An ordinary monthly general meeting was held at the Rooms on
Wednesday, August 8th, at 8 p.m., the President, Professor
W. C. Kernot, in the chair.

The minutes of the July ordinary meeting, and also of the special
general meeting held on July 11th, were confirmed.

As a result of a ballot, Messrs. E. J. Thompson and Harry
Conradi were elected Junior members of the Institute.

Professor W. C. Kernot read a paper upon "Railway Gauge."

Vice-President Mr. J. A. Smith (who occupied the chair
during the reading of the paper) said that those who had a personal
knowledge of the historical matters referred to were rapidly
passing away, and data was becoming increasingly difficult of access.
He thought that those who devoted time to eliciting and permanently
recording the facts performed valuable service, and he had much
pleasure in moving that Professor W. C. Kernot be cordially
thanked for his efforts in that direction.

The vote was carried by acclamation.

The paper was briefly discussed, the main discussion being
postponed until the next meeting.

At 10 p.m. the business was closed.

PAPER.

RAILWAY GAUGE.

Read by Professor W. C. Kernot.

The gauge of a railway is the distance between the inner sides of
the heads of the rails on a straight portion of the line. It is not, as
is sometimes supposed, the distance between the centres of the rails,
and it must be taken on the straight, or tangent, as the Americans
call it, because on curves it is usual to introduce a slight enlargement
to allow more freedom to the passage of wheels whose axles are not
strictly radial. The gauge is a dimension of primary importance to
the working of a railway, and must, subject to above-mentioned slight
enlargement, be most carefully preserved, but within moderate limits
its actual magnitude in feet and inches is of much less moment than its
consistent preservation throughout the whole distance travelled.

The most popular and widely adopted gauge has the somewhat odd
RAILWAY GAUGE.

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dimension of four feet eight and one-half inches, and is now generally spoken of as the Standard Gauge. How it originated is somewhat doubtful. A certain ingenious gentleman finds it in the cart tracks revealed by the excavations at Pompeii, and one is inclined to suggest that Professor Piazzi Smyth, the author of "Our Inheritance in the Great Pyramid," might, had his attention been called to the subject, have found it a divinely-inspired and absolutely perfect railway gauge, along with the British inch, and other wonderful things laid down in that building of hoary antiquity.

Another story is that a certain early engineer, by mistake, measured the gauge to the outside of the rails, and so changed five feet, which he meant to adopt, to one \(\frac{3}{2}\) inches less. But all this is mere speculation. The important fact is that the Standard Gauge has come, that it has come to stay, that in mileage it exceeds any other, or all other gauges put together, that the railways of nearly all Europe and North America have adopted it, and that the heaviest and fastest traffic in the world takes place upon it.

Some people seem to think there is some magical charm, some peculiar virtue in this particular dimension to account for its prevalence and success. I cannot agree with them. I regard it as a mere accident, which, once established and being found tolerably satisfactory, spread and occupied the field, compelling other gauges of later date to give way to it, the evils of break of gauge being found far greater than the benefits of the few extra inches that gauge reformers in numerous cases added. Had railway making started on a gauge anywhere between 5 and 6 feet, I am convinced we should never have heard of the present peculiar standard. It is noteworthy that nearly all the attempts to break away from it in the early days of railway making were in the direction of increase, and not of diminution, showing plainly that even then it was found hardly ample enough for growing practical requirements.

Of these attempts to enlarge the gauge two are worthy of special mention.

The first is that made by Brunel, on the Great Western Railway in England. This was constructed on a gauge usually given as 7 feet, but actually it is stated by some a fraction of an inch above that dimension, the idea being to make it just 50 per cent. larger than the Standard. Some splendid running was made on this noble gauge, and Great Western expresses were the admiration and envy of the other railways for many years. The attempt, however, came too late in the day, and it was further handicapped by most costly construction, involving heavy overcapitalisation. This delayed its extension till the Standard gauge grew round it on all sides, and choked it out of existence. The writer believes that he saw the last of it removed about the end of 1891, near Reading. Had Brunel made his attempt a few years earlier, and adopted a more economical type of construction, possibly the result might have been otherwise.

The other notable endeavour to enlarge the gauge was made in Ireland. With the complaints of restricted space on the English lines before them, and with an insular country having no conceivable possibilities of connection with the rest of the world except by sea, the
engineers had carte blanche, an open field untainted by legacies of past errors. They therefore adopted what they considered in view of all accessible experience the best possible gauge, and made it 5 feet 3 inches. This, then, was a gauge deliberately chosen after full and careful enquiry, contrasting with the Standard or English gauge, which, like Topsy in "Uncle Tom's Cabin," had no known parents, but merely "specs she growed." The Irish gauge of 5 feet 3 inches is that of the Victorian, and the primary system of South Australian Railways, and there is no question that it is an excellent gauge, full of most valuable possibilities.

The requirements of lines in very mountainous country where excessively sharp curves were the only possible alternative to prohibitively costly works, of mineral lines where the material carried is heavy, but not bulky, and high speed not necessary, and other special cases led to the development of a system of what are now called narrow gauge lines, varying from 2 feet up to 3 feet 6 inches. These little lines at first were never meant to compete with the Standard or Irish lines. They claimed merely to be an inferior but much more cheaply-constructed appliance, suitable to cases when full-size railways were too costly. But about the year 1870 great efforts were made to introduce them as main lines, and the most exaggerated estimates of saving in first cost were put forth, and with a certain loudly-advertised type of locomotive it was alleged that they would be nearly, if not quite, equal in speed and capacity to the broad gauge lines. Careful enquiries, including in the case of this colony comparative tenders for lines on both gauges, based on designs which the writer as a junior draughtsman assisted to prepare, happily led to the rejection of the 3 feet 6 inch gauge in Victoria and New South Wales, but it was adopted for a secondary system in South Australia, and for all the railways in Tasmania, Queensland, West Australia, New Zealand and South Africa, small lengths of Irish gauge already made being altered in New Zealand and Tasmania. This decision is now deplored by the leading officials in South Africa, while in Western United States the writer has seen hundreds of miles removed and replaced by Standard gauge. For a country of small size and slender possibilities like Tasmania it may be defensible, but in the other cases its justification is, in the writer's opinion, to say the least, difficult.

The fact is that of all the items that go to make up the total cost of making and working a railway, there are many important ones that are absolutely independent of gauge, there are others that are affected very slightly, and there are only a few that are affected at all seriously. Hence, in the comparative tenders obtained in Victoria, a reduction of 33 per cent. in the gauge led to a reduction in cost of construction of only 3 to 4 per cent. The writer has inspected and travelled on railways both broad and narrow in many parts of the world, and his average experience is that as the gauge goes down the speed goes down and the fares go up in just about the same proportion.

One of the most curious delusions about these narrow gauge lines is that they possess extraordinary flexibility—that they can be taken round very sharp curves, whereas the broad gauge cannot. The truth is that it is almost altogether a question of speed. Run the broad
gauge line at narrow gauge speeds and you can traverse narrow gauge curves. With a broad and narrow line having the same ruling curvature the result is, according to the dictum of one of the most experienced railway engineers in Australia, that “on the broad gauge you must go slow round the curves, and may run fast on the straights, but on the narrow you must go slow all the way.” The narrowest railway the writer ever travelled on—namely, 2 feet gauge—has curves no sharper than the Melbourne or Sydney tramways, which are more than double that gauge, and does not go round them as quickly or easily.

Let us now go fully into the history of the gauge question in Australia, paying special attention to the genesis of that most dreadful break of gauge between Victoria and New South Wales—a break of gauge far worse in its effects than if the difference had been twice or three times as large as it is. With 5 feet 3 inches and 3 feet 6 inches it is possible to lay three rails on one set of sleepers, and arrange points and crossings fairly easily, and so provide for trains on both gauges; but with only 6\(\frac{1}{2}\) inches between the Standard gauge in New South Wales and the Irish in Victoria this is impossible.

The subject of railways in Australia was, according to a lecture delivered before the Sydney University Engineering Society by Mr. Henry Deane, Engineer-in-Chief of Railway and Tramway Construction in New South Wales, on December 19th, 1902, first mooted at a public meeting in Sydney in January, 1846, but it was not until 1849 that a company was formed under Government guarantee of 6 per cent. interest. On July 3rd, 1850, the first sod of the Sydney and Parramatta Railway was turned at Redfern, with the usual rejoicings, by the Hon. Mrs. Keith Stewart, daughter of the Governor, Sir Charles A. Fitzroy. But to turn the first sod and to open the line for traffic are two very different things, and more than five years of conflicting counsels and financial difficulties intervened before a journey of about 13 miles was effected, and no less than three gentlemen filled the position of Engineer-in-Chief during that period, to be succeeded by a fourth before the trains had been running eighteen months. At the outset the English standard gauge of 4 feet 8\(\frac{1}{2}\) inches was recommended by Earl Grey, the Secretary of State for the Colonies, and New South Wales, Victoria, and South Australia all agreed to adopt it. In 1852, however, under the urgent representations of the Engineer-in-Chief (Mr. Shields), the New South Wales Government altered it to the Irish gauge of 5 feet 3 inches. The Act for this purpose received the Royal assent on July 27th of that year, and is to be found in No. V. of the Public Statutes of N.S.W., p. 2490, which the writer has consulted at the Melbourne Public Library. This Act is of an almost ferocious character in the stringency of its requirements, stating that if any person shall make a railway for conveyance of passengers on any other gauge he shall be fined £10 per mile per day of running, and that the Surveyor-General shall have power to remove such railway and restore its site to its former condition. As a matter of curiosity, the writer roughly calculated the amount of fines up to date on the New South Wales railways under this Act, and found it to be about double the total cost of construction.
As the mother colony was so desperately in earnest on this gauge question, the junior colonies could do nothing but follow suit, which they did promptly and without demur, Victoria on January 20th, 1853, passing an Act for the Melbourne and Hobson's Bay Railway Company, and in the following month two other Acts for the Geelong and Melbourne, and Melbourne, Mt. Alexander, and Murray River Railway Companies, all of which adopted the Irish gauge, while on December 9th of the same year South Australia passed a special Act repealing a previous Act, and making the Irish gauge compulsory there also. The next event is the opening of the Melbourne and Port Melbourne railway, the first railway opened in Australia. This took place on September 12th, 1854, as attested by the "Argus" of that date and the day following, where what seems now a quaint and amusing account is to be found. Under the heading, in small capitals, "The First Scream," is some excellent journalese as to the locomotive flying past the aboriginals' gunyah and rousing the echoes of the primeval forest, etc., etc., etc., while the speeches at the banquet after the wonderful colonial-made engine of 30 horse-power had propelled the train at a speed of 15 miles per hour to Port Melbourne and back, are most interesting reading, especially when grave fears are expressed that the trains will fail to negotiate the sharp curve entering the station at Flinders-street. It is a pity that this original locomotive has not been preserved for the inspection of future ages. Report says it was merely a large portable engine placed on a truck, with belt transmission from the crank shaft to the propelling wheels. But whatever it may have been, it holds the record as the first locomotive to propel a passenger train on a public railway in Australia.

Meanwhile strange and regrettable events were taking place at Sydney. A new Engineer-in-Chief, named Wallace, appeared on the scene, having arrived from England, according to Mr. Deane, on July 9th, 1852, or just before the passing of the Act making the Irish gauge compulsory under such enormous penalties. He was an intense partisan for the Standard gauge, and left no stone unturned to bring New South Wales back to her first love, entirely regardless of keeping faith with the other colonies, whose railways were now progressing with comparative rapidity, and who had already reversed their policy once in order to keep in line with New South Wales. The result was that on August 14th, 1855, the Act of 1852 was repealed, leaving the question of railway gauge in New South Wales absolutely open. See Public Statutes, No. VII., p. 2926. Six weeks later, on September 26th, 1855, the Sydney and Parramatta railway was opened on the Standard 4 feet 8½ inches gauge, and the most lamentable engineering disaster in Australia was an accomplished fact.

Now, what shall we say as to responsibility? Who was to blame? Or is the blame to be divided? The facts are clear, vouched for by the official publications of the three States and the daily papers of the various dates, and they are these:

1. All three States agreed originally to adopt the Standard gauge.
2. New South Wales broke away, and gave her allegiance to the Irish gauge.
3. Victoria and South Australia at once fell into line with New South Wales, and commenced railway making actively.

4. When Victoria had one line open for public traffic for nearly a year, a second—a country line of 40 miles long—well advanced, and much rolling stock ordered and under construction, and South Australia was also actively progressing, New South Wales reversed her policy, and went back to the Standard gauge.

5. Six weeks after the change of legislation New South Wales opened a line 13 miles long, with an English locomotive on the Standard gauge.

What went on behind the scenes, what strings were pulled, and influences exerted to bring about this remarkable result can probably not be traced now. Mr. Deane in his lecture passes over the matter briefly, evidently not desiring to direct too much attention to an action not creditable to the colony he represents. He does, however, state that Earl Grey, the Secretary of State for the Colonies, strongly opposed it, but ultimately gave way on being assured that much rolling stock had been ordered from England on the Standard gauge. But if this be so, it follows that this rolling stock must have been ordered illegally, in defiance of the extraordinarily stringent Act of July, 1852.

Further, when it is considered that at that time there was no telegraph to England, and that the mail steamers were small and slow, and ran only at monthly intervals, it must have taken many months, not improbably a full year, to send the order to England for the locomotive, have it made there, and send it out to Sydney and erect it, and that therefore this engine must have been ordered at least six, and most likely ten, or even twelve months, before the gauge it could run on was legally permissible in New South Wales. Is there any possible defence of the action of the mother colony, or any possible blame or responsibility on the part of Victoria or South Australia? And if there is none, on whom should the cost of unifying the gauges fall when so necessary and desirable an operation is undertaken?

The next cardinal event in the History of Australian Railways is the opening of the Adelaide and Port Adelaide line on April 21st, 1856, on the Irish gauge.

By this time the financial state of the Sydney Railway had become such as to lead to the Government taking it over, and Mr. Wallace having resigned, Mr. John Whitton was appointed Engineer-in-Chief in January, 1857. He at once grasped the situation, and begged his Government most earnestly to go back to the Irish gauge, now existing in considerable lengths in the other colonies, before the cost became too serious to be endured. But it was all in vain. The reply was, "We shall not meet for centuries, and it will cost several thousand pounds to effect; go on with what you have." In October of the same year Captain Martindale, the Chief Commissioner of Railways, again urged that this awful mistake be remedied ere it was too late, but without avail. These statements are from Mr. Deane's lecture, but the former was also personally made by Mr. Whitton to the writer in 1877, under circumstances leading to the conclusion that he (Mr. Whitton) felt that a great wrong had been done to Victoria, and that he was anxious to show that the responsibility in no way belonged to him.
Deane’s lecture of 19/12/02.

Do.

Do.

Public Statutes of N.S.W., No. V.

Public Statutes, Vic.

Public Statutes, S.A.

Public Statutes of N.S.W., No. V.

Deane.

Public Statutes, Vic.

Public Statutes, Vic.

Public Statutes, S.A.

Argus, 12 and 13/9/54.

Public Statutes, N.S.W., No. VII.

Railway Department of N.S.W.

Deane and Kernot

Argus and Geelong Advertiser, 25 and 26/6/57

Deane.

Australasian, 30/9/05, in which is a photo of the alleged “first train.”

The next railways opened were in Victoria—Melbourne and St. Kilda on May 15th, 1857, and Geelong and Melbourne, June 25th, 1857. After this railway making went on rapidly in Victoria, but for some years more slowly in the other colonies, till there are now about 4000 miles of Irish gauge in Victoria and South Australia, and over 3000 miles of English gauge in New South Wales. For convenience of reference the following tabular statement is inserted here:

**EARLY CHRONOLOGY OF NEW SOUTH WALES, VICTORIAN, AND SOUTH AUSTRALIAN RAILWAYS.**

<table>
<thead>
<tr>
<th>DATE</th>
<th>COLONY</th>
<th>EVENT</th>
<th>AUTHORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/1/46</td>
<td>N.S.W.</td>
<td>Public Meeting at Sydney about Railway construction</td>
<td>Deane’s lecture of 19/12/02.</td>
</tr>
<tr>
<td>27/1/48</td>
<td>N.S.W.</td>
<td>Sydney-Goulburn Railway Survey completed</td>
<td>Do.</td>
</tr>
<tr>
<td>10/10/49</td>
<td>N.S.W.</td>
<td>Act of Incorporation of Sydney Railway Company on Standard (4ft. 8½ in.) gauge</td>
<td>Do.</td>
</tr>
<tr>
<td>19/2/50</td>
<td>S.A.</td>
<td>Act Adelaide and Port Adelaide Railway, standard gauge</td>
<td>Public Statutes of S.A.</td>
</tr>
<tr>
<td>3/7/50</td>
<td>N.S.W.</td>
<td>Turning of first sod Sydney and Paramatta Railway</td>
<td>Deane.</td>
</tr>
<tr>
<td>27/7/52</td>
<td>N.S.W.</td>
<td>Act rendering Irish (5ft. 3½in.) gauge compulsory under extremely heavy penalties</td>
<td>Public Statutes of N.S.W., No. V.</td>
</tr>
<tr>
<td>12/58</td>
<td>S.A.</td>
<td>Act altering gauge from Standard to Irish</td>
<td>Public Statutes, S.A.</td>
</tr>
<tr>
<td>12/9/54</td>
<td>Vic.</td>
<td>Hobson’s Bay (Port Melbourne) Railway opened</td>
<td>Argus, 12 and 18/9/54.</td>
</tr>
<tr>
<td>14/8/55</td>
<td>N.S.W.</td>
<td>Act repealing Act of 27/7/52</td>
<td>Public Statutes, N.S.W., No. VII</td>
</tr>
<tr>
<td>26/9/55</td>
<td>N.S.W.</td>
<td>Sydney and Paramatta Railway opened, Standard gauge</td>
<td>Railway Department of N.S.W.</td>
</tr>
<tr>
<td>21/4/56</td>
<td>S.A.</td>
<td>Adelaide and Port Adelaide Railway opened, Irish gauge</td>
<td>Deane and Kernot</td>
</tr>
<tr>
<td>15/1/57</td>
<td>N.S.W.</td>
<td>Mr. Whitton urges return to Irish gauge unsuccessfully</td>
<td>Argus, 15/5/57.</td>
</tr>
<tr>
<td>15/5/57</td>
<td>Vic.</td>
<td>Melbourne and St. Kilda Railway opened, Irish gauge</td>
<td>Argus and Geelong Advertiser, 25 and 26/6/57</td>
</tr>
<tr>
<td>22/10/57</td>
<td>N.S.W.</td>
<td>Commissioner Martindale urges return to Irish gauge, but without success</td>
<td>Australasian, 30/9/05, in which is a photo of the alleged “first train.”</td>
</tr>
<tr>
<td>26/9/06</td>
<td>N.S.W.</td>
<td>Railway Jubilee at Sydney, at which it was claimed, contrary to fact, that the “first train to run in Australia” did so on 26/9/55, whereas the Melbourne and Port Melbourne Railway was opened for public traffic more than a year before</td>
<td></td>
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</table>
RAILWAY GAUGE.

But there is another gauge on railways of vast importance, and as to which the writer considers great mistakes have been and are being made. It is what is called "loading gauge," and may be defined as the outline of the smallest opening through which the train can pass without touching. In goods stations this loading gauge often has an actual physical existence in the form of an iron frame suspended by chains from a beam overhead, and provided with a bell attached by a spring. The loaded goods train is slowly passed through this gauge, and if any part projects in the least degree too far, the suspended frame is caught and shaken, and the bell rings. The projecting part is then attended to. At a certain distance outside the loading gauge, which distance may be called the clearance, another line is drawn, indicating the limits within which no standing work, such as bridge or tunnel, gate, or verandah post, etc., must be allowed to project. Now, the contention of this paper, a contention with which the writer believes the majority of experienced railway men will heartily agree, is that on the Standard and Irish gauge lines the loading gauge has been made much too small.

In the early days of railways engineers were almost abnormally nervous as to lateral stability. They seemed to think that trains were always wanting to overturn, to lie down on one side. Hence the advantages of a low centre of gravity were insisted upon, and this consideration, combined with the desire for an immense driving wheel, without which they imagined high speed could not be secured, led to the production of some of the quaintest monstrosities in the way of locomotives that can well be conceived. One of these had its boiler actually suspended below the driving axle, while the huge wheel towered up nearly to the top of the chimney. A second had two small boilers, one above and one below the driving axle. A third, and popular type had its driving axle placed in the rear, so that it could occupy the same level as the centre of the boiler. But modern experience has blown all this to the winds, and both the low centre of gravity and the huge 8, 9 or 10 foot driving wheel are conspicuous by their absence in the best modern practice. Probably narrow gauge requirements are to some extent responsible for this enlightenment. Some 30 years or so ago long lengths of 3 ft. 6 in. railways were made for light traffic and low speed, and were worked with diminutive engines and carriages. But in many countries, such as South Africa and New Zealand, the traffic developed rapidly, and the public demand for increased speed was strongly felt, so that boilers of a diameter greater than the rail gauge were a necessity, and as these had to bulge out over the wheels, a high centre of gravity was unavoidable, and, being reluctantly accepted, was found quite free from the dangers and defects previously dreaded. At the same time the necessity of good accommodation, dining and sleeping cars, led designers to gradually employ an amount of overhang that would at first have horrified them, but which was also found when tried to be comparatively harmless.

These changes have gradually spread to Standard and Irish gauge work, and now we have large and high-pitched boilers and moderately-sized but accurately-balanced wheels, instead of the huge, imper
fectly-balanced wheels and low and small boilers of earlier date, with every advantage from the point of view of power, speed and easy running. But the full development in this direction, especially as regards passenger carriages, has been impeded by the restricted loading gauge inherited from the early days, and the improvement of this is becoming every day more and more urgent. Doubtless many will say it is too late in the day to do anything; that the reconstruction of tunnels, bridges and platforms will be prohibitively expensive. With this pessimistic view I cannot concur. Doubtless the task is great, and improvement will take a long time to effect. Still, we should not despair, and the fact that in some foreign countries the loading gauge is more liberal than in most parts of the British Dominions should incite us to at any rate look into the question and discuss its possibilities.

The latest Board of Trade rules, by which all passenger railways in the United Kingdom are controlled, contain the requirements, first, that no standing work above the level of the floor of a carriage may come nearer than 2 feet 4 inches to the most projecting point of such carriage; and second, that the central space of a double line of railway must not be less than 6 feet. In fact, this space is generally known on this account as the “six foot.”

Now the first of these requirements is reasonable and ample, and to it no objection will be taken in this paper. In fact, it might in the writer's opinion be reduced slightly without serious danger. But the other is not so, and needs careful reconsideration. Established when carriages were narrow, and overhung the wheels but a little way, it is quite insufficient for the broad bodies of modern dining, sleeping and corridor cars, and the still broader bodies that we may desire in the future for better accommodation and more convenient internal arrangement.

A careful examination of the working drawings of passenger carriages and goods waggons on European, American and Australian railways shows that widths of 9 feet, 9 feet 6 inches, and even in the case of recent American and Chinese railways 10 feet, are by no means unusual, while in Victoria certain up-to-date cars are said to have reached 9 feet 8 inches. Let us therefore take 10 feet as the proper width of a carriage body on the Standard gauge, to which the Victorian lines will some day have to be reduced, it being much cheaper to reduce the Victorian than enlarge the New South Wales. The question is what width is needed between standing work on single and on double lines to safely and conveniently accommodate car bodies 10 feet wide, and how does that width compare with what is provided on our Victorian lines?

As to single lines, the width becomes 10 feet plus twice 2 feet 4 inches, or altogether 14 feet 8 inches, and as the standard width of our single line tunnels is 15 feet, it appears that all is well, which is a matter for satisfaction, especially as the bulk of our railway mileage is single line.

But how about double lines and the 6 foot centre space? Here the condition is far from satisfactory. We have on the Bendigo line our two largest and most expensive tunnels—namely, those at Elphin-
RAILWAY GAUGE.

stone and Big Hill. Built in the very early days, when rolling stock was diminutive, they show a maximum width of only 25 feet, and this only at one level, below and above which the width diminishes, so that 24 feet 6 inches will be the fair equivalent as between vertical walls. In this restricted space two 10 foot bodies have to pass, leaving only 4 feet 6 inches for the central and two side clearances, or only 1 foot 6 inches each. This is far too small, and in the writer's opinion the enlargement of these tunnels should receive early attention. Both are lined throughout with brickwork 1 foot 10 inches thick, and what ought to be done is to construct a new lining outside the old one, and then remove the old lining. This would increase the width from 25 feet to 28 feet 8 inches, which would be none too large for modern requirements. In fact, while they are about it, they might as well give 30 feet, or double the width of the single line tunnels. The cost of this enlargement should not be prohibitive. Many tunnels have been enlarged in other parts of the world; the ground is good, and with modern experience and methods the work could probably be done for the two tunnels well within £100,000. A serious accident, due to insufficient clearance, might easily cost as much. Bridges would be dealt with more easily than tunnels, as it would be necessary to take down one side only, and slightly lengthen the girders, and it is further to be noted that we are fortunate in having a comparatively small number of our bridges, and only two tunnels, neither very long, to deal with.

An examination of more recent bridge work, about 20 years old, reveals the fact that 27 feet has been allowed between vertical walls, or practically 2 feet 6 inches more than at the old tunnels. This may perhaps be accepted as sufficient; but in new double line work a foot more, or 28 feet, appears advisable. Having thus 8 feet total clearance, the question arises as to how it is to be distributed. Should it be in three equal spaces of 2 feet 8 inches, or in a central space of 4 feet and two side spaces of 2 feet each, or should some intermediate course be adopted? It certainly appears that the central space should be the larger, because two persons may be leaning out, one from each of two passing trains, and if their heads met there would be two fatalities; whereas at the side only one leans out. Further, the blow in the centre is far worse, the relative speed of approach being so much greater than at the side, though even this has been known to be fatal.

As a fair compromise, the writer would suggest 2 feet 3 inches at the sides and 3 feet 6 inches at the centre as reasonable.

But how will this agree with the old 6 feet space? A simple calculation will show that this must be enlarged to nearly 8 feet on the Irish, and more than 8 feet on the Standard gauge—a most serious advance on present practice, and calculated to upset platforms and other station arrangements to a considerable degree. If we take the other view, and content ourselves with 2 feet 8 inches in the centre, the present 6 feet must be enlarged to nearly 7 feet on the Irish and 7 feet 6 inches on the standard gauge.

But it may be asked, What are other countries doing? The reply is that some of the best American railways—the Pennsylvania for ex-
ample—have had a 7 feet central space instead of a 6 feet for at least a quarter of a century past, while the prominent and emphatic warnings against leaning out of windows, posted in every carriage on some of the best European railways, show that the authorities there are alive to the insufficiency of the clearance provided.

The conclusion then is this, that the total width for a double line of standard or Irish gauge should be increased to at least 28 feet, and that the old 6 feet prescribed by the Board of Trade rules is utterly out of date, and must be increased by at least a foot, and preferably 2 feet, and that our railway authorities should face this question at once, and without delay, before the construction of costly and permanent work renders it more difficult than at present.

In conclusion, the objects aimed at in this paper may be summed up as follows:

1st. To bring to light the true history of the lamentable break of gauge at Albury, and to exonerate Victoria from the blame attaching thereto.

2nd. To urge the immediate reconsideration of the widths and clearances on our double lines of railway, in view of the greatly increased width of modern rolling stock.

3rd. To urge the immediate alteration of the British Board of Trade rule requiring a width of only 6 feet between two lines of railway, as out of date and dangerous.

Note.—I have to thank Mr. H. C. Mais, M. Inst. C.E., for assistance in determining some of the early dates of Victorian Railways.

**Width of Tunnels.**

Elphinstone and Buxton Hill, Bendigo Line, Victoria, double, 25-ft. extreme width.

Geelong, Colac Line, Victoria, single, 15-ft. extreme width.

European and American Railway Tunnels standard gauge vary from 23 to 30-ft., most being over 26-ft. for double and from 14 to 16-ft. for single lines.

—Taken from Drinker on “Tunnelling.”

**Width of Rolling Stock.**

**Passenger.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Sleeping Cars</td>
<td>8-ft. 9-in. to 10-ft.</td>
</tr>
<tr>
<td>St. Gotthard First-class</td>
<td>8-ft. 4-in., doors shut.</td>
</tr>
<tr>
<td>Do.</td>
<td>12-ft. 6-in., doors open.</td>
</tr>
<tr>
<td>Victorian</td>
<td>8-ft. 6-in., doors shut.</td>
</tr>
<tr>
<td>Do.</td>
<td>12-ft. 8-in., doors open.</td>
</tr>
<tr>
<td>Recent, with end doors</td>
<td>9-ft. 8-in.</td>
</tr>
<tr>
<td>Victorian</td>
<td>8-ft. to 9-ft.</td>
</tr>
</tbody>
</table>

**Goods.**

| Victorian                   | 8-ft. to 9-ft. |
DISCUSSION—RAILWAY GAUGE.

DISCUSSION.

Professor Kernot said that one object of his paper was to induce others who had information on the subject to disclose it. As to the dates given in the paper he had satisfied himself as to their accuracy.

Mr. J. A. Smith said that the paper could hardly be discussed until members had had an opportunity of perusing it when printed. He thought he would be able to verify the fact that there had been two openings of the Port Melbourne line, one with a temporarily devised locomotive, another later (the line being closed in the interval) when the delayed locomotives came to hand.

As to the origin of the arbitrary dimension of the 4ft. 8½in. gauge, he had been informed in youth by those who had been personally connected with the earlier stages of English railway development that the gauge was at first that of the tram lines antedating the locomotive, i.e., 4ft. 6in., an even dimension, and that the difference of 2½ inches arose from the turning of the iron, or "plate" coated wood rails from "flat" to an "edge" position, the centres remaining at a constant distance apart. A point which the author did not embody in his remarks on clearances arose from the effect of curves. When engaged upon the design of the first bogie passenger stock built in Victoria he had found that on curves of even moderately short radius, and with long and wide cars, the clearance due to the "six feet" was seriously reduced when cars met on the curve, i.e., at the position of minimum clearance when the corner of one car was opposed to the centre of another car on a passing train. It was a question of the chord of the distance between bogie centres and the tangent of the length of the car overhanging those centres.

The paper dealt with the clearance of doors, and it appeared to be rather small—some few inches only—especially in tunnels. This might, in the latter case, be further reduced if the cars were not level upon the springs, if the rails were super-elevated, or if there was a side surge due to running. There was always a chance of a platelayer being caught in a tunnel.

The President: That means that you would say with me that tunnels should not be less than 30 feet wide.

Mr. Smith (continuing) said that he would always place security to life first in matters of design.

Mr. Thomas Hill asked if the comparison of 3 per cent. difference of cost between the narrow and standard gauges referred to flat or hilly country.

The President said that the figures were based upon actual examples. It would be found that the difference of the volume due to difference of gauge was but a small proportion of the whole volume requiring to be removed in cuttings.

The continuation of the discussion was postponed until the next general meeting.
The usual monthly meeting was held at the rooms on Wednesday, September 5th, at 8 p.m., the President (Professor W. C. Kernot) in the chair.

The minutes of the August meeting were confirmed.

The discussion on Professor W. C. Kernot's paper was continued but not concluded. Professor Kernot, Mr. H. M. Mais and Mr. J. A. Smith exhibited plans, photographs and data connected with early Victorian and other railways.

Mr. H. J. I. Bilton read his paper on "Notes and Experiments upon Water Meters."

Mr. J. A. Smith proposed a hearty vote of thanks to Mr. Bilton for his paper, which evidently embodied the results of an immense amount of work, which would be of great assistance to most of them for reference.

Mr. T. Hill seconded. They were indebted to Mr. Bilton for an excellent paper.

The vote was carried by acclamation.

After the discussion had been postponed the meeting terminated.

DISCUSSION.

The discussion on Professor W. C. Kernot's paper on "Railway Gauges" was resumed.

The President said there were one or two slight additions he would like to make to his paper. It was with great satisfaction he saw his old friend, Mr. Mais, present. He was a veteran Australian railway engineer, and held the position of Engineer-in-Chief in New South Wales more than half a century ago.
Mr. Mais, in a private letter, very fully and kindly discussing these matters, questioned two dates—the opening of the St. Kilda railway and of the Geelong and Melbourne railway. With reference to the St. Kilda railway, he had a difficulty in discovering the date of the opening within a few days, but he saw an advertisement with reference to goods traffic, and took that date as the date of the opening. It was possible the opening might have been a day or two earlier. In connection with the Geelong and Melbourne railway, he had verified the date from the “Argus” and “Geelong Advertiser,” of 25th and 26th June, 1857. There were extremely long and full accounts in each paper, in which they recorded what the people did and what they said, and what they ate and drank. Such an account as that, taken from newspapers at each end of the line, could hardly be gainsaid. A date about a week earlier was mentioned in the report of the Railway Department, but this could hardly be correct.

He desired to add some particulars from the inscription on the old locomotive No. 1, at the Sydney Technological Museum, that had arrived too late for insertion in the paper. They were as follows:

“This engine, built by R. Stephenson and Son, of Newcastle-on-Tyne, arrived in N.S.W. by the ship John Fielding, on Jan. 13, 1855. It commenced running on May 15, 1855, with the contractors’ ballast train. It was afterwards used for passenger traffic up to May 15th, 1877, when it had run 383,636 miles.

“*Its weight roadworthy, without tender, is 26 tons.*

“*Its cost, £3083 17s. 6d.*

“*The rails it ran on were Barlow rails, 72 lbs. per yard.*

This is the engine used at the opening of the Sydney and Parramatta railway, on 26th September, 1855, and it must have been ordered from England not later than the middle of 1854, or more than a year before the gauge it was adapted to run upon became legally permissible in New South Wales.

Mr. H. C. Mais said he had only a few remarks to make on the paper not with a view of finding fault with it, but endeavouring to add, if possible, and make more clear the question of gauge. In Sir Andrew Clarke’s report of 1856, there was an appendix by Mr. Alfred Woolley, dated 12th June, 1855, when the matter was fresh in the minds of everybody. If they did not mind his reading it, it might throw light upon the subject. It was merely a history, as far as it went, of the cause of the New South Wales gauge being altered from 4 ft. 8½ in. to 5 ft. 3 in., and back again. It was, in effect, what the Professor had said, but went a little more clearly into the matter as to how the changes came about. He noticed the Professor said in his paper there were all kinds of theories as to how the gauge came about. That statement appeared to be fairly true. About the year 1829 the average gauge throughout the tramways of Great Britain was 5 ft. out and out, and by subtracting the width of the rails, they

* Appendixed to discussion.
got the 4ft. 8½in. That was put forward by some people as one of the reasons why the gauge became 4ft. 8½in.

One item of great interest to those who had been "through the mill," as he had been, and had seen the broad gauge commenced in 1835—(he had not seen it removed, but he knew it had been done)—was the method in which the change was made. It occupied 31 hours, 5000 men being employed on the 200 miles, in gangs of 50, and a foreman to every 2 to 2½ miles. He would give a few figures connected with it. The last 200 miles of broad gauge in England was removed in May, 1892, the last broad gauge train leaving Paddington at 11.45 a.m. on Friday, the 20th May, and the first up train on the narrow gauge leaving Plymouth at 8.35 a.m. on Monday, the 23rd of May. The whole mileage of 7ft. gauge at this date was not large. Out of 2500 miles of railways in England in 1889, the mileage of broad gauge was only 426 miles. Out of 100 odd trains which ran from Paddington daily, only ten were broad gauge—seven passenger and three goods.

He would like to make a few remarks upon the comparative cost of the 3ft. 6in. and the 5ft. 3in. gauges, based upon actual surveys. It was proposed to carry a railway from Adelaide to the River Murray by running up the precipitous gorge of the River Torrens. The length of the 3ft. 6in. gauge line surveyed, was 3 miles 60 chains, and the broad or 5ft. 3in. gauge line, 3 miles 73.36 chains. The results worked out from the surveys, and with quantities based on contracts in progress, were as under:

For 3ft. 6in. gauge... £35,216 per mile, exclusive of rolling stock.
For 5ft. 3in. gauge... £63,465 " " " 
Or a difference of... £28,249 " " "

The cost in level country from actual contracts was as under:

For 3ft. 6in. gauge... £29,057 per mile, exclusive of rolling stock.
For 5ft. 3in. gauge... £33,687 " " "
Or a difference of... £4,630 " " "

The above figures were interesting and reliable, and could be seen in detail in pp. No. 22, of 1875, S. Australia, page xxvii.

The Port Melbourne railway was really opened twice, that is, it was temporarily opened on the 13th September, 1854, with a locally-made engine, and the first train left Flinders-street at 12.20 a.m., and proceeded to Sandridge at a speed of about 15 miles per hour ("Argus," 13/9/54), which was considered good work at the time. During the month the engine was frequently laid up for repairs, but when at work could keep time satisfactorily. Eventually the traffic was absolutely suspended, and an advertisement appeared in the daily papers, published 2nd December, 1854: "The locomotive having broke down, and those from England not yet landed, the trains will cease running until further notice." The traffic was resumed on 2nd January, 1855, with the imported engines.

A question of importance, raised by Professor Kernot in his paper, was the "loading gauge," or minimum structure diagram. The speaker brought some diagrams, which he would leave with the Insti-
DISCUSSION—RAILWAY GAUGE.

...tute, showing 'minimum structural dimensions' on the Victorian and South Australian 5ft. 3in. gauge railways plotted on the same sheet. An examination would show that in several of the structures the masonry and girders would not allow any alteration in the position of the rails, especially in the two tunnels on the main line to Bendigo. The minimum structure diagram adopted for the South Australian railways gave a little more clearance than was allowed in Victoria. [Diagram of South Australian railways minimum structure, also that of the 4ft 8½in. gauge of the Great Western railway, England, were laid on the table.]

The maximum width of locomotives in general use on English railways was 9ft. 6in., and the height to top of chimney is limited to 13ft. 6in. above the rails.

On the 4ft. 8½in. gauge the most recently (1905) constructed cars are 68ft. long, by 9ft. 6in. wide, by 8ft. 6½in. over all.

He was pleased to see the result of the trouble which Professor Kernot had taken in preparing his paper, and referring to the dates of the opening of the Sydney railway, he (the speaker) remembered the engine (No. 1) used on that occasion, being on the train. The rails laid were Barlow rails with riveted saddle joints, spiked to half-round cross sleepers, and after a hot day the noise of the rails contracting on the sleepers was very pronounced. Work was somewhat primitive in those days (1855) but matters gradually improved.

Mr. Hill asked if Mr. Mais would supply particulars of the difference in cost between the broad and narrow gauge lines.

Mr. Mais read the tabulated particulars.

Mr. J. A. Smith asked if the lines would have the same carrying capacity.

Mr. Mais said they would not. On the lines referred to, the curves were sharp, 5 chains for 3ft. 6in. gauge, and 10 chains radius for 5ft. 3in. gauge. The 3ft. 6in. waggons were one foot shorter in length and breadth than those on 5ft. 3in. gauge in 1875, and would not have the same carrying capacity.

The President said they might congratulate themselves on Mr. Mais having attended and given them such extremely good information. Those who possessed first-hand information were rapidly passing away. If they did not secure the information quickly, it would be too late.

Mr. Jas. Alex. Smith said that there were American engines in which the width across the buffer beams exceeded the figure given by Mr. Mais for English practice.

Professor Kernot had written that “had railway making started with a gauge anywhere between 5ft. and 6ft. they would never have heard of the present peculiar standard.” He (the speaker) could not fully concur with that, since 5ft. and wider gauges had been in use at the inception of railway construction.

Many railway systems sprang into existence simultaneously in Great Britain. They were separate—connection was apparently not contemplated—and in most cases the gauges differed. The contemporary records reveal that gauges of 3ft., 3ft. 6in., 4ft., 4ft.
6in., 4ft. 8½in. ("standard"), 4ft. 8¾in., 4ft. 9in., and Brunel's masterpiece of 7ft., were in use in England, whilst the Scottish gauges were 5ft. and 5ft 6in.

The author had also referred to the adoption, after consideration and selection, of the 5ft. 3in., or "Irish" gauge, by the Irish Commissioners. Most literature conveyed the impression that there had been one gauge only, but if the original reports were referred to, it would be found that the Commissioners deliberately introduced two gauges—i.e., the 5ft. 3in., and, upon the Ulster system, the inexplicable gauge of 6ft. 2¼in.

Apparently the concentration of the manufacture of locomotives and rolling stock in the hands of a few firms soon became a potent factor in eliminating these unreasonable discrepancies.

As to the academic point referring to the genesis of the 4ft. 8¼in. gauge, reference to records of the construction of the roads of two hundred years ago, showed that before the days of Macadam, timber or stone ways were laid to take the wear of wheeled traffic; that gauge was handed on to the mine tramways and so to the railways. The weight of evidence pointed to the initial dimension of 4ft. 6in., with an accidental variation to 4ft. 8½in.

The question of loading gauges, which the author had considered, was a most important one. Considering the persistency with which the early gauges had been adhered to, it might be assumed that there was good reason for that course, and that they had been fixed with a full knowledge, not only of the conditions existing, but also of those which might reasonably be expected to exist in the future. It was not so. Those gauges and clearances were absolutely chance dimensions.

Taking first the overhead minimum limit, it had been fixed by two purely arbitrary conditions, the then height of the locomotive chimney and the nature of the first class stock.

Reference to the plan [exhibited], published in 1830, and delineating one of the standard locomotives of that time, showed that the chimney was designed as a Corinthian column, fluting, entablature, and acanthus leaves complete. Fortunately for their posterity, the engineers of that time considered it essential to construct the chimneys of great relative height. This was one—and the chief—limiting factor.

The first passengers were carried in open trucks, but provision was made for the more wealthy by the construction of flat trucks, on to which the ordinary wheeled road carriages of the time were run and lashed, the owner taking his place inside and his servants theirs on the box outside. Many of the characteristics of the horse vehicles were adopted in the original first-class rolling stock—some are even yet discernible. That of interest in connection with head space, was the adoption of the driver's or guard's box, or perch, upon the roof of the carriages, as the contemporary plans exhibited would show. The clearance necessary for the men's heads thus formed the second limiting factor.

The side clearances were equally fortuitous, depending largely
upon the width of flat truck necessary to accommodate the vehicles. The earlier British standing works were monumental in their solidity, hence the limitations were perpetuated.

The railway pioneers in Australia had had an absolutely free field, and might have dealt with the question upon broad principles, but they elected, or had been compelled to servilely copy the fashion of the times, and succeeding administrators had not cared to deviate widely from it, at the cost of increased expenditure. Thus conditions that were based upon quite trivial reasons might become ultimately dominant.

Looking forward, it was clear that the hauls from the interior to the coast of Australia would be as much as 1000 miles. Unless those distant regions were to be isolated, or confined to interchange with adjoining districts, the cost of haulage upon many products must be greatly reduced.

Whatever the future held in the matter of traction, it was a fundamental axiom in cheap haulage that the load should be great. This could only be accomplished by increasing the length or cross section of the trains. In America they seemed to have reached the length limit; trains of 4000 feet worked the prairie runs. Here, fifteen years ago, he had experimented on light trains of 2000 feet, and it was quite the extreme on the undulating lines here.

Heavier loads could only be dealt with, after the length limit had been reached, by stock of increased cross section, and that meant increased clearances. They were cut very fine now, as the author had pointed out in his paper. It was to be hoped that full consideration would be given to the fact that enlargement would become essential, and that it should be given effect to in projected works.

Upon the prescience and power to provide broadly for matters that might be yet half a century distant, largely rested economic haulage and the development of Australia.

Mr. Mais asked if it had ever occurred to Mr. Smith that the whole system might be changed to 4ft. 8½in.? It would be as costly again to alter the New South Wales gauge. Then they would have much more clearance.

Mr. Smith said he had taken the clearance gauges of the other States into consideration.

Mr. Mais did not think New South Wales had any wagons 10ft. wide.

Mr. Smith said the new bogey stock was long as well as wide, and the question of curves had to be considered, and the crossing curves in station yards.

Mr. W. R. Rennick said there could be no doubt about what Professor Kernot said, that the clearance on their lines was much too small. The professor did not give them credit for having wide enough stock. He thought the majority of their cars were 9ft. 8in., both suburban and country. On double lines of way they had about two feet between passing carriages on the straight. Their doors were about 1ft. 8in. wide, and when two trains were passing one another, there was only three or four inches between one train and the open
door of the other. It showed the risk people ran when they put their heads out. But it was remarkable how very few accidents there had been. There was no doubt the clearance diagram which had been selected in the early days was much too small, but they had to look at the commercial aspect of the question. If they spent the £100,000 in altering the clearances, would it bring any more revenue to the Railway Department? Supposing some Government were liberal enough to give them the money to spend as they thought best, what would they do with it?

One mistake made by our predecessors—and a serious one—was that of having too much slack between the trucks. To carry their loads economically, they must carry a big load in each train. To do that they must have big engines and a long train. The length of the trains in this State was practically limited by the amount of slack between the trucks. It amounted to about eight inches per truck. With a train of 40 or 60 trucks, it would amount to 27 or 40 feet, which is tremendous. On account of the natural configuration of the country, they have a lot of sags and humps on their lines, and when a long train passes over a sag, the trucks come together, and then, when passing out of the sag, the slack is taken out with a very severe jerk, which sometimes causes breaks-away. This was a very serious matter in railway running, not only on account of the risk of accident, but on account of actual damage done to the trucks. It was impossible to assess the actual money value of these jerks, but it must be a very considerable item. At present the Department was face to face with this very difficulty. He thought they had nearly reached the limit of the length of trains, because with trains drawn by two engines, drivers had to "nurse" them carefully over many parts of the lines. The cost of regrading was very serious. They did a good deal of it a few years ago advisedly, but the cost of regrading to suit the very much longer trains which could be drawn by the heavier engines we could build, would be prohibitive. The only alternative was to alter the couplings.

What he was arguing was that although their clearance was too small in the first instance, they had not yet exhausted the possibilities of it. When they had the heaviest engines they could pass through the present clearances, and their rolling stock close coupled, and were faced with the necessity of carrying further loads by means of wider trucks, and a higher load diagram, or whenever the time arrived when they had done the best with what they had got, and were compelled to improve, that would be the time to pull down the existing structures and rebuild them. But at present the most important matter was to strengthen the bridges to carry heavier locomotives. They were doing that on the North-Eastern lines. On the suburban system they could not increase their loads because the bridges were not strong enough. If they had heavier locomotives they could run the railways more economically. If they made any alteration of their couplings it would probably be in the direction of centre couplings. It would be buffer and coupling combined. They might be able to adopt something better than the Americans had.
The future uniformity in gauge, and the consequent interchange of stock, would necessitate that all States used the same coupling. That appeared to him to be more urgent than the increase in the width of the clearance. All new structures were being built to wider clearances than at first, but whether they were building them sufficiently wide was a moot question. The principal officers of the Commonwealth railways and New Zealand met every year and discussed such questions. They had decided a few of them, but they were so complicated that they could not all be fixed at one or two conferences. As far as the radical alteration in couplings was concerned, he thought they would have to wait until the railways were federated, and there was only one management of the whole system throughout Australia.

Mr. J. A. Smith said the view the author had taken was that existing structures should be increased. He (the speaker) took the view that structures to be constructed should be on a much more liberal scale, then no question of present expenditure arose.

The President said he was extremely gratified with the result of his paper. Mr. Mais had brought out some interesting facts that he was glad to hear. Mr. Smith had done the same. He did not think he had anything to answer. Mr. Smith's information was certainly very interesting, and he hoped it would be fully recorded. Mr. Rennick was a little on the side of defending the present action of the department. That was quite right. He was glad he had done so. He did not think the alterations should be made at once. At the same time he thought the figure stated was a good deal beyond what ought to be required. He thought it should be done for much less than £100,000. But he wanted to be on the safe side. He did not think it should be done this year or next year, but it should be insisted that it must be done sooner or later. If they got the impression that certain things were not satisfactory and should not be repeated, that impression would satisfy him for some time to come. With reference to the length of trains, Mr. Rennick had not said anything about the northern plains, where grades of 1 in 1000 were about the average, and they could have trains as long as they could handle.

Report of Sir Andrew Clarke, R.E., Surveyor-General of Victoria, 1856, p. 238.

Communicated by Mr. H. C. Mais.

"APPENDIX XLVIII.

[1846. 4 ft. 8½ in. recommended as the gauge for N.S. Wales railways.]—It appears from documents laid before the Legislative Council of this [Victoria] and the neighbouring Colonies that in 1846 Mr. Gladstone recommended that in the event of railways being constructed in New South Wales one uniform gauge of 4 ft. 8½ in. should be adopted.
[1848. Lord Grey applied to English Railway Commissioners for advice.]—In 1848 some railway projects were brought forward in that Colony, and, being referred to the Home Government, Lord Grey applied to the Commissioners of Railways to state what gauge would in their opinion be the most advantageous for Australia.

[Commissioners recommended the adoption of the 4ft. 8½in. gauge for Australia (Despatch No. 106, June 30th, 1848).]—The Commissioners recommended the adoption of the 4ft. 8½in. gauge, and stated the grounds upon which they based their recommendations. Lord Grey, in consequence of this opinion, pressed the Australian Colonies to adopt that gauge.

[1850. Sydney Railway Company recommended the adoption of a gauge of 5ft. 3in., giving reasons.]—In 1850 the Sydney Railway Company strongly recommended to the Governor-General, Sir Chas. Fitzroy, the expediency of adopting the 5ft. 3in. gauge, arguing that as that railway would be the first line constructed in Australia a timely notification to the other Colonies would prevent any inconvenience which might arise otherwise from such alteration.

[Application from Company referred to Secretary of State, and submitted to Commissioners of Railways—Commissioners do not press their previous recommendation.]—This application from the Sydney Company was referred to Lord Grey, and by him submitted to the Commissioners of Railways, who, upon a reconsideration of the subject, and more particularly the statement of the Company's Engineer (F. W. Shields), "that the Colony was deficient in materials and workmen suited to the manufacture of rolling stock," stated that they did not attach much importance to their previous recommendations of the 4ft. 8½in. gauge, as to induce them to press its adoption upon the Colonists in opposition to what appeared to be their wishes.

[1851. Her Majesty's Government would not object to 5ft. 3in. gauge (Despatch No. 13, February 14th, 1851).]—Lord Grey subsequently informed the Governor-General in a despatch dated February, 1851, that Her Majesty's Government would not object to the gauge of 5ft. 3in.

[1852. Gauge of 5ft. 3in. made the legal gauge of New South Wales railways.]—An Act of the Legislature of New South Wales (16 Vict., No. V., 1852) was accordingly passed in 1852, which provided that the gauge of all railways in that Colony should be 5ft. 3in.

[Royal assent to Act, and Governors of Victoria and South Australia advised.]—This last Act subsequently received the Royal assent, and was transmitted to the Governors of Victoria and South Australia for the guidance of the Legislatures of those Colonies.

[1853. Under advice of their Engineer, the Railway Company applied for permission to revert to the original gauge of 4ft. 8½in.]—In 1853 the Sydney Railway Company, having changed their Engineer
(H. C. Mais to W. Wallace), altered their views on the subject of gauge. They subsequently again applied to the Governor-General, and urged that the gauge of 4ft. 8½in. was preferable to the gauge of 5ft. 3in., previously sanctioned.

[Act fixing gauge at 5ft. 3in. repealed—Act passed making gauge of 4ft. 8½in. imperative in New South Wales.]—Sir Chas. Fitzroy having placed this renewed application before the Legislature, the Act fixing the gauge at 5ft. 3in. was repealed, and another Act making the gauge of 4ft. 8½in. imperative throughout that Colony was passed.

[Mr. La Trobe forwarded a remonstrance to Colonial Office—Sir Geo. Grey advised Her Majesty to withhold her assent to the Act—Her Majesty's assent given to Act fixing gauge of New South Wales railways at 4ft. 8½in.]

—As this was at variance with the proceedings of those Companies which had been established in this [Victoria] Colony, and which had already ordered rolling stock from Europe adapted to the 5ft. 3in. gauge on the faith of what was understood to be a definite arrangement among the several Colonies on the subject, Mr. La Trobe forwarded a strong remonstrance to the Colonial Office against this vacillating course of legislation, in consequence of which Sir Geo. Grey in the first instance appears to have recommended Her Majesty to withhold her assent to this Act last mentioned, and instructed the Governor-General to move the Legislature to reconsider the question. Whether he adopted this course or not does not appear; if he did he was not successful in inducing the Legislature to revert to the original gauge of 5ft. 3in., for Her Majesty's assent was shortly after given to the Act recommending the 4ft. 8½in. gauge, and that has since been carried out in New South Wales.

[1853. Select Committee of Legislative Council of Victoria appointed—Report conclusively in favor of a gauge of 5ft. 3in. for Victorian railways.]

—Consequent upon these extraordinary proceedings in the Legislature of New South Wales, a Select Committee of the Legislative Council [Victoria] was appointed in September (29th) 1853, to take evidence and report upon the best gauge for railways for this Colony. Their decision (Appendix LIV., A. Clarke's Report, 1856) being conclusively in favor of the 5ft. 3in. gauge, that has since been recognised and acted upon as the standard gauge of Victoria.

(Signed) RICHARD WOOLLEY, Secretary.

12th July, 1853.”

[Sydney Railway Company's Act, 13 Vict., 1849: gauge 4ft. 8½in.]

—The first Railway Act fixing the gauge in the Australian Colonies was that of Act 13 Vict., 1849, of New South Wales, incorporating
the Sydney Railway Company and fixing the gauge at 4ft. 8\(\frac{1}{2}\)in.
Royal assent obtained 10th October, 1849.

[Incorporation of three Railway Companies in Victoria by Act 16 Vict., 20th January, 1853: gauge 5ft. 3in.]—The first Railway Act in Victoria was for the incorporation of the Melbourne and Hobson's Bay Railway Company, the Melbourne and Geelong Railway Company, and the Melbourne and Mt. Alexander Railway Company (16 Vict., 20th January, 1853; gauge 5ft. 3in.)

[Act No. 1 of 1851, South Australia: gauge 5ft. 3in.]—The first Railway Act in South Australia was for the construction of a railway between Adelaide and Port Adelaide by private company (Act No. 1, 1851: gauge 5ft. 3in.)—Lapsed.

[Act 16 Vict., No. 18, 1853: gauge 5ft. 3in.]—Another Act was passed in 1853 for the same purpose, but line to be built by Government (Act No. 18, 1853).

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**INFORMATION SUPPLIED BY MR. MAIS.**

**COST OF 3FT. 6IN. AND 5FT. 3IN. RAILWAYS COMPARED ON LEVEL AND THROUGH MOUNTAINOUS COUNTRY.**

On a level line from actual survey, and from rates based on contract for construction of the Port Pirie and Gladstone 3ft. 6in. line, the cost is as under per mile:

<table>
<thead>
<tr>
<th></th>
<th>3ft. 6in.</th>
<th>5ft. 3in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land and Clearing</td>
<td>£100</td>
<td>£100</td>
</tr>
<tr>
<td>Fencing</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Earth Works</td>
<td>300</td>
<td>360</td>
</tr>
<tr>
<td>Bridges and Culverts</td>
<td>211</td>
<td>248</td>
</tr>
<tr>
<td>P. Crossings and Private Crossings</td>
<td>86</td>
<td>97</td>
</tr>
<tr>
<td>Permanent Way, 90 Steel Rails</td>
<td>2,060</td>
<td>2,526</td>
</tr>
<tr>
<td>Engineering</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>3,057</td>
<td>3,637</td>
</tr>
<tr>
<td>Rolling Stock</td>
<td>402</td>
<td>490</td>
</tr>
<tr>
<td>Stations, Goods Sheds, etc.</td>
<td>200</td>
<td>228</td>
</tr>
<tr>
<td></td>
<td><strong>£3,659</strong></td>
<td><strong>4,355</strong></td>
</tr>
<tr>
<td>Difference per mile</td>
<td><strong>£696</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Received after conclusion of the discussion.—[PUBLICATION COMMITTEE.]
DISCUSSION—RAILWAY GAUGE.

COMPARISON IN MOUNTAINOUS COUNTRY PER MILE.

<table>
<thead>
<tr>
<th></th>
<th>3ft. 6in. gauge.</th>
<th>5ft. 3in. gauge.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length Surveyed</td>
<td>3 m. 60 c.</td>
<td>3 m. 78 c. 361.</td>
</tr>
<tr>
<td>Grubbing and Clearing</td>
<td>£58 10 0</td>
<td>£56 5 0</td>
</tr>
<tr>
<td>Fencing</td>
<td>940 0 0</td>
<td>900 0 0</td>
</tr>
<tr>
<td>Excavation</td>
<td>37,916 0 0</td>
<td>47,463 0 0</td>
</tr>
<tr>
<td>Tunnels</td>
<td>40,718 8 0</td>
<td>95,741 6 0</td>
</tr>
<tr>
<td>Retaining Walls</td>
<td>17,488 4 0</td>
<td>26,915 2 0</td>
</tr>
<tr>
<td>Bridges</td>
<td>13,435 6 6</td>
<td>26,836 1 6</td>
</tr>
<tr>
<td>Culverts</td>
<td>2,755 10 0</td>
<td>3,416 0 0</td>
</tr>
<tr>
<td>Permanent Way</td>
<td>9,069 2 0</td>
<td>9,750 0 0</td>
</tr>
<tr>
<td>Engineering and Surveying</td>
<td>3,058 10 6</td>
<td>5,277 0 4</td>
</tr>
<tr>
<td>Contingencies</td>
<td>12,539 19 1</td>
<td>21,635 15 6</td>
</tr>
<tr>
<td></td>
<td><strong>£137,939 10 1</strong></td>
<td><strong>£237,990 10 4</strong></td>
</tr>
<tr>
<td>Average cost per mile</td>
<td><strong>£35,216 0 0</strong></td>
<td><strong>£63,465 0 0</strong></td>
</tr>
<tr>
<td>Proportionate Cost of Stations</td>
<td>800 0 0</td>
<td>800 0 0</td>
</tr>
<tr>
<td></td>
<td><strong>£36,016 0 0</strong></td>
<td><strong>£64,265 0 0</strong></td>
</tr>
</tbody>
</table>

Exclusive of land and rolling stock.

P.P., No. 22, S.A., 1875.

DOUBLE OPENING OF PORT MELBOURNE OR SANDRIDGE RAILWAY.

It was temporarily opened with a locomotive built by Robertson Martin, and Smith, of Melbourne. The first train started from Flinders Street at 12.20 p.m., and proceeded to Sandridge at the rate of fifteen miles an hour, on 13th September, 1854.

1805.—The new boat train carriages on the South-Eastern and Chatham Railway, England (oft. 8½in. gauge), are in length of body, 51ft.; width over mouldings, 8ft. 0½in.

1805.—Composite dining cars, West Coast Joint Stock (4ft. 8½in. gauge) are in length of body, 60ft.; width of body outside, 8ft. 1in.; height of body at sides (inside), 6ft. 7in.; total height to top of roof from level of rails, 12ft. 7¼in.
they required it or not. The cost of repairs might interest members, and he had prepared statistics running back a number of years, showing the average cost of repairs. The \( \frac{3}{4} \)-inch, \( \frac{5}{8} \)-inch, 1-inch and \( \frac{11}{4} \)-inch meters cost on an average 22s. each for repairs. They sometimes put in spare meters while testing meters; \( \frac{3}{4} \)-inch and 2-inch meters cost about £1 15s. for repairs; 3-inch and 4-inch, £2 10s.; 5-inch, £3; and 6-inch, £4. If these meters were repaired once every five years the cost of repairing the smaller meters would be about 4s. 5d. per annum, and the largest meters would not cost more than £1 per annum. That was not excessive. If the meters were tested and repaired systematically, he believed they could be done for much less than 4s. 5d. per annum. He thought the mistake was made with inferential meters in just putting them in and letting them go. He knew one case of a meter which had been in use for 17 years, and was running 40 per cent. slow. The turbine was worn out, and the water was passing through it without being registered. He also had come across a meter which was registering 40 per cent. fast. It was taken out and taken to pieces, and it was found that one of the regulating fans had corroded through and fallen off. When it was taken to the shop and tested it only showed 18 per cent. fast. He accounted for that by the incrustation being shaken off in the removal of the meter.

In the case of positive meters, when they broke down, they cut off the supply altogether, and thus compelled attention. But the inferential meter would go on for ever, and the consequence was it was simply left in. He thought they should be inspected regularly. He had not seen many cases of the fans corroding. He supposed the reason why they were allowed to go on without inspection was because there was always a minimum water rate, which was seldom exceeded, so that in many cases there was really no necessity for a meter. A very large proportion of the meters in Melbourne were unnecessary. The larger meters were not so much affected by incrustation as smaller ones.

RAILWAY GAUGES.

The President said the only other business was the further discussion of his paper on Railway Gauges. It was thought by the Council that it might as well be kept open in case any further information should crop up. He had received a few letters from friends to whom he had sent copies of the paper. The Hon. Jas. Balfour said he "was present as an invited guest at the opening of the Hobson's Bay railway. To get the loaded train to start some had to get out and shove." That was not a very dignified way of starting, but even Stephenson's engines in England did not behave very well at first. Mr. Mais had given some very interesting information, which had been printed and circulated.

The matter was perfectly clear that the three colonies started with the intention of having the English gauge. New South Wales
then went in for the Irish gauge of 5 ft. 3 in. The others followed in her lead. Then New South Wales suddenly reverted to the 4 ft. 8 1/2 in. gauge. There was no excuse for that, especially as the reversal of policy did not take place until months after the first Victorian railway was running. That was recognised by Mr. Deane in his lecture. Mr. Wallace was the great opponent of the 5 ft. 3 in. gauge. He left no stone unturned to get New South Wales to reverse her policy. In 1854 a bill was passed by the New South Wales Legislature, making the English gauge legal. On exactly what date the bill was passed he did not know, or whether it was before or after the opening of the Hobson’s Bay railway. But, before that bill could become an Act it was necessary that the Royal assent should be given, and in due course the bill was forwarded to the Home Government. On the 8th of November, 1854, Earl Grey wrote to Governor Fitzroy, and pointed out that that was breaking faith with the other colonies. Governor Fitzroy tried to induce the New South Wales Legislature to reverse the policy again. But the objection was that the rolling stock was ordered. Then the Home Government gave way. He did not think they should have done so; and eleven months after trains first began to run on the 5 ft. 3 in. gauge in this country, the 4 ft. 8 1/2 in. gauge became the gauge of New South Wales.

With reference to the other part of his paper—the loading gauges and clearance—they had had an electric tramway opened during the last few weeks to Flemington and Essendon. There they had the central pole system a good part of the way. He did not like those central poles. The clearance was remarkably small. He had tried putting his hand out of the cars. He would be sorry to put his head out. If any one put their head out he believed the result would be fatal. The whole system of putting those poles in the centre of streets was one he was much opposed to. Some of the streets were done with the span wire system. That was not at all a nice system aesthetically regarded. But it was much safer than the central pole system. His own experience in motoring, cycling, etc., led him to look upon those central poles with very great aversion. They had competitive designs for the Queen’s Bridge, and another which was not executed in Williams'-road, and in both cases the judges would not have girders rising in the middle of the roadway. But, in spite of the policy having been not to have central girders of bridges, they had any amount of things placed in the middle of streets now. There was one fatal accident in Launceston some time ago, when a cyclist ran his head against a pole, and was killed instantly. In the case of runaway vehicles the central pole was very dangerous.

He did not know that there was any more to be said on the general question of the clearance on railways. Mr. Rennick had had something to say upon it. His position was a very natural one. It was that the defect was admitted, but the difficulty was to get money to deal with even more important defects than that. But he thought that sooner or later the question of giving greater clear-
might be considered. Some relief would be obtained by getting rid of the doors opening outward. The question was a serious one. When he travelled in Northern Europe some years ago he noticed that it was regarded as serious there, because over every carriage window in the train was a large and most urgently-worded notice begging people on no account to put their heads out of the window. To alter the clearance throughout the whole of the railways meant a large sum of money, but it would pay in the long run.

Mr. A. F. Smith drew attention to the estimates given by Mr. Mais at a previous meeting for lines on the Torrens Gorge, and to the great difference in the cost of broad and narrow gauge lines there.

The President said there was an enormous difference between the two estimates, but it was due to the difference in curvature, five chains and ten chains respectively. He had looked up some of the plans. The Torrens Gorge was a peculiar and unique place. It was a place where any railway would be enormously expensive, and alterations of the curves from five chains to ten chains would greatly increase the expense. His recollection of the investigations which took place here 35 years ago—in which he took part as a junior in making the drawings—was pretty clear. There were two lines to be made: one from Ballarat to Ararat, which was very easy, open country; and the other from Castlemaine towards Maryborough, which followed a somewhat rougher country. The two lines were to be made on the same alignment. For lines which were estimated at a cost of £5,000 per mile there was a saving of £149 per mile on the easy country, and £189 per mile on the rough country. In the Torrens Gorge the two lines were not on the same alignment. That accounted completely for the great difference in the costs.