of opinion that whilst present Ministers were seized of the facts, future Ministers might not be in the same position. It might, therefore, result that without the comprehensive examination by responsible representatives of the incidence of each clause, which every clause of the present measure had received; alterations might be assented to which might give rise to very serious results.

The question of the sufficiency of a factor of safety of 4, for timber, as against the factor of 6 recommended by this Institute as a minimum, and as embodied in the draft Government measure, had again been brought before the public by press quotations from a paper read before the Royal Victorian Institute of Architects.

He would again point out that the representatives of this Institute had, not once, but repeatedly, at the various conferences requested to be shown authority for the statement that 4 was a sufficient margin. Not one instance of the sanction of a factor of 4 by any government or municipal authority, or by any authoritative text book, had been adduced. They had been unable to discover legal sanction for any factor less than 6. He thought proof should precede public reiteration of the statement.

It had been said that only in America, and because of the use of cheap and inferior timber there, was 6 required. He laid on the table the Glasgow code, which required 7.

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PAPER.

LIGHT RAILWAYS AND CLOSER SETTLEMENT.

By J. Conway.

INTRODUCTION.—This is a national problem, as all States of the Commonwealth have a goodly portion of their inland bush country without proper access or means for conveying the product of the districts to the central markets, thus placing the settler who would open up these fertile regions at a disadvantage in getting to and fro with his produce.
To overcome this difficulty to a great extent, roads are opened up by the Government, but the construction of these is slow, and the up-to-date settler is nothing if not a "hustler," as our American friends have it, and must have an outlet that can be more expeditiously pushed out into his locality, the cost of which must be so reasonable as to induce his Government or the local authority to seize the opportunity, and thus open up immense forest areas, which to-day are only awaiting some means of transport to turn them into veritable Gardens of Eden, for the settler is land hungry, and the means of access lamentably lacking.

You will, I am sure, agree with me that in encouraging this class of settler to go into our back country there must be a considerably increased population, which should eventually result in a decrease of the present overburden of taxation, as the present scattered state of the population no doubt compels the Governments of the various States to impose a system of taxation which is abnormally high per capita. Therefore methods that will bring about the desired consummation must all be given deep consideration, and one amongst these which appeals to the writer is the light railway of cheap construction, built by the State through Crown lands, as feeders to the main lines of railway, and the waterways of the Commonwealth; and the crux of my paper is that by this means, methods of transport can be given to the back country settler (and it is he that needs most encouragement), both cheaply and efficiently. With regard now to the method of construction, or, rather, the style of tramway which it would be most advantageous to exploit, of course, much depends on the circumstances surrounding the case, but the class I propose to treat of is that carrying a 3ft. 6in. gauge, with not less than 45 lb. rails, and it is possible with a road of this description to negotiate grades of 1 in 20, with a load of 50 tons (exclusive of the weight of engine and rolling stock) with consummate ease.

Survey.—The survey of the proposed route would be one of the most important considerations, and I would like to say here, that the men most competent to carry out this portion of the work are the various District Surveyors of the several States, who, by reason of their long connection with the districts that they control, are more familiar with the local topography of the
country that it is proposed to operate than an engineer who has
probably no direct knowledge of the country through which it
is proposed to locate a light tramway. Thus the cost of survey
may be minimised by doing away with several trial surveys,
which the local knowledge of the representative surveyor would
render unnecessary. It is advisable that every penny of ex-
penditure should be judiciously laid out, and nothing should be
left undone to as far as possible bring this about.

CONSTRUCTION.—Having located our line of railway, we will
now proceed to consider the best class of construction to adopt
in the building of a line of railway such as is desirable for the
opening up of our interior country, and we should avoid as
much as possible expensive earthworks, so under the circum-
stances it becomes necessary to have steeper grades than obtain
on our main lines of railway, where expense in construction has
not been a consideration; we should therefore aim to construct
our country feeders of a surface nature as much as possible,
avoiding deep cuttings and high embankments by the judicious
use of sharp curves, such as are not permissible on main lines
of railway, but which are not a detriment to light railway con-
struction. Curves of two chains radius, when the speed of the
train does not exceed 15 miles per hour, are easily permissible
in this class of construction, especially as their use permits of
very rough country being negotiated.

Now, with regard to the road bed, I should suggest
a width of not more than 10 feet in cutting, nor
more than 12 feet on banks, thus avoiding unnecessary
expense from surplus earthworks, and a considerable sav-
ing can be effected in this direction without unduly affecting
the stability or utility of the road. Sleepers for use in the
construction of the road can in many cases be cheaply obtained
alongside the route of the line, and, as well-hewn sleepers have
a longer life than sawn ones, by reason of the chopping process
in hewing timber keeping the pores of the fibre of the wood
closed, thus excluding the passage of moisture, which does not
obtain with sawn sleepers for just the opposite reasons; there-
fore these could be contracted for, and it would enable the set-
tler to turn some of his refuse into a by-product. Side ditching
where required to carry off storm waters should be at least 1 ft.
6 in. bottom width, with slopes of 1 to 1, and need only be cut
where absolutely necessary to protect the works from erosion. Culverts of timber construction would be quite ample where necessary to be employed. Slopes of the embankments will, of course, be governed by the nature of the country of which they are composed, although those necessary in the class of work under review will not be a great consideration, because it is the writer's idea to avoid excessive depth in cutting, and height of embankment. I would not recommend the use of a lighter section of rail than 45 lbs. per yard, but, if funds will permit of it, I would say by all means let us use a 60 lb. rail, and thus add to the stability of the road. However, this is a matter for choice, and depends a great deal on circumstances, and there is always a quantity of these lighter rails being replaced on the main lines with heavier material, which could be advantageously used up in the construction of these light lines, and so again help to minimise the cost.

Wherever streams or declivities have to be crossed, and embankments would be too costly or unsuitable, by reason of a large watershed to be cleared, I would say that bridges of trestle design should be used, constructed of wood or steel, the former to be used where easily obtained, and concrete piers provided at all piers and abutments, bearing in mind that efficiency with cheapness must be the aim of the engineer who would exploit this class of tramway for the closer settlement of his district. The ballasting of the road should be as carefully carried out as upon the main lines, for the maintenance of the road will depend upon the manner that the ballasting is carried out in the first place. Stone or gravel is preferable where obtainable, but of course that is a matter that must be left to the nature of the surrounding country and the discretion of the engineer. Loading platforms, with sidings, should be provided at intervals along the route, so that the settler may be enabled to load up his produce in readiness for passing trains. The class of construction of these need be of the cheapest nature only, and of timber in all cases where obtainable. At the more important centres, temporary rough sheds could be erected over same at a minimum of expense. It must be clearly borne in mind that the writer's idea is, that to be effective, the light railway must be inexpensive, but, at the same time, the stability must not be sacrificed.
Traction.—The method of traction is the next consideration, and for this purpose I would recommend the use of a "Shay" geared locomotive. This machine, though of necessity slow, has the merit of negotiating steep grades with a heavy load, and of course it is not the aim with this class of railway to make fast running, but rather to make the railway a house-to-house convenience, and the grade of the road could be inclined in the direction in which the greater portion of the load has to be carried, viz., from the source of the supply towards the outlet, leaving only the lighter traffic to be hauled against the grade. The "Shay" locomotive is an American engine, and is principally used in that country upon logging railways, where, by reason of its extreme elasticity and adhesive force, it has proved itself second to none in pushing heavy loads up steep grades, and this is the class of work that may be reasonably expected upon a light country tramway. "Shay" geared locomotives are driven by vertical engines, direct-coupled on to a horizontal shaft running the whole length of the engine and tender, and this shaft carries bevelled pinions, which are in turn geared on to the rims of the wheels; thus every wheel is a driver, and maximum tractive power is developed. The shaft is
fitted with sleeve joints and universal couplings, thus enabling the engine to negotiate the sharpest curve with a minimum of strain and little or no diminution of power. It is claimed that these engines will work on the most temporary class of track, and in taking the sharpest of curves will not displace the road, even in the softest of places. I recommend this machine after an intimate knowledge of its capabilities for the past five years, and have no hesitation in saying that we have no other locomotive in use in Tasmania that is its equal under the circumstances that I have described. Other features of this engine that we might profitably note are—(1) the possession of very large fire boxes, with liberal heating surface, thus enabling wood to be used for fuel as well as coal; (2) the trucks of the engine, being four-wheeled and connected to the frame through centre-plates only, they are free to adjust themselves to great variation in the surface of the track; (3) there are from 12 to 18 impulses per revolution of the drivers, which enables the drawbar pull of the engine to be steadily maintained, and does not cause the variable draw which follows the four impulses of the two-cylinder locomotive; (4) the connecting of the crank shaft to the pinion shaft by universal couplings and slip joints gives flexibility to the driving mechanism in any direction, but still maintains perfect rigidity as to revolution.

ROLLING STOCK.—Rolling stock suitable for the haulage of goods traffic for these feeder lines should be of a cheap and simple nature, and in cases where the 3ft. 6in. gauge line prevails as the leading gauge of the State, profitable exchanges of rolling stock could be made, but where the standard or other gauge prevails, special stock would need to be constructed to suit the narrower gauge.

As you are well aware, the line that I have described in my paper is one of steam traction, and is, I think, one that would prove eminently suitable for pushing into and settling such districts as are not easily tapped by the main lines or permanent branch roads. Of course, there would be nothing to prevent sending out spur lines from these feeders, which would again tap a much larger area of country, and I am sure that our various State Governments should pause before locking up their lands, and consider the advisability of adopting some such policy as I have outlined in this paper.
ELECTRIC TRACTION.—The economy of electricity in traction is becoming so pronounced that we should consider at all times the advisability of substituting electrical energy in place of steam, although, perhaps, the electrification of the light tramway outlined would not permit of such heavy loads being hauled upon it, still, by adopting the system of having the grade of the line inclined as much as possible from the end that the heavier traffic would prevail, by electric traction under these circumstances as great a load may be handled as by steam; but, of course, we should not be able to haul up against the grade anything like the load that could be propelled by the "Shay" geared locomotives; still, the cost saved in fuel, maintenance, and the expense of stock, would perhaps more than compensate for the lesser tonnage carried each trip, and it may be that under the electrical system, an extra train per day could be run, if necessary, to cope with the traffic, without much increase in cost. The progress of the efficiency of the Edison storage batteries will be carefully watched by those interested in light railways, as the advent of this method of supplying power for traction will, if successful, altogether revolutionise railway traffic, as its adoption will do away with expensive distributing lines, poles, and other impedimenta of the overhead system, and will render the use of electrical energy a much safer proposition than hitherto.

Of course, in such States as possess unlimited water power to generate electric power cheaply, there is no just reason why electric energy should not be at once installed upon suburban and other light passenger lines, as this class of traction in those circumstances is considerably past the experimental stage, and, wherever introduced, has proved its capability to perform all that was asked of it, at considerably cheaper rates than steam traction.

Cost of Construction of Permanent Way.—I will now give an approximate estimate of the cost of constructing this class of light line that I have been advocating, and in arriving at this, I am presuming that average conditions such as I have experienced hitherto with this class of work will prevail; and no expensive bridges or rock cuttings are provided for, as it should be the fixed idea of the engineer to avoid these as much as possible. I am just assuming that surface formation alone is
necessary, in order to push the line ahead rapidly, without in-
curring great expense.

**APPROXIMATE COST OF PERMANENT WAY PER MILE.**
(Under average conditions.)

1. — Grubbing and clearing, 80 chains at £3 ... £240 0 0
2. — Formation of road bed, 80 chains at £6 ... 480 0 0
3. — Culverts of bed logs and sawn timber, item 50 0 0
4. — Side ditching, 80 chains at 30s. ... ... 120 0 0
5. — Sleepers, 2000 at 1s. 6d. ... ... 150 0 0
6. — Rails (new), 71 tons at £8 10s. ... 603 10 0
7. — Fastenings (fishplates, bolts, dogspikes), 8 tons ... ... ... ... ... 100 0 0
8. — Platelaying, 80 chains at 30s. ... ... 120 0 0
9. — Ballasting, 80 chains at 40s. ... ... ... 160 0 0
10. — Fencing, split or round post and five wires 160 chains at 12s. ... ... 96 0 0
11. — Accommodation works, crossings, extras, 10 per cent. ... ... ... ... 211 19 0

£2,331 9 0

In the above estimate I have allowed for the purchase of new rails and fastenings, but if sufficient superseded metal is available, then this estimate may be written down to about £2,000 per mile, and for this figure a first-class road could be constructed, suitable for carrying the traffic of outlying districts for years to come.

**CONCLUSION.** — I have endeavoured to submit for discussion a subject fraught with immense interest to all the States, for each of them has a very valuable asset in its unselected lands, which for all one knows may contain untold mineral wealth just lying dormant for want of communication with the outside world.

As this is a subject into which a great deal of detail may be worked, I have only dealt superficially with the various headings, but trust that in discussion many valuable suggestions will emanate from my fellow engineers, that will surely influence the powers that be to awake to the vast possibilities that may accrue, if the right policy is adopted in relation to the most important system of light railways.
DISCUSSION.

The President said there were many points in the paper which must command the attention of all. But there were many other points on which there might be difference of opinion. He would not like to discuss the paper closely without having read it carefully. But there was one vital point which suggested itself to him. Lines of the type described might be exceedingly useful in opening up forest or heavy mountainous country, where a grade of 1 in 20 could be temporarily tolerated. But as a principle proposed for general railway construction he had consistently objected to heavy grades. Imperfectly located lines might be laid down as purely ephemeral feeders. But the great objection was that once they were laid down in new country the population crystallised round those routes and the surface roads were made to converge upon them, and it was difficult to the point of impossibility at any later period to divert that traffic so that it would revert to the true lines where moderate grades might be obtained and economy be assured.

It was a question for grave consideration whether it was wise policy to put down any line in the first place in any position other than the position that would be dictated by the best canons of engineering. For the lines were lines not for a day, but for centuries.

Mr. J. T. N. Anderson said it struck him that while the author claimed to be advocating the cheapest possible line, there were several items that it was not advisable to have on a merely preliminary line. For instance, fencing. It was very unusual to fence such lines at all. If there was any fencing required the farmers did it themselves. In all the countries he had seen where feeder lines had been put in he had never yet come across fenced railways.

Some 17 or 18 years ago, before the first Standing Committee on Railways had been constituted in this country, he had strongly advocated a 2ft. 6in. gauge. To some extent that suggestion was followed, and the reason he then gave was the same that the President had advanced, the danger that those lines would otherwise become permanent. There was a great temptation when a line was once laid down, to make it the ultimate location. To emphasise the fact that it was only a temporary line, and one
built as cheaply as possible, he had advocated a 2ft. 6in. gauge. And in going through America he saw that there they did the same thing. The "Shay" locomotives were of 3ft. gauge and six cylinders. He had seen them hauling on a 1 in 14 grade, and at an average speed of about four miles per hour. He had travelled on one such train, and in twenty miles it descended 6000 ft., at an average speed of about twenty miles per hour. And considering that on going round practically one chain radius curves they had to slow down, they must at times have been travelling thirty miles per hour.

The trucks there used were not the usual type of railway rolling stock by any means. They were simply wheels mounted under ordinary steel rails, constituting frames, without springs, and the draw-bar in every case was a rail of about 70 lbs. per yard. The rail was set with the flanges horizontal.

The author spoke of pushing the train up. Evidently it was the practice in Tasmania for the engine going up a grade to be behind; but in America, on heavy grades, they had an engine at both ends. Then there arose the danger of a train being crumpled up.

That sort of railway in America did not cost anything like £2000 per mile. So if that indicated the practice in Tasmania they were going in for a good many more or less permanent works. However, he did not wish to criticise the paper adversely. These were matters of opinion. The author took great care to say that locality guided almost everything, whilst that which he (the speaker) had said was with a view to Victorian conditions, and not as a challenge to the views expressed in the paper.

Mr. A. C. Mountain said he would like to understand clearly whether the writer was describing what was a useful and a cheap method of locomotion for a private company carrying on developmental work, or whether he intended to introduce it as a suitable railway system of a cheap character for the public railways of the Australian States. Because, of course, consideration and criticism of a paper would turn upon the purpose for which the writer desired it to be applied. He could quite follow the remarks of the President as to the false economy of putting down cheap lines in a growing community that would have to serve a continually growing population.
DISCUSSION—LIGHT RAILWAYS

He would join issue altogether with the statement that local surveyors should carry out the location. He had surveyed some hundreds of miles of railways in New South Wales, and they never started without first of all obtaining from the Lands Office all the information it possessed and the records of the municipal surveys, and with that knowledge he did not see why the railway engineer, who knew exactly the difficulties of construction, and what he had to avoid and what obtain, should be inferior in his judgment to district surveyors, who, as far as his own experience was concerned, was greatly occupied in checking the work of licensed surveyors, and who were very largely confined to their offices. And, therefore, when the result of the work of these surveyors was compared with that of the railway engineer, who went out to explore, he could not see why the latter should not be better qualified to produce a good, serviceable line than the land surveyor.

The President said he agreed with Mr. Mountain. If lines were intended to be simply ephemeral lines with grades of 1 in 20, the local man might have the advantage arising from some special local knowledge. But if they were to be laid out in a permanent location he thought the work of the railway engineer and planner was of such a special nature, and was so related to the whole system, that it was not to be expected of the many-functioned local man.

Mr. J. A. Griffiths said the paper opened up a very large question that had been discussed in many parts of the world, and was still a burning question, particularly in Australia. The first object of building a railway in a country like Australia was to make it easily accessible. In doing that they must look ahead into the future. And he had been very much surprised in his experience, particularly in relation to railway construction and waterworks, to notice one serious omission, that was, in locating railways, the almost absolute neglect of what would be the conditions 50 years hence.

Take for example the line passing through the eastern suburbs. If he was correctly informed that was largely promulgated as a pioneer line to open up the suburbs to the east of Melbourne. It was laid out as a surface railway. The earthworks were almost a negligible quantity. And yet they found that rail-
way had grades considerably greater than 1 in 50 over long stretches, although the total elevation obtained was trifling. It had commenced as a railway to Hawthorn, and ended in about the deepest hole they could find. Then it was extended and crossed over the Surrey Hills, opening up the upper levels for occupation. But they did not adopt a uniform grade. It got up to Camberwell and then dropped down again as low as it could get, then rising again to Mont Albert, it reached Box Hill after dipping down about 50 feet unnecessarily. Then, taking the next section to Lilydale, after leaving Box Hill it followed the tops of the ridges mainly, but it had to get down to Lilydale on a very low flat, which apparently was the remains of an alluvial lake. And then instead of following the valley, it must needs go right over the top of the Wandin hill, with a total rise of about 400 feet, with steep grades, and then at Warburton they were very little higher than at Auburn.

It was all very well to lay out pioneer railways, but in doing that the survey should be so made as to include a thorough recognition of the possibilities 50 years hence. On the routes of pioneer lines there was always a very large quantity of Crown lands, and large reserves could be made, so that the line would be available 50 years hence without the cost of resumption. They had heard a great deal of the necessity of duplicating the lines of the suburban railways, but if the land had been reserved 50 years ago, at a time when it was possible, they would have been able to duplicate the lines at no greater cost than the making of new lines.

It was said, humorously, that the modern engineer distinguished himself by making no big bridges and viaducts. It was true. In the same way they should make no big grades. If the railway could not be carried out as a temporary expedient at a grade of 1 in 50, then they ought to get to the bottom of the valleys at 1 in 100.

The writer had suggested that local surveyors be asked to select routes. He had lately read Col. Monash's remarks as to the amount of assistance he got from municipal surveyors in regard to military topographic survey. Municipal surveyors were so busy that they had no time to give to topography. And that was the principal thing in this instance.

In Queensland one Government had insisted that the Govern-
ment surveyors should select a line. This was done, and now they were likely to scrap the line altogether. As regarded the expense in Queensland, 1 in 50 was practically the ruling grade, and with a 3ft. gauge they could make the line easily under £3000 per mile. It was done by going on natural routes, and not attempting to cross natural routes at right angles.

The President said that the Eastern line referred to by Mr. Griffiths was admittedly bad from an engineering point of view. But it must be clearly borne in mind that in most of such lines they were not located on the advice of the engineers. The position was this: The Governments for the time being had said, “Here is your starting point, and there your objective. Here are a number of intermediate points, which, for political reasons, you must serve, and you must not diverge more than so much from a line which we lay down.” The result was often bad, but the engineer was not to blame.

Mr. Griffiths said he was aware of that. But the main point was the neglect of topographic surveys.

After a vote of thanks (see “Proceedings”) had been passed to the author, further discussion was postponed.

FEDERAL CAPITAL SITE PLANS.

By the courtesy of Lieut. Colonel D. Millar, V.D., I.S.O., Secretary of the Federal Home Affairs Department, a complete set of the plans of the Territory and City site, also a relief model of the actual city area, were exhibited.

Mr. T. Hill described the various sections, and explained the general nature and conditions of the country, and the engineering problems involved. Unfortunately, without a large number of illustrations, the gist of these remarks cannot be conveyed through the medium of the “Proceedings.”

The exhibits included:
3. Map of portion of N.S.W., showing location of territory.
4. Topographical map of Federal Territory (about 900 sq. miles).
5. Contour survey of Canberra.
LIGHT RAILWAYS AND CLOSER SETTLEMENT.

The discussion on Mr. J. Conway's paper was resumed.

Mr. M. E. Kernot said he would like to express his regret that he had not been present to hear the paper read, but he had managed to make a few notes on it.

The subject was one which appealed to him, for he had spent the best part of his life on the job. He would not like to approach the paper as a critic. Mr. Conway had done them the honour of submitting a most interesting paper, which showed that the subject had been well thought out. But he did not in all things agree with Mr. Conway, and for the sake of provoking discussion on the subject he would state his views, and hoped they would be received as being in good part, and as simply an expression of his opinion.

The author recommended a light railway of cheap construction. That was the very thing they had all been looking for as long as he could recollect. It was the thing politicians had been looking for. They were looking for it still, but no one had found it. But he thought after all it was largely a matter of the use of words. When his wife heard of a butcher who advertised cheap meat he advised her to keep away from him. He thought they were all very tired of the word "cheap." In the present case, however, the word "cheap" was not used in the offensive sense he had suggested. Mr. Conway went on to say he wanted a line constructed both cheaply and efficiently. In that he agreed with the author at once. The most efficient was the cheapest, and it was only the efficient lines that should be constructed in any case.

As to survey. The survey should be one of the most important considerations. There was more money to be saved in the survey of a railway than in anything that came afterwards. But Mr. Conway suggested that the district surveyor should be the man to make the survey. That he could not understand. They were excellent men, no doubt, in their own line. But they were not experts in railway location. The art of railway location had been reduced to something much more definite than it used
DISCUSSION—LIGHT RAILWAYS.

It was much more definite than was usually thought. If a man would take up his "Wellington on Railway Location," he would find such problems worked out to a definite conclusion. No land surveyor, however clever he might be, could survey such a line properly. If a man thought he had heart disease or consumption he did not go to the most eminent surgeon. And if they wanted a first-class railway they did not go to the land surveyor. All their work was so much specialised to-day that they must go to a specialist if they wanted the best results.

Mr. Conway's description of the construction of the railway indicated that he had had experience in Tasmanian country. He had gone into the question of traction, and recommended the use of "Shay" geared locomotives. The capabilities of that locomotive were well known. He did not know why the choice should be limited to that. There were others similar—for instance, the "Climax" was made in America, and was very similar to the "Shay." These were very useful engines in their place. They were classed by the Americans as good slaves. They were slow and sure. They would pull a big load, but were very slow. If they could do their work with a "Shay" locomotive they should not go in for a rack railway. They should have the adhesion railway pursued to its extreme limit before they adopted the rack, because it was an expensive proposition. He happened to know the "Shay" locomotive, for he had it under test with one of the members of the company which makes it, and he was there to show what it could do. They managed to get it up to 18 miles an hour; but they could scarcely stand on the footplate. When travelling at that speed it was necessary to hold on with the hands and let the feet take care of themselves. The consequence of the slow speed was that the quantity of stuff that could be hauled was very much reduced. There were certain circumstances under which the "Shay" locomotive was most suitable. It was largely used on timber tramways of short length. But seeing that the ordinary average speed was not more than eight miles an hour, if they had a railway 100 miles long they could easily work out how long it would take to accomplish the journey.

The next point was electrical traction. This was a matter he had investigated. But he did not know of one case where electrical traction had been adapted to light railways with suc-
cess. All the evidence that he could obtain went to show that it was being used where the traffic was the heaviest. Perhaps if water power were available they might do something, but equipment was expensive. He was driven to estimating for it in a case where economy was to be pushed to the extreme, and a person fairly high up in political circles suggested that bark might be used in place of iron for the power house! But they could not work out figures to show that electric traction was right. So he could not see much hope in that direction.

Mr. Conway had submitted an estimate of construction which would suit moderately rough country, and though he had left out some items he showed a cost of about £2,000 per mile. It happened that in Victoria they had constructed lines at just about that cost, but they had been of 2ft. 6in. gauge, whilst Mr. Conway advocated 3ft.6in. His own experience was in favour of having the gauge as wide as they could get it, up to the standard.

The difficulty was to make such a railway a paying proposition. No railway was justified unless they were able to work it efficiently and to show that it was going to pay.

Railways brought indirect benefits which had not been sufficiently allowed for for many years past. By allowing for these every railway should become a commercial proposition. They must keep their finances in order. And the engineer must understand finance to some extent, and work out his scheme so that it would pay. No doubt the profession must be specialised in different branches; but at the root of all he found that finance controlled the whole thing. And he did not object to it so controlling it. It was a good thing to be kept within bounds. He had never yet been in the position where he had not had to try to get the very best he could for every pound he spent.

The difficulty in Victoria with a railway of the class recommended in the paper was that they could not make it pay, because of the low fares charged. They built the railways to encourage closer settlement, and they were being run at the same rates for freight as on the standard gauge. The lighter the line the lower the speed. They might be hauling a full train load of stuff on such a line and be losing money on it. Take, for instance, a case where the load was about 50 tons behind the locomotive. They would do very well if they got two-thirds of that as paying load. There were 34 tons left, which were run here at
a penny a ton per mile. That meant—it being necessary to allow for the return journey with empty trucks—17d. per train mile. They could not run the train profitably at that price. The lighter the railway the slower the speed, and the cost for wages went up as the speed fell off. They could not run a train profitably for less than about 5s. per mile for working expenses. Of course that was not a statement of the whole case. Some classes of freight paid very well. They charged as much for a passenger weighing 1½ cwt. as for a ton of goods. If they could get plenty of passenger traffic they could hope to make the line pay. But in such cases as the one under consideration they could not get the passenger traffic, because the population was not large, and those who were there were not frequent travellers by train. The matter had to be boiled down sooner or later to this proposition—the revenue must cover the working expenses and the interest on capital expenditure. If it did not somebody had to make up the difference.

The point he would like to press was that they had large tracts of territory in Victoria still to be opened up. New South Wales had the same; also Tasmania and Queensland. They were all trying to work out schemes to provide the best possible service for those districts. They had not found that electricity would do it. The conclusion was that the most efficient railway was the one most closely adjusted to the traffic requirements; and to determine the most suitable railway for any district, they must estimate the traffic to be provided for, and then fit the railway to its work. They could start on certain premises and work out something very close to the mark. In cases of purely developmental work they had to speculate to some extent, and often lines had been built to develop a locality, and the country had refused to be developed. It was not always in the past a question of whether a payable line could be constructed or not; but it often had something to do with the number of people who had votes.

All that had been brought up to the mark in Victoria by the Standing Committee on Railways. That committee had done very valuable work in bringing things down to their bearings; and the consequence was that during the past twenty years they had constructed a number of railways, and those railways as a whole were paying their way, with the aid of certain subsidies willingly paid by those who were benefited by them. The Vic-
torian system as a whole was paying its way. They had got the whole thing into a healthy system. But they were all still looking for a light railway to be built cheaply. His own opinion was they had got very near to it already. They had attacked the problem in a definite way, and had brought out results which were as nearly satisfactory as they could hope for. In comparing the procedure in Victoria with that of other States he could not find where the problem had been attacked as efficiently as here. They might make mistakes still, but they had made steady progress, and had set an example to their neighbours of which they need not be ashamed, and of which, indeed, they might even feel proud.

The President asked what exact meaning Mr. Kernot attached to the phrase that the line be adjusted to its conditions. Were they the present or the ultimate conditions? For it had to be remembered that conditions altered materially.

Then did not Mr. Kernot's criticism very largely turn or hinge on the question of grade? Did Mr. Kernot think from his experience that a permanent line that had been constructed with a 1 in 20 grade was the line that should be constructed? Was not that a grade that must of necessity constitute an uneconomical line? except, perhaps, in the case of timber or similar country, where the loading was chiefly unidirectional, and usually down grade.

Mr. Kernot said the conditions to be taken into consideration must be thoroughly comprehensive—both present and future. Money borrowed, as it was borrowed in Victoria, accumulated interest at a compound rate, and it did not pay to spend a very large sum of money now to effect a moderate saving in the future. For that reason they sometimes built railways with steeper ruling grades than they considered they should have ultimately, because they found it would pay better to regrade in the future when the traffic had developed. If they had done it at the first they would have had to pay interest on the cost until the regrading was needed. It had been proposed that they might make a cheap railway on a location with sharp curves and steep grades and reserve the land for a new line later on, but he did not know of a case where that had been done. If they made the 1 in 20 grade as advocated by Mr. Conway, then to obtain an easy grade later on
they would get into a new location altogether. As a general rule they located their lines to suit the ruling grade which would be required in the future. If they wanted cheap haulage it was essential to get easy grades. In America, where they had a grade as easy as 1 in 100, they would spend a great deal of money to get a grade of 1 in 200, on which they hauled trains of 5,000 tons. To get the cheapest haulage they must provide for such grades, but the traffic on the Victorian railways at present and their prospects did not justify such practice in any of their hilly country.

The President exhibited a dynograph record of a railway run showing the variation of the rotative effort. He said that it referred, not to a "Shay" locomotive, but to an ordinary six-coupled goods engine hauling a full load at slow speed.

It, however, illustrated markedly the variation of the turning effort at different arcs of each revolution. In this particular case the variation was accentuated by an imperfect setting of the valves, so that the rotary effort varied as much as 20 per cent, during each revolution. But even with perfect adjustment, when the engine was exercising its full tractive effort on a grade—that is when the train ceased to act as a "rectilinear flywheel," and the load became a "hanging" one—the variation was quite appreciable. In locomotives of the "Shay" type, with their more numerous impulses per revolution, the variation was inappreciable, therefore a somewhat heavier load, in relation to mean tractive effort, could be hauled.

Mr. F. W. Clements, in response to an invitation to speak, said he was not qualified to speak to the paper as a whole, as it was out of his special electrical line. But he thoroughly agreed with the remark made by Mr. Kernot that electric traction was not suited for light railways. Electric traction was only suitable where there was very dense traffic and quick traffic. That was the reason that electrification of suburban railways had been adopted in many parts of the world. He could not remember any case where satisfactory electrification of lines of the class they were considering had been accomplished. It seemed to him that it must be very evident that self-contained steam locomotion, especially of relatively light trains, running at a slow speed, must be much cheaper to operate. The electric motor
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would very likely cost nearly as much as a steam motor, even without the paraphernalia of power house, transmission lines, and possibly hydraulic head works. No doubt these light railways were principally put down where wood was cheap, and in that case fuel economy was not a very great matter, for they might just as well burn it in the locomotive as 30 or 50 miles away at a power station. It became a question of interest on a larger capital.

PAPER.

NOTES ON MODERN MACHINE TOOLS.

By M. EADY.

The past 15 to 20 years have brought the machine tool designer and builder many serious problems. The call of commerce for rapid production, and the introduction of high-speed steels, the qualities of which have rendered it possible to greatly increase speeds and feeds, have made it imperative for many complete re-designs. These changes have been so rapid and radical that in many instances the new problems of yesterday have become the old ones of to-day. Machine tool builders have responded to the new conditions, and it is my intention to point to some of the alterations in some of the latter tools, which are to-day playing such an important part in general engineering.

Attendant with the call for rapid production has come the demand for accuracy, and to-day the designing engineer relies upon obtaining accurate work. We know this to be true in the case of designs of steam engines, explosion engines for automobiles and flying machines, as well as pieces of intricate mechanism. Those who are connected with workshop practice know that the old 2ft. wooden rule is becoming, or should have become, as rare as the dodo, as a means of measurement to the machinist. To-day the micrometer should take the place of the ordinary rule, and a system of limit gauges to enforce accuracy. Even now, however, we have turners or machinists given instructions to make the job "a good, solid fit," or a "fairly loose fit"; one even still hears the old expression of making a job larger by the thickness of a piece of paper. These terms are
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The discussion on Mr. J. Conway's paper was resumed.

Mr. J. A. Griffiths suggested that as the paper to be read that evening was on a similar subject—the opening up of the country—it might be convenient to discuss the two conjointly.

The President replied that their experience was against that course. Each author had the right of reply, which made the joint discussion of differing papers very difficult.

Before closing the matter he might point out that the question of gauge was involved. That question seemed to be too important to deal with as a portion of a discussion on a paper, in which it was only incidentally referred to. It was rather a subject for a separate paper. An endeavour would be made to have a number of papers presented dealing with the matter in its several aspects. His own view was that decision upon the gauge to be adopted throughout Australia would not be justified upon the consideration which had, so far, been accorded the question. It would be nothing less than a national calamity if they adopted the wrong gauge at the present period. Personally he thought the gauge most suitable was the existing 5ft. 3in. He hoped that at the next meeting they would have a number of papers to submit that would make the fundamental principles of the gauge question clear.

Mr. T. W. Fowler said he had had his time taken up lately with other matters, and had not an opportunity of considering the paper as he would like. But several years ago he had the pleasure of meeting Mr. Conway in Tasmania, and by his courtesy had the pleasure of going over a portion of one of the tram lines in connection with the timber industry. He noticed in glancing through the paper that Mr. Conway advocated the "Shay" locomotive. That was the only time he had seen the "Shay" locomotive at work. He had made inquiries from the man engaged in connection with it, and the impression he gathered from what he saw and heard was that the "Shay" locomotives were remarkably efficient engines for the purpose of getting over very diffi-
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cult country. They could negotiate roads which locomotives of the ordinary type could not very well deal with, and they were remarkable as regarded their flexibility. But he gathered that the maintenance of those locomotives was considerably higher than that of the ordinary type. That was a matter on which he should be glad if Mr. Conway could give them some information. He thought they would find that the "Shay" locomotive was a grand "beast of burden" for dealing with very difficult country, so long as they did not mind a little expense in maintenance. But where the more ordinary type of locomotive could be adopted it would prove more economical.

The President said it must be borne in mind that the lines Mr. Conway appeared to have in view were those where some special form of locomotive was absolutely necessary, because the grades were very steep and the curves so sharp that an ordinary locomotive could not negotiate them.

Mr. Fowler said he found there were some of the more ordinary locomotives in use on the same road; but the "Shay" was dealing with heavier loads. In both cases the work of the locomotive seemed to be to push the empty trucks up the line. The grades were all down hill towards the sawmill.

Mr. J. T. N. Anderson said on the question of maintenance there was one point he was struck with. If anything went wrong the "Shay" engines were much more accessible and easy to repair than the ordinary locomotive. The cylinders were placed vertically outside the engine, and were therefore very accessible for examination. Whether they got out of order more rapidly he was not in a position to say. He had employed 2ft. 6in. ordinary locomotives, and if the "Shay" got out of order more quickly than these, they were very bad indeed. The people in America did not seem to think the maintenance excessive. Until they had had intimate charge of a machine of that sort they were not in a position to say much about its character. On one occasion (Huchiango, Mexico), and with such an engine, he went up a distance of 4,000 feet high with only one stop, at a speed of four miles an hour. He travelled on the return journey at about 20 miles an hour.

The discussion was closed, subject to the author's right of reply.
Light railways and closer settlement (Paper & Discussion)

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