the same weight by Sharp, which with 40 tons, had a speed of 37 miles an hour; but with 70 tons she only attained 26 miles an hour. (*See* Barlow's description in Tredgold). . . . The use of 4-wheeled trucks on engines, tender, and cars is a saving of power. . . . It cannot, in opposition, be pretended that the use of trucks is unsafe, when the whole experience of America proves the reverse even at the highest speeds."

NOTE.—The engine Champlain commenced running in December, 1849, and up to March, 1851, had run, in 15½ months, 46,111 miles. This is at the rate of 35,652 miles for the year. This running gives 114·4 miles for every running day the engine was on this road, which is a continued line of curves with a rigid rock foundation. During these 15 months this engine had to encounter the ice and snow of two New York winters, such as engines in England have never come in contact with.—W.W.E.

Vol. 2, page 321. "A paper was read by Mr. Bishop, before the Institution of Civil Engineers, describing the American bogie engines on the Birmingham and Gloucester Railway. He says, 'In a comparative trial of various engines on the inclined plane an American bogie engine, with cylinders 12·5 inches diameter, driving wheels 4 feet diameter, weighing 14 tons, conveyed a gross load of 54 tons up the incline at the rate of 12 miles per hour, while the best of the English engines, with 13 inch cylinders, 5-feet driving wheels, and weighing 22 tons, drew 38 tons up the plane at a speed of 6 miles per hour.'"

NOTE.—From the above it appears that the merits of the American bogie engine were tried and proved in the very heart of England forty-two years ago. The *United States Magazine*, in 1838, published a statement of the above-mentioned engines and their performance in England, and stated that in 1837 the B. and G. Railway Company ordered seventeen locomotives of Norris. They were sent out in 1838, and after being tried an order was sent for more, but in a few weeks the order was countermanded. The reason given was that the builders of locomotives in England had obtained from the Lords of the Treasury (the Board of Trade, I suppose) a decree forbidding the importation of locomotives into England.—W.W.E.

Vol. 3, page 87. "The 4-wheeled-truck contrivance introduced by the Americans has been found to answer admirably, and is now universally used on their railways. Let not, then, jealousy or vain national pride prevent English engineers copying an American improvement, but rather let us thank them for the invention, and confess its excellence by at once adopting it. This is not the only point of superiority in American locomotive engines, as may be seen by a perusal of Mr. Passavant's very sensible remarks thereon: 'But it is the principle of the movable truck for carrying the two pairs of leading wheels that I allude to, and which undoubtedly is the simplest and best plan that can be thought of for accommodating the engine to a curved railway. Sound reasoning convinces me that this alteration would be judicious—long practice in America confirms it—and I hope to see it before long followed in England.' I consider the American engine-framing to be very soundly constructed, and should be glad to see more attention paid to this in England, being convinced that a stronger frame, in some cases, could be made with less metal—that is, putting the strength where the strain is felt. I would principally direct attention to the two fore-mentioned points—the truck for the leading wheels, and a better proportioned framing—believing that by the one alteration the danger of railway travelling may be lessened, and, by the other, the power of the locomotive increased."

NOTE.—It must be recollected that the articles by Mr. Passavant were written and published some twenty-eight or twenty-nine years ago, so it is very clear that this matter of the bogie, the bar-frame, the centre buffers, the oil-tight boxes, and other American railway appliances are not new things; they are old, and their merits have been proved long years ago. All that Americans have done, or tried to do, is to bring these devices to the attention of the railway world outside of the United States, so that they might enjoy the benefit and economy resulting from their use. All the opinions I have given are those of Englishmen, educated gentlemen, and they should have some weight among railway engineers. After giving the opinion of Sir John Hawkshaw on steel fire-boxes and iron tubes, and shown that Mr. Webb and Mr. Worsdell are using steel fire-boxes on the London and North-Western Railway instead of copper, we need not fear the vapourings of those ignorant critics who say the Americans use poor and cheap materials in their locomotives. When we can show that a locomotive with a steel fire-box will cost about $400 less than one with copper, and that the steel will outlast the copper twice over in hard service, we need not fear the carpings of critics who accuse us of using "miserable, poor materials" and "execrable workmanship." It would be well for some of these would-be wise men of the East to understand that iron and coal are the two great elements of civilization, and not gold or silver, or even copper or brass.—W.W.E.

Captain Douglas Galton, R.E., C.B., F.R.S., English Commissioner to the Philadelphia Exhibition, read a paper, 12th March, 1878, before the Institution of Civil Engineers on "American Railway Appliances." I need not tell Englishmen that Captain Galton is an accomplished engineer; that he was, for a long time, the Chief Inspecting Engineer of Railways in England, and that he is a great authority on all matters relating to railways. After speaking of the merits of the chilled cast-iron wheels, the stability of the locomotives, the importance and uses of the bogie truck, the size, comfort and convenience of the American cars, &c., in the same terms of praise and commendation that other clever and unprejudiced, clear-thinking English minds had often done before, Captain Galton winds up his paper with the following remarks: "The American engineer has been far more fettered by his surroundings in framing designs than his European brother. His appliances have not been such as to enable him, even if he so desired, to follow the precedents of Europe. He has had to make the most of the materials which lay to his hand, and with them to overcome vast natural difficulties. The result has been the development of great originality of design. It is on this ground that the records of the details of American engineering afford the English engineer much food for reflection. It is not probable that American railway appliances could be adopted as a whole in this country; but it is certain that in many of the colonies, and in parts of India, where the requirements of the traffic more nearly resemble the conditions which exist in America than those prevalent in Europe, 'much economy would result from following the American, in preference to the English, pattern of railroad.'"

NOTE.—A writer in a colonial village paper, in commenting on the official review of Mr. Brereton's and Mr. Evans's letters (on the economy of railway machinery) by Mr. Maxwell, says, "Mr. Maxwell pooh-poohs Mr. Evans's and Mr. Brereton's rather gushing tributes in a tone of unconcealed contempt." I wonder if this brilliant editor will extend the same complimentary remarks to the opinions of Captain Galton, to say nothing of those of Sir John Hawkshaw, Sir Charles Hartley, Sir Henry Tyler, Mr. Fox, Mr. Thompson, Mr. Higinbotham, Mr. Bromley, Mr. Brunner, and many more clear but lesser lights.—W.W.E.

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