RAILWAYS FOR VICTORIA.

BROAD AND NARROW GAUGE CONSIDERED.

A PAPER BY MR. J. HUGH DAVIES.

Read before the Victorian Institute of Engineers on June 7, 1893.

In reading this paper before the Victorian Institute of Engineers, I do so as a Member of this Institute, apart from my official connection with the Victorian Railway Department; and I submit the many-sided questions involved, with a full recognition of the vast amount already written and said by distinguished professional men in various parts of the world, hoping that Members of this Institute, with the evidence of modern experience, will enter upon a discussion which may lead to results of practical value.

While the common uses of railways are recognised, it may be profitable to direct attention to some of their higher purposes and more important and far-reaching effects, especially in relation to the growth and advancement of a young colony like Victoria.

Broadly stated, railways may be regarded, as of all material agents, among the most important for developing valuable material resource, and, in connection therewith, promoting settlement and conditions of well-being and prosperity among the people.

The advantages of direct and swift communication with the markets and commercial activities of the world and the great centres of civilisation and progress which railways afford, are admittedly of incalculable value; while simultaneously encouraging and stimulating people to efficiently apply their best energies to extract wealth from the elements, and in districts which, in the absence of railways, would languish and waste.

Given ample resource in fertile soil, sufficient rainfall, and a genial climate—such as we have beneficently distributed over our favoured colony of Victoria—then with sufficiently applied labour and capital, a wise conservation and application of natural forces, together with the necessary facilities for distribution and communication, we should become a wealthy and prosperous people; and, with judicious economy, solve, it may be, the worst financial problems of the day.

Whether in an undeveloped district railways should precede in order to induce settlement and traffic, or be postponed to follow the latter, will necessarily depend upon varying circumstances. If the resources are undoubted, and there is an available population, then the one thing needful may be to unite them; as, for example, in our tertiary territory of the north and north-west, which, including the unalienated Mallee lands, comprise a large proportion of the colony specially adapted for wheat, fruit, vines, and other profitable marketable products. These lands, at present largely wasting, await only a judicious application of moderate
capital and labour, and the necessary cheap and expeditious railway transit, to render settlement and railway communication successful, and produce exports which would bring the much desired monetary returns to the colony.*

To the above may also be added the rich alienated and unalienated areas of Gippsland and other parts of the colony, suitable for agriculture, dairying, and intense culture, at present largely lying idle, neglected, defectively worked, or only partially utilised. These, together with the rich volcanic soils of the Western district, which though at present used chiefly for grazing, etc., are specially adapted for agriculture, dairying, and intense culture, and for which more profitable uses present owners are prepared, on suitable terms, to dispose of their land.

Among these areas, and especially in the Mallee country, a present judicious railway extension, with our own people settled on the producing areas under suitable conditions, we may reasonably hope would lead to magnificent results, while contributing, it may be, a veritable eldorado for the large surplus classes who, from whatever defective cause in the past, are now congregated about our cities. If proper efforts were also made to bring the true character and extent of our available resources before the surplus thrifty and experienced overcrowded farmers and capitalists of the old world we may reasonably expect valuable accessions to the ranks of our wealth producers, and, perhaps, secure worthy successors to the pioneer heroes of earlier days (all honour to their memory), and thus help to make our railways pay and our country prosperous.

Referring to the present non-paying direct results of many of our railways, it may be remarked that while we have from the first obtained indirect benefits (in some cases of great value), we have in our railways investments which, while contributing to the development of the colony, are correspondingly enhancing their own values; also affording reasonable hope that, in the future, they will not only prove a source of direct financial profit, but may also become an important factor in the discharge of our public debt.

How to fulfil the best conditions in railway provision, i.e., to obtain the maximum of efficiency, combined with the minimum of cost in railway location, construction, and working expenses,

* Since writing the above, I see the last Review of Reviews (May), in a paragraph styled the “Golden Mallee,” says that the representative of the London Times, who has been lately studying us, “grows enthusiastic and even poetical over the coming profits of intense culture in Victoria and the landscape beauty and fat harvests of the Mallee country,” stating that “the Mallee has the exquisite climate and rich soil of Southern California, with some advantages all its own. Its landscape would delight an artist; its air, charged with balsamic odours, would cure the lungs of a consumptive. It will grow wheat like the Egyptian delta itself,” ... and “these estuaries of vanished rivers, clad at present with the melancholy mallee, ... will yet be fragrant with orchards, lush with rich pastures, golden with wheat harvests, and as thickly populated as Lower Bengal itself.” Following with elaborate calculations, “proving that from 1000 (one thousand) acres of mallee and an initial expenditure of about £800 (eight hundred) an energetic young Englishman may extract a profit of £600 (six hundred) per year and enjoy existence in the process.”—Vide Review of Reviews.
is a recurring problem in railway projects, and for the solution we may do well not only to utilise the experience of the past in our own colony, but also that of other parts of the world.

Wellington, the eminent railway authority, quotes that “the destruction of the poor is their poverty,” which, in his valuable work on Railways, has an illustrative application to the mistake sometimes made by railway economists in advocating excessively cheap light lines under the delusion of a saving being effected by reducing first cost, overlooking the fact that all such invested capital is reducible to a question of interest, and that the extra cost of renewals, permanent maintenance, and working expenses, apart from other defects, may amount to more than sufficient to pay interest on the additional capital required for the superior line.

And this appears to be verified in every department of work. The man with insufficient capital does not work his selection or farm to the best economic advantage, especially if he has to contend with bad roads, which the temporary poverty of a district may be unable to improve. Doubtless, the work and difficulties overcome by some pioneer settlers in new districts in parts of our colony in converting the primeval forest to food-producing areas are of a truly heroic character—too great for the multitude who have succumbed or who may be still struggling against crushing odds; while those who have succeeded, or partially so, bear testimony to how much greater may be the success with sufficient capital to command the more efficient help for their pioneer work; and not least, the help of a tolerable road for their local traffic instead of an almost impassable pack track, which for many miles and years may constitute the only means of communication with neighbours and the outskirts of civilisation. And I think we may admit in passing that however difficult our country, and whatever may be urged in favour of narrow gauge railways, narrow gauge common roads for narrow coffin like vehicular public traffic are never made or advocated.

Railways will not necessarily take the place of roads. Roads would be required even for the conveyance of traffic to a railway; and until there is sufficient justification for the essentials of a skeleton railway reasonable local roads should be provided; and it may be in many cases profitably supplemented with local tramways, which may be worked by horse or steam.

[It may be here observed that this paper has special reference to the future pioneer railways of the colony.]

**Future Pioneer Railways.**

It is conceded that a pioneer railway providing the bare essentials for a primitive traffic may be wisely and profitably made in districts of ample resource years in advance of the probable period of payable traffic; and recognising that in a new country the present condition of its settlement and traffic may be small and insignificant in comparison with its capabilities and ultimate development, due provision should of course be made for future expansion to meet growing requirements.

In cases where the traffic may, in general, be of an exceptionally light character, it should of course be a matter for careful
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consideration what class of line it would be economic and judicious to adopt. It being highly suggestive, that between a well constructed common road and a railway of medium strength, there is ample room for a line of light construction; and in connection with its consideration all the elements affecting the question should be fully considered, i.e., the first capital outlay, combined with cost of permanent maintenance, working expenses, and durability, and the safety and convenience of traffic, together with the relation of line to prospective developments.

I think it will be accepted in general that, whatever may be the present condition of things, wherever in our colony a railway of any kind would be justified, an increasing and ultimately heavy traffic may be anticipated; while in many cases there may be immediate occasional moderately heavy traffic during productive seasons, and for stock and timber; and provision for such and a safe reasonable speed for passengers and for the conveyance of mails and light perishable goods, may be among the elementary demands upon such lines from their inception.

We next inquire what kind of railway will meet such demands and, all things considered, give the best results. To answer this question in its simplest form, first take the case of a line in comparatively flat country, with few or slight engineering difficulties, such for example as the average formation over the north and north-west of the colony, and for the occasional heavy traffic of these parts, such as wheat. Then it is submitted that one of the chief economic factors in the construction of such a line consists in the selection of a rail of right weight.

Upon a sufficiency of weight and corresponding stiffness, strength and durability of rail depends the weight of engine and maximum train loads it will carry; also, largely, the safety and greater speed of trains, facilities for interchange of rolling stock, reduction in cost of maintenance, and generally its own economic value.

We therefore conclude that even in cases where the traffic, at least at the commencement of running, may be comparatively light, a good substantial rail, notwithstanding the extra first cost, may be an economic success even for our lighter lines where the poverty of a cheap rail would lead to loss.

It may here be mentioned that the chief concensus of opinion the world over appears to be in favour of heavier rails and heavier engines, and these are now in various parts of the world taking the place of the lighter rails and lighter engines on economic grounds.

In the neighbouring colony of New South Wales the Railway Commissioners have raised the weight of their steel rails to an 80lb. standard, their lowest weight being 71½lb. per yard, and a Royal Commission recently commended the change on economic grounds, apart from other considerations.

The rails formerly in most general use in the United States of America are said to vary from 56lbs. to 67lbs. to the yard, but during late years much heavier rails are being used, and so we may quote from various parts of the world.
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Roughly, it appears to be in accordance with modern practice to allow about 10 lbs. per yard of steel rail of medium weight for each ton weight on driver; about 20 per cent. less proportionate weight of rail has been used on some of such lines in America. In that country, however, it appears they place their sleepers (of much inferior timber to our ironbark sleepers) about 2 ft. apart centres, a source of strengthening road which is, of course, available for our lines when heavier traffic render such desirable, and especially on curves; possibly, also, in some cases where ballast is scarce and timber plentiful.

Wellington, the acknowledged eminent authority on all such subjects, says:—

"Whether a new project as a whole will pay or not it is almost sure to return a heavy profit on the additional capital invested, obtained at any probable cost to buy reasonably heavy rail sections for the sake of their durability alone . . . and of all directions for economy cutting down the rail section is the most costly in the end."

And it is submitted that for pioneer lines for general traffic in Victoria the 60 lb. steel rail at present in use on some of our lines is the lightest which should be adopted.

Should exceptional cases arise of prospective permanent light traffic, such should of course, in common with all cases, be dealt with on their merits, and light railways constructed, all things considered, proportioned to requirements, ever remembering the pressing importance of reducing the first capital outlay so far as may be consistent with economic principles. And this view appears to be admitted by authorities everywhere.

But the question then arises to what degree of lightness could such lines be profitably reduced.

In regard to such economies there appears to be a general concurrence of opinion among ourselves and the most advanced authorities elsewhere that for pioneer light lines only the bare essentials should be provided at the start. For example, station accommodation, etc., should so far as practicable be reduced to the most economic description and extent, i.e., to the absolute requirements of traffic; cattle pits used in general in lieu of gate crossings, and fencing of wire, etc., and only where necessary, and so on.

The line should of course be located on true economic principles, having in view future possible improvements.

The narrowest formation width should be adopted consistent with stability and the ample support of ballast and road and provision for drainage in cuttings, etc.

The late Parliamentary Standing Committee on Railways recommended that the width for all cuttings for our standard gauge lines should be 15 ft., and for very low banks 13 ft. 6 in. The common practice of the Railway Department was to adopt a uniform width of 15 ft. 6 in. for all cuttings, and the same width for banks up to a certain height. Re these formation widths there is room for some difference of opinion.

The bridges and culverts should in general be of timber, unless where in exceptional cases other material may be found more profitable, and all should be of the most economical construction consistent with strength and durability.
And now comes the question of the road, ballast, sleepers, and the item of chief importance, the rail. In order to remind ourselves what is involved in this question of weight of steel rail, let us compare a 30lb. per yard rail with a 60lb. per yard rail. The latter would cost twice as much as the former, but, according to deductions, the latter would have four times the stiffness, nearly three times the strength, and judging by Wellington's acknowledged “extreme illustration,” would have three times the durability of the lighter rail, whilst also having at the finish a heavier weight of rail remaining than the 30lb. rail when new. Such a substantial rail as the 60lb. for the lighter traffic would distribute the weight of engines and trains over the larger area of road bed, necessitating only the minimum number of sleepers, and less ballast and labour to keep the road in an equal condition of repair, and in its greater proportion of stiffness, strength and weight have the larger factor of safety and resistance to the shock and blows of passing trains, which sometimes twist and even break defective rails, and play sad havoc with ballast and road bed. And to appreciate what this may mean I refer to our expert, Mr. Todd, Superintending Inspector of Permanent Way, who represents that the difference in labour for maintenance between the good road of ample strength and the weaker road may mean that instead of two miles a man may only keep in order daily 1 ½ miles. Now, assuming that the man is paid at the rate of 6s. per diem then the extra cost of maintenance in this item alone would amount to 1s. per mile per day, or approaching in amount per annum what would pay 4 per cent. interest on the difference in cost between the 30lb. and 60lb. rail.

It may also be pointed out that the convenience of being able occasionally to run some of our heavier rolling stock over such lines may be of considerable value.

While we may refer to the impossibility of determining with absolute certainty, especially in a young country like this, what may be the nature and extent of future traffic on a line which at present it may be justifiable to construct only for a light traffic, should occasion arise for heavier traffic and greater speed with the heavier rail any reasonable speed may be obtained, and the weight of the single train of the lighter rail may be multiplied nearly three times over, whilst also the value of the time saved to the travelling public and otherwise should not be overlooked.

It is also a subject of complaint in various parts of the world where a specially light line is connected with the medium or heavier constructed lines that occasionally, notwithstanding restrictions and regulations to the contrary, heavier engines and greater speeds are run to the great damage of the lighter lines.

And when all the items of this comparison are put into a money value, it may be difficult to determine where the lighter rail would come in as an economic factor, or its adoption be justified, unless we were reduced to that condition of poverty of present capital which would compel us to buy the inferior article and thereby tax ourselves with heavier interest in the future.

We then arrive at the following as practically the cheapest
railroad which it may be profitable to adopt for such pioneer lines on our standard gauge, namely, about 60lb. rails on sleepers 9ft. x 9in. x 4 1\(\frac{1}{2}\) placed not more than 3ft. apart centres, on ballast where necessary, up to 6in. in depth under sleepers. Recognising that on some of our formations, as, for example, on part of our tertiaries of the north and north west referred to, as also elsewhere, little or no special ballast may be necessary on parts of line at the commencement of running with light traffic, provided there is ample drainage; recognising also that in all cases where good ballast can be obtained at moderate cost, it may be a profitable investment to ballast the whole of such lines from the commencement, when the formation is not of the favourable character above described, to a depth of 6in. under sleepers.

All the etceteras of line, including sidings, platforms, general station accommodation, etc., to be provided only as they are absolutely required, leaving the fuller equipment to follow developments of traffic. These lines in such country may be constructed for a sum not much over £3,000 per mile.

An illustrative example of the relative cost of medium and light lines and the chief source of economy in railway construction in mountainous and difficult country is shown on accompanying drawings, representing plan and sections, etc., of a typical mountain line (altered to illustrate), where it will be seen that to effect large savings other means outside of the permanent way were found in the more suitable location of line. The said drawings show a line, located in the first instance, with curves not to be sharper than 10 chains radius, necessitating the crossing of formidable spurs and gullies in a direct line, thereby involving enormously heavy earthworks, etc., at a total cost of £57,336 for two miles of line; while by adopting curves of five chains radius, and locating the line to fit the natural features, the heavy and expensive earthworks are avoided; and though the length of line would be thereby increased by 1 mile 3 chains a total saving of £30,738 would be effected, and the flatter gradient thus obtained, together with the sharper curves, would reduce in an important degree the resistance to traction of the shorter line with its steeper grades and larger curves.

In much of our most difficult country curves of five chains radius would not be sufficiently sharp to head the gullies and round the spurs contoured by mountain lines. Curves of three chains radius and occasionally even less may be necessary to obtain the lowest constructive cost; though the extra length which would in many cases be involved in contouring such sharp gullies and spurs with curves of three chains radius and less, together with the extra resistance of curvature where extra length was not required to obtain flatter gradients, may more than neutralise the advantage of reduction in first constructive cost. A test of three chains radius curves to effect such a saving is also indicated on sheet of drawings referred to.

It will be observed that in locating lines in such difficult country by contouring round sharp spurs and gullies with exceptionally sharp curves as expedients for reducing first cost, due
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regard should be had to probable future improvements which a developed traffic may justify.

Briefly referring to the established lines of moderate and heavy traffic, main trunk, and city and suburban lines, we will all, doubtless, be fully agreed that their permanent way, rolling stock and fuller equipment should be rightly apportioned to their present and prospective traffic on the most modern and economic principles.

Probably most of us recognise that the best selection and adaptation of means to ends for the satisfaction of public necessities should be the ideal of administration in every department, and eminently the principle which should guide the railway engineer.

NARROW GAUGE LINES.

In view of the great importance of reducing the cost of railways to the lowest minimum, consistent with efficiency, we are led to inquire whether a substantial saving, at least in cost of construction in mountainous and difficult country, may not be made by reducing the width of gauge: a question which has long engaged the attention of leading engineers and others; and in various parts of the world narrow gauge railways, from less than two feet and upwards, have been constructed and worked for many years, and formed the subject of elaborate investigation, discussion and voluminous writings, with the result that many, apparently, are still undecided, whether, under certain circumstances, such as exist in many parts of our own colony, narrow gauge railways are, or are not, the most suitable to adopt for general traffic as branch lines to our present standard gauge lines.

In India there are five gauges. Broad gauge, 5ft. 6in.; metre gauge, 3ft. 3¾in.; 4ft., 2ft. 6in., and 2ft gauge. The lines of India, however, are chiefly of the 5ft. 6in. and metre gauges.

In America their most complete system of narrow gauge railways appears to be the 3ft. gauge of Colorado. The standard gauge of the United States, to which it appears other gauge railways of that country are rapidly conforming, is the same as the English, 4ft. 8½in.

The narrow gauge pioneer lines of Ireland are also, it appears, 3ft.; the standard gauge, of which our Victorian, apparently, is a copy, being 5ft. 3in.

The standard narrow gauge lines of New Zealand and the other neighbouring colonies, excepting New South Wales, are 3ft. 6in.; New South Wales being of the English standard gauge, 4ft. 8½in.

For purposes of comparison I have here assumed the 3ft. gauge as that which for general traffic may be about the most suitable for narrow gauge lines.

The difference in cost between this line and the broad standard gauge line on the flat country before described, comparing like with like, may be estimated to average about £250 per mile.
In making a comparison of the relative cost of broad and narrow gauge lines in this simple form of application, attention may be drawn to a fallacy which sometimes leads to very erroneous conclusions. This fallacy consists in comparing a lighter construction of the narrow gauge with the heavier construction of the broad, apparently overlooking the fact that the strength of the broad gauge may be similarly reduced.

It is of course in the heavy earthwork in mountainous and difficult country where the principal saving in constructive cost of the narrow gauge may be effected, due to the narrower formation, width in deep cuttings and high banks.

In the example of the typical mountain line before referred to with five chains radius curves, the total saving in favour of the narrow gauge may be stated in round numbers to be about £500 per mile.

There are cases, however, of still more difficult country where the saving in earthwork would be greater by the adoption of the narrower gauge. Yet by the use of sufficiently sharp curves the difference in cost between the two gauges may not exceed the latter amount, and this course of adopting sharper curvature at the commencement, to keep down first construction cost, in exceptionally difficult country may be resorted to with either gauge, though when the line is afterwards improved the additional extra cost on the broad, as compared with the narrow, would then be incurred.

In this connection another important question arises, namely, the comparative suitability of broad and narrow gauge lines for exceptional sharp curvature; and on this subject I think we may not do better than quote Wellington, who appears to have investigated the subject in a very thorough manner and writes with a live experience of American practice, where curves ranging from 300ft. down to 50ft. radius were in regular use on standard gauge lines. He says—

"As respects curvature, we have already shown (Paragraph 335-36) that while the gain in curve resistance from a narrowing of gauge only with no other change, is very slight, yet when the wheel base is reduced correspondingly the curve resistance is probably diminished about in proportion to the gauge; as this is what is usually done in practice, we may consider it from that point.

"But the question then arises, 'What is saved thereby'? ... We have already seen (Paragraph 290) that any radius that is likely to be desired is readily practicable for properly designed standard gauge engines. If it be to save the wear and tear and loss of power, a small reduction in an item the whole of which is so small (Table 115, page 322) is not worth any considerable sacrifice, nor can it be taken for granted, nor is it probable, that there is any such reduction.

"As respects rolling stock, there cannot be a question that there is absolutely no practical advantage in the narrower gauge. Any reputable locomotive builder will contract to build engines of the same weight and power for either gauge which will traverse the same curves for the same price. The standard gauge engine in fact will or can have enough shorter wheel base because of its greater width to make it take curves a little better, a very important point which narrow gauge advocates and opponents alike have almost wholly lost sight of."
The great and serious objections to the narrow gauge, considered in connection with our standard broad gauge, may be stated to consist—

1st. In the extra cost of transhipment, delay and occasional damage to freight, and inconvenience to passengers, resulting in cases, it may be, in loss of traffic; loss of work of the rolling stock, due to transhipment, instead of running trains through without stoppage; also, loss of work from inability to distribute engines and vehicles, according to requirements of traffic, over different gauge lines, and loss, it may be, in a special local maintenance of stock.

2nd. Increased cost of maintenance of way when traffic becomes sufficiently heavy, and increased working expenses proportioned to results.

3rd. Increased resistance and lower speed of trains, due to the smaller wheels and greater oscillation, owing to greater overhanging of body of vehicle, and which, added to the necessarily lower height of passenger cars, contributes further to the inconvenience and discomfort of passengers.

Wellington says—

"The cost of maintaining track to a given standard of excellence is likewise greater, the cost of track labour being in about inverse proportion to the length of ties. The less bearing area of the ties on the ballast increases the disadvantage materially."

And adds—

"The reconstruction of narrow to standard gauge is now going on with great rapidity, several thousand miles of narrow gauge lines have already been changed, and it is plainly only a matter of a few years when practically all the remaining lines will be changed."

And further—

"The use of a narrow gauge to cheapen construction has been proved by actual experience to be in all cases inexpedient for any road handling a general traffic or having any reasonable chance of wishing to exchange traffic with other lines."

Referring to the different gauges already existing in the Australian Colonies, the New South Wales Railway Commissioners, in their report for the year 1889, say—

"We feel confident that if the break of gauge is allowed to continue, the consequent inconvenience and cost will in a few years be so great as to render the adoption of a universal gauge imperative."

And this quotation has doubtless a special application in view of the near prospect, let us hope, of a federated Australia, when present barriers to commercial intercourse between the colonies are removed.

In India, where they have shared the largest experience of mixed broad and narrow gauge lines, the Director-General of Railways, Colonel L. Conway Gordon, in a printed note accompanying correspondence issued from their Public Works Department, says—

"I do not seriously incline either to the Indian standard gauge or to the metre gauge. I have a flickering regret that the Indian railways were not made on the English standard gauge of 4ft. 8½in. The only opinion I do hold strongly is that whatever the gauge may be the whole of the railways in one country should be on one and the same gauge."
Attached to these notes are the printed views of Mr. Horace Bell, Engineer-in-Chief M. S. H. Ry. Sy., who regards "a light broad gauge line as being little better than a snare and delusion," adding that "it would fail us in time of pressure."

Probable the golden mean between these apparent widely diverse views re the use of a light broad gauge line will be found in the suggested light pioneer lines of this paper, and fully considered, may prove satisfactory to each of these gentlemen. That line, while having the merits of an economic light line, possesses the essentials for an emergency of pressure and an economic provision for future expansion of traffic, in addition to the present larger interchangeability of rolling stock.

Another Indian authority, Colonel T. F. Dowden, R.E., Consulting Engineer for Railways, Lucknow, in a printed statement attached to Colonel Conway Gordon's note, represents that after minute investigation he considers it established that—

"The expense of working for the work done, that is, for the freight carried and delivered, increases as the scale of construction or the gauge diminishes," and

"That the comparative efficiency is greater as the gauge increases."

I would also draw attention to the instructive discussion on "Indian Railways" before the Institute of Civil Engineers (Volume XCVII) in which both sides of the gauge question are elaborately dealt with. The important remarks therein of almost historical interest re the gauge question of England and the pioneer narrow gauge lines of Ireland, by J. Wolfe Barry, expresses so well and with so much greater authority some things that I would like to say myself that I attach a full extract to this paper.

While arguments for and against both broad and narrow gauge lines may be quoted almost ad lib., the most advanced opinions the world around seems to favour a close approach to the English standard, 4ft. 8½in. gauge, for all lines for general public traffic, and specially the avoidance of break of gauge, with, however, some exceptions.

Re the cost of working traffic on the broad and narrow gauge, there appears to have been much controversy, the chief confusion in which appears to have arisen from a similar cause to that which has led to such erroneous conclusions re the difference in first cost of construction, namely, in imperfectly comparing things which were unlike, such as character of line, and nature and proportion of traffic, etc. In which comparison advocates on both sides have claimed a victory, and in this connection it may be noted that in railway traffic there are elements of difference between Britain, America, India, and the Colonies.

It appears to me, after noting the experience and deductions of eminent engineers in various parts of the world, that the relative merits of the broad and narrow gauge, apart from the question of a break of gauge and its multifarious objections,
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necessarily depends upon the character of the traffic; for a line with a reasonable prospect of an ultimate heavy traffic unquestionably the broader gauge would have the advantage; while for a limited light traffic, within the compass of a narrow gauge line, the latter may be the most economical; for though it seems tolerably conclusive that whether the rails be 3ft. or 5ft. 3in. apart on any line which it may be justifiable to construct for light public traffic, the total working expenses would not differ materially, any saving effected therefore in the first constructive cost of the narrow gauge under such circumstances would be so much monetary gain. It is, however, I think, equally conclusive that could we predict such a limited light traffic for any ordinary branch line to our standard 5ft. 3in. gauge railways, any saving in the first constructive cost of such narrow gauge line may be insufficient to compensate for inconvenience, loss, and disadvantage of break of gauge. While it also appears to be almost impossible to predict before a line is constructed what may be the amount of its ultimate traffic.

And I think we are led to the conclusion that for general public traffic the adoption of narrow gauge for branch lines to our standard gauge system of State railways may in all cases be unsatisfactory and less profitable than the broad, while recognising the use of narrow gauge local tramways in certain cases.

There remains, however, a question whether, in view of what has been or what may be advanced, there is any part of our colony, especially the mountainous regions, where the larger savings would be effected in first constructive cost, where a system of narrow gauge lines complete, or nearly so, in itself, could be profitably adopted.

If it could be shown, for example, that a system of narrow gauge lines could be constructed where railways are required in our mountainous country at any saving per mile which would be more than sufficient to pay for any loss from break of gauge or other inconvenience or disadvantage, present or prospective, which may be involved, then such saving may represent justification for their construction; a subject for discussion.

REMARKS BY J. WOLFE BARRY (1889).

"Mr. J. Wolfe Barry remarked that it had been lately his lot to investigate the subject of railway gauge with some considerable care, in conjunction with his colleagues on the Royal Commission on Irish Public Works. The matter had been debated with a great amount of heat in Ireland, as it had been in England and in India, and indeed everywhere, since the battle of the gauges between the Great Western Railway and the narrow gauge system in this country. Some years ago the Lord-Lieutenant of Ireland, led away by an idea of the advantages of narrow gauge lines, had put a premium upon the promotion of those lines rather than of light railways of the Irish standard gauge. The inducement offered was that the Government would guarantee a per centage upon the cost of the narrow gauge lines, but that any additional cost of light broad gauge lines would have to be paid by the promoters out of their own pockets. Accordingly some lines had been made in Ireland on the 3ft. gauge. The circumstances connected with these railways had been investigated with great care, and the result of the investigation was contained in the second report of the Commissioners. It was found, after careful estimates made by experienced engineers, that the extra cost of about ten contemplated lines of a total length of 202 miles, if
made on the Irish gauge, would vary from £300 to £500 per mile. Some portions of those lines were in mountainous districts, where curves were of importance as materially affecting the cost of construction. But allowing for such circumstances, the Commissioners came to the conclusion that the Government might safely take it that a broad gauge line would not cost more than £500 per mile in excess of one of the narrow gauge, assuming that the weight to be carried on the engine wheels was the same in both cases—in fact comparing like with like. It was necessary to remember, when comparing like with like in regard to the weight of the rails and general construction, that the limiting matter to be considered was the weight on the engine wheels, and not on those of the carriages and waggons. The Government had settled what was to be the limiting weight on the engine wheels in Ireland, in the case of all light railways of either gauge, and that limit was adopted by the Commissioners as a standard of comparison in the two cases. The quantity of rolling stock necessary, where a break of gauge occurred, had to be so estimated that the maximum amount of rolling stock must be taken for each section of the line; so that in the case of a short branch line there should be such an amount of rolling stock as would deal with the maximum traffic, and not merely with the average traffic. Rolling stock could not, owing to the difference of gauge, be drawn from other portions of the railway to deal with exceptional circumstances, and it was therefore obvious, in the case of short lines, that an unnecessarily large amount of rolling stock must be provided on lines isolated by break of gauge, and this fact was a considerable set off against any increase of cost of construction. In Ireland the lines were short, and therefore perhaps, speaking generally, any comparison with the lines in India was not quite appropriate. But it should be remembered that it was very difficult to foresee the future of a railway. It could not always be a matter of certainty that a new railway, even in India, would always start from the point of production and finish at the port of export, though it might be designed to do so. Such might be the case for a year or two, but in a short time circumstances might alter, and it might have to be considered how the traffic was to be sent over other railways. Then, even in the case of long lines, the question arose of a break of gauge, and the weight of evidence in England, in the United States and in Canada was so enormously against any break of gauge that any one proposing it ought to be able to show some great and overwhelming advantage in cost of construction or working. Even with regard to India, he thought that the table submitted by General Williams, so far from showing any advantage for the narrow gauge, would only, even strained to the utmost, bring it up to something like an equality in cost of working some descriptions of traffic. When the subject was discussed many years ago in that room with great energy on both sides, a former Governor-General of India expressed his belief that a break of gauge was rather an advantage from a military point of view, because at some particular places troops had to be landed and refreshed, and it was therefore a good thing that there should be some points at which the process was obligatory. It did not appear to have occurred to the speaker in question that it was possible that they might be landed and refreshed without any break of gauge. To show, on the other hand, what a break of gauge really meant, he might mention that one of his colleagues on the Royal Commission on Irish Public Works was Sir James Allport, who had been all through the battle of the gauges, and his recollection, which was corroborated by that of other experienced railway managers, was that in the division of through rates for goods passing from one gauge to another, thirty miles were credited to the company that undertook the expenses of the transfer from one gauge to the other. That certainly seemed a very startling thing. If all that had been gone through in England, with the result that the Great Western Railway Company had almost entirely rejected the broad gauge, and if in Ireland the testimony was almost overwhelming against a break of gauge (some gentlemen who had made narrow gauge lines saying that they were very sorry for it), he thought that the case against these narrow gauge lines was thoroughly established. He hoped that if people wanted a cheap line they would still make it on the existing gauge. They were surely strong enough to resist the seductions of civil engineers, who were supposed to want to make an expensive line. Let engineers at any rate have the courage of their opinions, and if a cheap line was wanted do as contractors did, who, when they
RAILWAYS FOR VICTORIA.

wanted to make an overland route to last merely a year or two, did not make a 
break of gauge in order to save a few hundred pounds per mile, but always 
adopted the standard gauge so as to convey all the goods required for con-
struction without transhipment. Let the public be content with a light 
railway of the standard gauge, and be content also with low speeds, thus 
not attempting to send over the railway heavy engines which were suitable for 
other parts of the line. Under those circumstances all supposed economies 
connected with narrow gauge lines would vanish, and a great advantage 
would be gained in the development of traffic and in saving of working 
expenses, looking at the railway as a whole and not cutting the traffic up into 
fanciful divisions."

"With these remarks," says Lieutenant Colonel R.A. 
Sargeaunt, R.E., Manager Oudh and Rohilkhand Railway, "I 
entirely agree," and your humble servant is also inclined to agree.

With permission I attach an interesting "Statement of Rail-
ways in English Speaking Countries, India, &c., compiled from 
Official Sources," by Mr. W. Walker, of the Victorian Railway 
Department.
<table>
<thead>
<tr>
<th>Country</th>
<th>Year ended</th>
<th>Miles open.</th>
<th>Proportion of</th>
<th>Capital</th>
<th>Revenue</th>
<th>Working Expenses</th>
<th>Net Earnings</th>
<th>Proportion of</th>
<th>Proportion of</th>
<th>Proportion of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>5' 6&quot;</td>
<td>5' 3&quot;</td>
<td>4' 8½&quot;</td>
<td>3' 6&quot;</td>
<td>2' 3½&quot;</td>
<td>Other</td>
<td>£</td>
<td>£</td>
</tr>
<tr>
<td><strong>VICTORIA</strong></td>
<td>30/9/02</td>
<td>2,003</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>37,065,369</td>
<td>3,066,122</td>
</tr>
<tr>
<td><strong>NEW SOUTH WALES</strong></td>
<td>30/9/02</td>
<td>11,185</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>35,314,892</td>
<td>3,107,806</td>
</tr>
<tr>
<td><strong>QUEENSLAND</strong></td>
<td>30/9/02</td>
<td>2,330</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>16,046,351</td>
<td>1,025,256</td>
</tr>
<tr>
<td><strong>SOUTH AUSTRALIA</strong></td>
<td>30/9/02</td>
<td>1,650</td>
<td>29</td>
<td>%</td>
<td>71</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>11,714,434</td>
<td>11,312,240</td>
</tr>
<tr>
<td><strong>DO. PALMERSTON LINE</strong></td>
<td>30/9/02</td>
<td>146</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1,154,634</td>
<td>15,321</td>
</tr>
<tr>
<td><strong>WESTERN AUSTRALIA</strong></td>
<td>31/12/91</td>
<td>203</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>384,439</td>
<td>64,094</td>
</tr>
<tr>
<td><strong>AUSTRALIA</strong></td>
<td>1851-2</td>
<td>9,417</td>
<td>28</td>
<td>23</td>
<td>41</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>106,157,675</td>
<td>5,474,499</td>
</tr>
<tr>
<td><strong>TASMANIA</strong></td>
<td>31/12/91</td>
<td>377</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>3,029,037</td>
<td>169,090</td>
</tr>
<tr>
<td><strong>NEW ZEALAND</strong></td>
<td>31/12/91</td>
<td>1,589</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>14,656,691</td>
<td>1,116,422</td>
</tr>
<tr>
<td><strong>AUSTRALASIA</strong></td>
<td>1851-2</td>
<td>11,662</td>
<td>29</td>
<td>19</td>
<td>62</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>117,907,403</td>
<td>9,381,961</td>
</tr>
<tr>
<td><strong>INDIA</strong></td>
<td>31/12/91</td>
<td>17,823</td>
<td>58</td>
<td>%</td>
<td>40</td>
<td>2</td>
<td>%</td>
<td>%</td>
<td>231,054,192</td>
<td>14,140,379</td>
</tr>
<tr>
<td><strong>Ceylon Colony</strong></td>
<td>31/12/91</td>
<td>2,323</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>18,527,568</td>
<td>2,248,540</td>
</tr>
<tr>
<td><strong>Bengal</strong></td>
<td>31/12/91</td>
<td>376</td>
<td>100</td>
<td>%</td>
<td>100</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>4,029,242</td>
<td>572,290</td>
</tr>
<tr>
<td><strong>Canada</strong></td>
<td>31/12/91</td>
<td>14,870</td>
<td>98</td>
<td>1</td>
<td>1</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>176,085,948</td>
<td>10,767,468</td>
</tr>
<tr>
<td><strong>United Kingdom</strong></td>
<td>31/12/91</td>
<td>23,191</td>
<td>12</td>
<td>98</td>
<td>2</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>918,452,121</td>
<td>81,589,607</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td>31/12/91</td>
<td>167,846</td>
<td>94</td>
<td>%</td>
<td>5</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>2,216,025,779</td>
<td>224,456,283</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1851-2</td>
<td>254,450</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8,676,215,474</td>
<td>883,868,453</td>
</tr>
</tbody>
</table>

This statement comprises more than half the railway mileage of the world.

* Compared with the year ending 30th June, 1888, the mileage of the Victorian Railways has increased 44 per cent., the capital 40 per cent., the gross revenue 12 per cent., the working expenses 22 per cent., and the percentage of working expenses to revenue 9 per cent.; while the net revenue has fallen 5 per cent., the percentage of gross earnings to capital 20 per cent., and of net earnings to capital 22 per cent. on the figures for the earlier period.

† N.S.W. figures are exclusive of the 48 miles of State owned tramways.

‡ 44 per cent. of this revenue, viz., £395,074, was earned on 411,744 tons of Baller (N.S.W.) traffic = 246. per ton; while on the Victorian Railways the average receipts per ton of goods and live stock = 96.

§ Rupees converted at 2s. sterling.

|| Dollar converted at 4s. 2d. sterling.

Accountant's Office, Railway Department, Melbourne, June, 1892.
Typical Railway Lines.

In Mountainous Country:

Note: The loads and prices are given chiefly for purposes of comparison and may be modified by various circumstances.

Scale for Plan and Sections of Lines except where otherwise stated:

Gradient: 1 in 50

Carr Victorian Railways

Approximate load exclusive of Engine & Tender 25 tons.

Length of Line ABCG 2 miles.

Line located on level ground, tail incline level with road in normal direction of traffic.

Section on Line A-B-C-G

Standard Gauge 3 ft 6 in (107 mm)

Trench 30 ft per yard

Ballast 3 ft under sleepers

Load per mile £2.50

Total cost ABCG £15.36.

Section on Line A-H-I-J-K-L

Gradient 1 in 50

Carr Victorian Railways

Approximate load exclusive of Engine & Tender 25 tons.


Line located on level ground, tail incline level with road in normal direction of traffic.

Section on Line A-M-N-O-P-L

Gradient 1 in 50

Carr Victorian Railways

Approximate load exclusive of Engine & Tender 25 tons.

Length of Line A-M-N-O-P-L 3 miles.

Line located on level ground, tail incline level with road in normal direction of traffic.

Section on Line A-D-E-F-G

Standard Gauge 3 ft 6 in (107 mm)

Trench 30 ft per yard

Ballast 3 ft under sleepers

Load per mile £2.50

Total cost A-D-E-F-G £15.36.

Section on Line A-D-E-F-G

Gradient 1 in 50

Carr Victorian Railways

Approximate load exclusive of Engine & Tender 25 tons.

Length of Line A-D-E-F-G 3 miles.

Line located on level ground, tail incline level with road in normal direction of traffic.
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