On the motion of the President, a hearty vote of thanks to the author of the paper was carried by acclamation.

The discussion on the paper on "The Influence Line," by Professor H. Payne was closed.

The paper by Mr. J. T. N. Anderson, on "Road Construction to Stand Modern Traffic," was resumed, and its conclusion was, upon the motion of Mr. J. A. Smith, seconded by Mr. M. E. Kernot, further postponed.

In the absence of the author, discussion on the paper by Mr. F. K. Esling, on "A Method of Strengthening Existing Iron and Steel Bridges," was postponed.

At 10 p.m. the meeting closed.

**PAPER.**

**BAIRNSDALE TO ORBOST RAILWAY.**

Paper by Maurice E. Kernot (Vice-President).

The Bairnsdale to Orbost Railway forms one more section in the long-talked-of coast railway route from Melbourne to Sydney. The gap from Orbost to Bombala railway terminus in New South Wales is only 75 miles in a direct line. See Figure No. 1. The distance to Sydney by this route would, however, be about 650 miles as compared with 581 miles via Albury, and the average maximum speed would be less owing to steep gradients and sharp curves prevailing on a greater proportion of the distance.

From Melbourne to Canberra—the Federal Capital—the distance by the coast route would also be greater, about 450 miles as compared with about 430 miles via Albury and Yass, and the average travelling speed lower.

**GENERAL:**

This railway has been built under the writer's administration (as Chief Engineer for Construction, Victorian Railways) to serve the Eastern part of Victoria, included in the Counties of Tambo and Croajingolong, which have an area of 3,400,000 acres, and which up to the present have been without railway facilities.
The territory is bounded on the South by the Southern Ocean, but there are no natural harbours fit for craft which can navigate the ocean, and the cost of making artificial harbours would be very high.

Access to this territory has been difficult and costly owing to the roughness and steepness of the bush tracks, and its development has been greatly hindered in consequence.

**FIGURE 1.**
RAILWAY ROUTES—MELBOURNE TO SYDNEY.

The country for 10 to 20 miles from the sea is comparatively flat. North of this there is rangy and mountainous country rising towards the Dividing Range up to an altitude of from 2,000 to 4,000 feet.

Several fine rivers flow South to the ocean. The principal ones are the Mitchell, Nicholson, Tambo, Snowy, Bemm, Cann, and the Genoa. There are numerous smaller but perennial streams.

The climate is usually mild and salubrious, with a good rainfall. The country generally is heavily timbered, the
quantity being enormous; the best classes of timber, such as Ironbark and Box, occur only in small proportion to Messmate, Stringybark and other less durable timbers. Native Mahogany, Woolly-butt and Bloodwood are also found.

At present, settlement exists only on the best areas of land, the extent of Crown lands totalling over 2,000,000 acres, but a considerable portion of this latter area is more adapted for grazing than cultivation. Rich land is found at Bruthen, where there are 3,000 acres worth from £40 to £60 per acre, and the Snowy and Brodribb flats near Orbost, where there are 30,000 acres of exceptionally rich soil, which yields from 80 to 120 bushels of maize to the acre. There are other areas of good flats, and also a considerable extent of basaltic tablelands, which carry rich soil.

Mining prospects have been described by a leading geologist as excellent. There are fine marble quarries, and rich iron ore and manganese deposits between Nowa Nowa and Buchan.

As a step towards opening up this country, the Railways Standing Committee recommended in November, 1909, the construction of a railway from Bairnsdale through Bruthen to Orbost, having a length of 60 miles, at an estimated cost of £391,360. On account of increased wage rates since the estimate was made, the cost of the completed line will be ten (10) per cent. over the estimate. But for the increase of wages its cost would have been within the estimate.

It was opened for public traffic on 10th April, 1916. The goods traffic which has already come to the line indicates that the prospects of business in timber, stock, maize, and dairy produce are good.

This line is the heaviest and most expensive extension of the Victorian railway system which has been constructed during the last 23 years. The amount of earthwork which has been involved is nearly 2,000,000 cubic yards. Three large rivers are crossed by permanent bridges, which have deep and difficult foundations, viz., the Mitchell, the Nicholson, and the Tambo. The latter is subject to floods of great impetuosity. At the Nicholson River the foundations had to be executed in a depth of 80 ft. of mud.

The line has been constructed with 60 lb. steel rails, and
track to carry the standard rolling stock as used by the Department on country lines, and, in spite of the rough country passed through, a ruling grade of 1 in 50 has been secured throughout.

Beyond Orbost a graded road has been made by the Government, past the Cann Valley, which is very fertile, to Genoa and Mallacoota, near the New South Wales border, and is encouraging settlement and the development of the natural resources of the district. Many other roads and tracks have been made.

LOCATION:

The starting and terminal points being fixed, the examination of the intermediate country soon showed that Nowa Nowa, at the head of Lake Tyers, which lies not far from a direct line, could also be adopted as a fixed point. South from Nowa Nowa the crossing of Lake Tyers would be very diffi-
cult, while Northward from Nowa Nowa the country also increased in difficulty. See Figure No. 2.

Between Bairnsdale and Nowa Nowa much consideration was given to the question whether the line should pass through the Township of Bruthen, on the Tambo River, or keep to the South. After testing routes to the South sufficiently for an economical comparison, it was found advisable to make Bruthen another fixed point on the route.

Between Bairnsdale and Bruthen a trial survey for a railway had been made, keeping near the main road, which is fairly direct and passes through a small township known as Sarsfield. This survey had required the use of curves of 5 chains radius, combined with 1 in 30 grades, in order to keep down the cost of works, which were still very heavy. Further examination of the country proved that, by deviating the line southwards, a line with 12 chains radius curves and 1 in 50 grades could be constructed with moderate works. This could be worked with the standard rolling stock of the Victorian railway system, and the locomotives of the same tractive power would haul twice the load behind a tender. The advantages far outweighed the disadvantage due to an increased length of about 2 miles, particularly as, with the easier curvature and gradients, the running time would be considerably less.

A fairly direct route from Bruthen to Nowa Nowa was found, and also from Nowa Nowa to within a few miles of Orbost. Here the crossing of the flooded flats of the Snowy River required careful study.

The first railway surveyors were so impressed with the difficulty of descending from the tableland and crossing the flooded flats of the river opposite Orbost, which is on the East side of the river, that the trial survey for the railway was carried to a point about 6 miles upstream from Orbost where the river debouches from the hills, thence skirting the edge of the flooded country down to Orbost. A crossing of the river was thus obtained which, at first sight, seemed almost ideal, but in making the permanent survey it was further investigated, with the result that the bed and bank of the river were found to be of soft silt, which at high floods would be liable to severe scouring action which would be increased by the erection of
bridge piers, while borings in the bed of the river went down 80 feet through soft silt without striking a firm foundation.

A direct line to Orbost, saving about 1 1/4 miles in distance, was then tested, and the difficulties found to be so much less than had been formerly anticipated that it became quite clear that the direct route was the best one. For instance, it was found that solid rock foundation could be obtained at the crossing of the river a few feet below the bottom of the stream.

The result of the permanent survey work on the whole line thus increased its length between Bairnsdale and Bruthen by about 2 miles, while it shortened the length by 1 1/4 miles at the Orbost end, thus giving a line of about the same length as indicated by the original trial surveys, but with an improvement in gradients and curves which more than doubled the traffic capacity of the line and largely reduced its working expenses.

The detailed location of the line as well as the choice of alternative routes—where it was found worth while to test these—were carried out by the application of location factors as adopted in up-to-date location work in America. The most important factor is that of Ruling Grade. Sufficient work was done to determine that, on the estimate of traffic, it would pay to adopt a 1 in 50 grade in preference to anything steeper, but a flatter grade would involve a capital expenditure on which the interest would far exceed the saving in working expenses.

Without going into elaborate details it may be said that the estimated traffic on which location factors were based was two (2) return trains per day. The business since the opening of the line has required only one (1) return train per day, but future developments will in time make many trains per day necessary. The present value of the traffic, worked out in the same way as the present value of periodical payments of money is worked out, came out at the two (2) return trains per day.

**Length:** The value of length, that is, the amount which it was economical to spend in reduction of length, was worked out at—

£50 per chain for distances great enough to introduce additional stations or stopping places;
£35 per chain for distances great enough to affect the wages of train crews, but not great enough to introduce additional stations; and

£25 per chain for short distances not sufficient to affect train wages.

Curvature: The value of curvature, as expressed in the capital expenditure which was economically justifiable to save one degree of central angle of curve, was worked out at £3 6s. 8d.

Rise and Fall: The value of Rise and Fall was worked out on the basis of the capital expenditure justifiable to eliminate one (1) foot of rise and fall—one foot up-hill, and one foot down-hill—and came to £20 per foot on 1 in 50 grades of considerable length tapering down to nothing on short grades.

Compensation of Grades on Curves: The compensation of grade applied on curves so that locomotives shall haul the same load up-hill at the same speed whether on straight track or curves, was slightly in excess of American practice, being based on Victorian experience with standard rolling stock. It varied from .04 of a foot per degree of curvature to .035, recent American practice being about .035.

The calculations for working out these location factors may, of course, be very elaborate. To go into detail would inordinately extend the length of this paper, so I have had to be content with giving the results with a rough general indication of the way they were arrived at. As an illustration of the use of location factors in determining the choice between alternative routes, the following is given as an example:

Alternative Routes Between Fixed Points.

<table>
<thead>
<tr>
<th></th>
<th>Route &quot;A.&quot;</th>
<th>Route &quot;B.&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Works</td>
<td>£93,500</td>
<td>£90,500</td>
</tr>
<tr>
<td>Ruling Grade</td>
<td>1 in 50</td>
<td>1 in 50</td>
</tr>
<tr>
<td>Length</td>
<td>14m. 20c.</td>
<td>19m. 70c.</td>
</tr>
<tr>
<td>Curvature</td>
<td>940 deg.</td>
<td>1630 deg.</td>
</tr>
<tr>
<td>Rise and Fall</td>
<td>920 feet</td>
<td>380 feet</td>
</tr>
</tbody>
</table>
In this case the shorter and more expensive route with more hill climbing proves to be the more economical when allowance has been made for the extra length and curvature of the cheaper route.

The final adjustment of the centre line was made on contour sheets plotted to a scale of 2 chains to an inch, the contours being taken on the ground for sufficient width on each side of the centre line to cover any probable adjustments. The most economical position for the centre line was worked out on these contour sheets by trial and error. The location factors previously described being applied in this way, it was often possible to make substantial reductions in curvature. This process was not pushed to extremes, but when, say, £3 of expenditure can be saved by £1 worth of survey and office work it is surely worth while, though it is often difficult to obtain time for such final economies. The centre line, as adjusted on paper, was first marked out by rough stakes on the ground, and any corrections which then appeared advisable were made before the centre line was finally pegged.

Following the course described above, railway location becomes a systematic process, and avoids the unsatisfactory rule of thumb methods followed by many old-fashioned surveyors.

CONSTRUCTION WORK:

The whole of the works of the line were carried out by day work and piece work, mostly day work, under the control of the Staff employed under me. We have been carrying out
work in this way continuously for 24 years, and, though on two (2) occasions public tenders for constructing railways have been called, on both occasions it was found advisable for the Department to carry out the work itself, which it did to its own profit.

On this particular line, as the Department had neither plant nor trained staff for sinking concrete bridge piers, tenders were called and well advertised for that part of the work, but not a single tender was received, and we had to buy the plant and do the work ourselves. Now we have finished it, we are quite satisfied that we have saved money by doing without a contractor.

The heaviest cutting on the line—about 50,000 cubic yards—was advertised for public contract. Several tenders were received, but only one came near the Departmental estimate, which was about £6,000. The tenderer was called upon to carry out the work, but after some delay refused to proceed, so we got to work and executed the cutting in quick time at a cost of 3 per cent. below that of the lowest tender. It is the continuance of results like this that has confirmed us in carrying out work by Direct Labour, though we are quite ready to let contracts if by doing so we can get the work done at the same price as we can do it for ourselves.

**Earthworks.**

As before stated, the total quantity of earthwork on the line is, in round figures, two million (2,000,000) yards. At first sight the work seemed suitable for the employment of heavy plant, such as steam shovels, but, on going into working costs and obtaining the experience in other States, it was found that, for the narrow single line cuttings which had to be made, steam shovels could not do the work as cheaply as the simpler appliances of earth waggons and horses and tip drays. The country was such that the cost of transporting steam shovels to the works, together with the necessary waggon plant, would have constituted an overhead charge so large that they would have had no opportunity of doing payable work.

The American Grader, which we had worked successfully elsewhere, was sent to Bairnsdale and started there in a situ-
ation favourable for its use, but wet weather came on and stopped it. The grader, like other modern earthwork machines, will soon pay for itself if it gets into a job that suits it. The great difficulty is to fit the machine to the job.

BRIDGES:

Three (3) permanent bridges of considerable size were required for the Mitchell, Nicholson, and Tambo Rivers. As there were several interesting features connected with the design and construction of these bridges, I have made them the principal feature of this paper. See Plate II.

Bridge at Mitchell River:

The line crosses the Mitchell River close to the existing road bridge, the centre lines of the two structures being 50 feet apart and parallel. As the river is subject to sudden and severe floods which bring down a quantity of floating timber, etc., it was necessary to keep the piers in line with those of the existing bridge. The road bridge has 5 river spans of 76 ft. 8 in. each, and 5 flood openings of 30 feet. It was found advisable to adopt the same spans.

In this, as in the other river bridges, the superstructure was designed to carry the "120" ton engine (Cooper's E. 40), which may run on the line within 25 years. The substructure was computed for the "160 ton" engine (Cooper's E. 50), to provide for developments in the far future, the additional present cost of doing so being small. The clearance above summer water level is 21 ft. 9 in., which is reduced to 4 ft. 6 in. with highest known flood.

Piers: Borings at the site showed sandy silt, black clay, and drift, overlaying coarse gravel at a depth of 50 ft. below summer level, and the four (4) central piers of river spans were taken approximately to this depth.

Piers 2 and 3 are in the river; soundings taken during survey showed a depth of 8 ft. and 11 ft. respectively at these points, but when construction commenced it was found that the river bed had deepened considerably, and the scour caused by staging, etc., increased this again, so that eventually 22 ft. of water was met with at Pier 3.

Elliptical concrete "well" piers 17 ft. 6 in. x 14 ft., with walls 3 ft. 6 in. thick, were adopted for the foundations. This
type of pier is largely used in the East, and has been used in Victoria for the two railway bridges across the Avon.

The use of twin cylinder piers, either of cast iron or reinforced concrete, was considered, but these could not be braced together below the surface of the ground. Then, in the event of considerable scour occurring in the river bed, it was evident that two long columns of comparatively small diameter only braced together for a short distance at their tops, would not be as satisfactory as a monolithic pier, either for transverse or brake stresses. It was estimated also that the twin cylinders would cost at least £200 per pier more than the type adopted. The wisdom of the choice made was seen later, as during construction it was found that the river bed had scoured during recent years to a depth of at least 35 ft. below summer level.

No precedent could be found for sinking concrete well piers through such a depth of water as was shown by the soundings, excepting where expensive expedients, such as steel shells or coffer-dams, were resorted to. The following methods were successfully used:—A substantial staging, consisting of 6 piles from 60 ft. to 70 ft. long, well braced together, was built round the site of each river pier, and the steel and timber cutting edge of the well was suspended from cross heads by four 2½ in. diam. rods. The concrete shell or "steining" of the well was built up with cellular compartments (8 in. walls reinforced with "Clinton fabric") to save weight, and, as the concrete was built up, the pier was lowered by nuts on the upper ends of the suspension rods. The pressure of each nut was conveyed through a pair of large rubber washers to the staging, and observation of the compression of these enabled the workmen to keep the loads on rods approximately uniform. In this manner the well for Pier No. 2 was lowered to river bed, a depth of about 12 ft. The cells were then filled with concrete, and excavation inside the shaft commenced.

The suspension rods were found extremely useful for controlling and guiding the wells during the early stage of their penetration, and were eventually used in all well piers for this purpose. The rods were not screwed throughout their whole length, only one length of 9 ft. 6 in. being threaded; each ex-
tension of the rod was added as required by means of an auxiliary pair of suspension rods which carried the load while the new rod was being attached. This method worked satisfactorily, and the rods proved their capacity to carry and lower a load of 100 tons, but when Pier No. 3 was started it was discovered that the presence of staging had caused the river to scour to a depth of 16 ft. at this pier, and a hole 22 ft. deep (below summer level) was found close by.

It was evident that scour would increase while well was being placed, and, in that case, the load on rods might become excessive before well was self-supporting. Therefore, after experimenting with concrete placed under water, only the lower portion of the concrete shell was built above water, and then forms for the 3 ft. 6 in. wall were placed and lowered with the cutting edge to the river bed. Vertical 60 lb. rails, spaced 2 ft. apart and wired to horizontal 1 in. diam. rod reinforcement, were placed before lowering; and then the whole annular space was filled with concrete up to water level by means of a tremie (galv. iron 10 in. diam.), which was continuously moved round the well while placing the concrete. Later on, when an air lock had to be installed for the purpose of removing logs, this concrete was examined and found to be thoroughly satisfactory. 4 to 1 concrete was used under water to give a surplus of cement, and it proved fairly dense.

A hydraulic ejector (See Plate V.) was installed for excavating the silt and sand, but, owing to the presence of numerous seams of clay, etc., not shown by the bores, also logs, brushwood, etc., it was found more economical to use a small grab bucket, a very efficient type of which was designed by Mr. Moore, Assistant Engineer, and by its use the cost of excavation was largely reduced.

For large wells in sand or gravel (or even for small wells wholly in sand or gravel) the hydraulic ejector is very efficient, but it does not pay when it is necessary to remove the installation during the progress of the work and substitute a grab bucket in order to deal with clay, etc., in wells of the size used. No difficulty was experienced in sinking the wells (excepting Pier No. 3 as will be explained later) nor in keeping them in position, but careful observations were made with plumb lines on both axes of well, and any deviation from the
vertical was adjusted by excavating deeper on one side or the other. The services of a diver were required in several instances to cut logs, etc., and to manipulate ejector when wells tilted.

As the wells neared their final position and surface friction increased, lowering the water inside by pumping was found insufficient to cause them to sink. Rails were placed on the staging (about 70 tons in the case of Pier No. 1), and this weight was added to that of the well by means of jacks. When the foundation bed was reached, bag concrete was carefully packed by a diver into any cavities under the cutting edge and under the cone. Then after sealing the well with about 10 ft. of concrete deposited through water by means of a box with a movable bottom, the well was pumped out and the hearting concrete deposited.

The concrete in walls varied from 6 to 1 to 7 to 1, and was proportioned according to experiments made with test blocks as the work progressed, so as to obtain a concrete of maximum density; 8 to 1 was used for the hearting, but the watertight seal at bottom of well was made 5 to 1.

In order to curtail the waterway as little as possible, the section of the wells between river bed and summer level was reduced by flattening the sides to 7 ft. 6 in. width, the wall being only 12 in. thick here; reinforcement was added to withstand hydrostatic pressure when wells were pumped out. Bores were put down in each well about 15 feet before reaching the expected foundation bed, and its position verified, so as to determine where to commence this reduced section.

The shortest time for sinking a well 50 feet deep was five (5) months; this was for Pier No. 4, and it included 8 weeks lost while hung up on a log. In fact, the large number of logs met with delayed progress very considerably. The number of weeks occupied in sinking each well was as follows:—(the first figure being total time in weeks, and the figure in brackets being the number of weeks lost through logs, etc.).

No. 1 = 34 (10) No. 2 = 26 (8)
No. 3 = 56 (28) No. 4 = 21 (8)

Pier No. 3: In Pier 3, at 31 feet below summer level and nearly 20 feet below river bottom as it existed before com-
mencing work, quite a nest of logs and stumps was met with. After removing 3 logs and 2 stumps by means of a diver, a large forked log about 2ft. 6in. diam. was found lying under-
neath the cutting edge and roughly conforming to its contour for nearly the full length of one side of the well, so that it could not be cut by the diver. It may be mentioned here that divers found it very difficult to cut hardwood logs half submerged in drift sand, and it could only be done by the use of two saws—one of which was constantly being re-sharpened—and inter-
changing them every half hour or less.

As an air lock was at this time in use at the Tambo River, progress was suspended until it could be installed here. When this was done, the timber was cut and removed without further difficulty, but while hung up for nearly four (4) months on these logs the well had tilted towards the East bank of river, and it was found quite impracticable to straighten it up, although many expedients were tried. The angle was about 1 in 27, and in its final position the base was 1 ft. 9in. out of correct place, although at the river bed the centre line of well was approximately correct.

It was feared that, if further scour took place, the lateral support being removed, the eccentric loading of the base might crush the soft limestone rock on lower side and cause the well to tilt still further. With the object of reducing this effect, the centre of pier superstructure and of girder bed-
plates was moved 13 in. back towards the West side of the river, and the foundation was taken down into fairly solid lime-
stone. The latter was a very slow operation, and 10 weeks were occupied in sinking 4 feet. At this depth (58 feet below summer level) computation showed that the pressure per square foot might reach 9.2 tons on the lower side, and 3.2 tons on the upper side. In order to determine whether under this load any eccentric settlement of the base was possible, a test column was put into the well and the settlement under load noted.

The problem of measuring a very small subsidence under 60 feet of water, where it was impracticable to put down a rigid column and where it would be impossible to expect a diver to prepare a level surface for test, was solved success-
fully in the following manner:—Several timbers 7½ in. square
and about 20 feet long were bolted together (breaking joint longitudinally) so as to form a column 80 feet long \times 15\text{ inches square}. At its base a plate about 8\frac{1}{2} \text{ in. square} (half a square foot) was fixed with a ball and socket joint, so that after the diver had scraped a plane surface approximately level, and the column was lowered, the plate would be in contact over its full area. Attached to opposite sides of this plate were two piano wires which were carried to top of staging and ran over pulleys with counter weights to keep them taut. Another wire was suspended elsewhere and weighted as a check on stretch of these wires. This device was thus independent of any bending or compression in the testing column. Two tests (at different places) were made with this apparatus and showed a subsidence of 9/32\text{-inch} in 16 hours with a load of 15.6 tons per square foot, and 7/32\text{-inch} in 7\frac{1}{2} \text{ hours under 10.4 tons per square foot.}

As this was on a small area surrounded by uncompressed stone, it was evident that in the actual structure larger loads could be safely taken, and a piece of the limestone tested on the surface (dry) carried a load of 18 tons per square foot for several days with practically no indentation beyond the initial 3/32\text{-inch}. (This might, however, have been a hard lump).

It was also doubtful as to whether in the well tests the diver had been able to clear away all the stone disturbed by the rail chisel. It was, therefore, decided to accept these tests as satisfactory evidence that there was no danger of tilting due to an eccentric load. Up to the date of writing there has been no evidence whatever of further settlement.

The rail chisel mentioned above was formed from a pair of 80 lb. rails rivetted together, flange to flange, and pointed.

The concrete for all piers was mixed with a batch mixer on the Western side of river and tipped into small waggons which ran along the temporary bridge (utilising one running rail and a third outer rail), and, by means of turnouts, delivered the material at each pier as required.

Superstructure: Cantilever plate girders were adopted for the five 76 ft. 8 in. spans in preference to simple spans. Economy was one consideration, it being estimated that simple spans would have cost about £400 additional, but an important advantage was that, in case of a river well being out of
position along axis of bridge, a small alteration to the girders, would enable the spans to be altered by a foot or two without seriously increasing the stresses. This feature was taken advantage of in Pier No. 3 where the bedplates and stiffeners were moved 13 inches, the increased stress being only \( \frac{1}{2} \)-ton per square inch. Transverse displacement was more easily arranged for in the pier superstructure than displacement along line of bridge. Cantilever length was fixed at 11 ft. 8 in.; it was found that 15 ft. would have given the maximum economy in metal, but would have caused objectionable deflection.

The 100 ft. girders (6 ft. 3 in. depth) were taken down to Bairnsdale on a special train, travelling at reduced speed, and represent probably the maximum size that could be transported without danger to structures or passing trains on curves. They were erected quickly and simply by a method devised by Mr. Moore.

The girder being skidded to a position along the centre of running track, a truck was backed up to each end of it. An 18 in. x 12 in. timber had been fastened by stirrups and screwed rods at each end of girder so as to form an extension of the top flange. The projecting end of this timber rested on a turntable on the truck so that the girder, when jacked up, hung suspended between the two trucks. This combination was easily pulled round sharp curves and on to the temporary bridge, where the girder was lowered to the rail level and skidded down transverse rails to its position on the permanent piers. This proved a very quick, simple, and economical method of erection.

The five 30 ft. approach spans are of simple type—six 100 lbs. R.S. joists on 4 pile timber piers.

**Mitchell River Temporary Bridge.**

In order to enable rails to be laid over the Mitchell River, to facilitate work beyond, a temporary bridge was built before commencing work on the permanent piers. This bridge was of considerable help in the construction of the permanent bridge, and reduced the cost of placing concrete and of erection of steelwork. It consisted of 28 openings of 20 feet—
each span being formed of two round logs 22 inches diameter, with sleepers 10 inches apart laid directly on them.

_Bridge at Nicholson River._

Here the character of the foundation was the determining factor in fixing span lengths and type of bridge. No attempt was made at uniformity, the most economical type being chosen for each side of the river. This has resulted in a very unsymmetrical structure, but it was considered that the location of the bridge did not justify any increase of cost merely for the sake of appearance. See Plate III.

Extensive boring was done here to test the foundation bed; the original river bed was 80 feet below the present surface, and some 500 feet in width. This basin is now filled up with black river silt, and the existing channel hugs the western bank, the present river bed being 50 feet above its original position.

The most economical span length over the river channel proved to be about 120 feet—a more expensive type of truss is required for a longer span, and the cost of the deep foundation at Pier No. 4 would have been approximately the same, wherever placed.

Pier No. 3, on Western side of this span, was carried as far into the river as the shelving rock safely permitted, and, taking this as a fixed point, various span lengths were tried, so as to get the most economical construction. As there is rock on the west bank, concrete piers were adopted for the two 24-feet and the 50-feet approach spans. On the eastern side, where 80 feet of mud was shown by the bores, a pile trestle structure was built, consisting of 12 spans of 27 feet.

_River Piers (Pier No. 3):_ Pier No. 3 is founded on a shelving limestone ledge, which runs down sharply to 80 feet below water level. This rock was thoroughly bored to test for cavities, and the loose surface rock was excavated over an area 22 feet square for a depth of from 2 to 5 feet by means of rail chisel, and grab.

Preliminary bores had indicated hard limestone, but, when work was commenced, many soft spots were found, and it was eventually proved to be chiefly soft or rotten limestone with numerous boulders of hard stone. To get comparative results, the number of turns of auger per foot of penetration...
was recorded and the softest rock was compared with specimens on the surface, which showed the same boring resistance. It was thus demonstrated that the softest rock was perfectly reliable for the moderate pressures to be provided for (3.6 tons at edge of base).

In the design of this pier the variation of load due to brake action on trains was a considerable factor. Until about 20 years ago, the majority of bridge piers were designed without consideration for this, but latterly the practice has been to provide for a horizontal force equal to 20 per cent. of the "live" pier load at each pier. This results in unusually large dimensions for piers of small spans. The proportions recommended by Kunz are based on correct principles, and were followed in this design (co-efficient of 25 per cent., computed on 75 per cent. of engine weight, 100 per cent. of empty tender weight, 70 per cent. of empty passenger carriage, 90 per cent. of empty goods truck).

The concrete in base of this pier (22 feet in height up to water level) was laid under water by means of a box with collapsible bottom (which was found easier to handle than a tremie), the forms being placed by a diver. It was originally intended to build a coffer dam at this pier after the steel sheet piling had been removed from Pier No. 4, but, on account of the delay it would have caused, and in view of the satisfactory experience with subaqueous concrete at the Mitchell River Pier No. 3, the construction was carried out as here described, and it appears to be quite satisfactory. The subaqueous portion was well bonded together with old 80lb. rails laid about 2 feet apart in three horizontal layers at right angles to each other. There are also 8 vertical rails tied to the foundation, and extending up to within a few feet of the coping to take the tensile stress which may be produced by brakes. Arched recesses are moulded in each face of pier above water level to reduce weight while retaining the desired base area.

Pier No. 4: The conditions here, viz., 20 feet of water above 60 feet of river silt, required special consideration. Several designs were worked out, of which the following may be mentioned:—

(1) Concrete well pier 20 feet diameter. In case of landing on sloping rock, it was proposed to grout
through vertical tubes in wall, which would also act as tie rods. The difficulty of handling well was almost prohibitive here without an artificial island.

(2) Open timber caisson containing base of concrete pier, to be sunk to a piled foundation. This was rejected on account of the uncertainty of obtaining satisfactory bearing on piles, and the danger of subsequent settlement.

(3) Reinforced concrete cellular pier constructed in steel coffer dam. The doubt about permanence of reinforcement near edge of concrete under salt water, and absence of economy compared with adopted type, were the reasons for rejecting this.

(4) Mass concrete pier (with arched recesses) on piled foundation, with circular steel sheet pile coffer dam.

The pier, as actually built, is of the latest type, and above water is similar to Pier No. 3, but, to facilitate driving sheeting, the steel coffer dam was made square (27ft. 7in. on a side). Work was commenced by driving the 56 foundation piles (58 to 64 feet long) down to water level, and the eight 70 feet guide piles for coffer dam were also driven. No logs of any size were encountered. After this the walings and internal bracing for coffer dam were placed in position and the steel sheet piling driven. The internal braces were of 16in. x 12in. hardwood, with struttcd corner, and were spaced 6ft., 7ft. 6in., and 11ft. apart, according to the hydrostatic pressure.

No difficulty was experienced in making a closure with the steel sheeting, but the timber driving strips were cut a little too small, and this allowed a leakage later on. The bottom of enclosure was then dredged between heads of foundation piles by the hydraulic ejector to 24 feet below water level, and the coffer dam frames forced down to their correct places by tapping with a light monkey. The coffer dam was then pumped out, the leaky joints being caulked with white lead and hemp by a diver. The foundation piles were then driven
down to final position and cut off. After placing and tamping a layer of gravel on the bottom concrete construction was commenced.

As soon as this pier was built up to water level, the sheeting was pulled: this was easily done by the pile engine after starting each pile with a jack. The steel sheeting was found to be in first-class condition. About 100 tons of "United States" steel sheet piles 38lbs. per lin. ft., were used, mostly in 50ft. lengths, a few shorter lengths being taken to assist the closure. The total cost of driving was 1/½d., and of pulling 6½d. per lin. ft.; this included necessary staging, etc.

120ft. Span: The steel work for this span was brought down from Melbourne in sections and rivetted up on a temporary staging, a pneumatic rivetting plant being provided for the purpose. Deflection under two A² Engines was one (1) inch; permanent set being ½ inch.

Nicholson River Trestle and Anchor Abutment: Experiments made in 1912 had demonstrated that 60ft. piles driven down into the black river silt could carry an ultimate static load of about 40 tons, although a pile would sink nearly 20 ft. with its own weight. (See Proceedings, Vic. Inst. of Engineers, Vol. XIV. p. 97.)

The Trestle on Eastern side of river—40ft. high with 27ft. spans—produced a pier load at ground level (with max. engine load) of about 145 tons. To provide for effect of vibration, etc., eight 60ft. foundation piles were used to each pier. These were capped with a concrete block 24ft. long, 3ft. 6in. width at top, 6ft. at base, and 5ft. 6in. deep—the top of block being about 12in. above ground. These blocks were reinforced at top and bottom with steel rails, and four (4) upper piles at each pier were set in pockets left between the rails in the upper surface and grouted with pitch.

As this structure—325ft. long—was virtually "hinged" at ground level, it was necessary to provide longitudinal bracing. In addition to this, an "anchor" abutment was built at the East end, founded on rock, and the steel superstructure was firmly fixed to channels embedded in the concrete. This was done as a safeguard against brake pressure on the trestle being conveyed to Pier No. 4 in river. (Both the 120ft. span and the first span of trestle are supported on rockers at Pier
BAIRNSDALE TO ORBOST RAILWAY.

No. 4 with a sliding connection at deck.) This anchor abutment is of triangular shape in side elevation 30ft. high, base 26ft. long, top 7ft. 6in. long by 10ft. 6in. width. Viewed along the line of bridge it consists of two walls from 2ft. 6in. to 3ft. 9in. in width, 6ft. apart, arched over a few feet below the top to carry the ends of R.S. joists. This shape gives the maximum resistance to horizontal force at the top, combined with the least obstruction to movement of the embankment by which it is surrounded. It was designed to withstand 60 tons pull or push at joist level, combined with unbalanced pressure at the back from embankment.

Temporary Bridge at Nicholson River.

This comprised 21 openings of 20ft., and one of 35ft. for navigation. Piers were formed of four 80ft. piles in the river channel, with a log cap and two upper piles about 32ft. long. Elsewhere two 60ft. foundation piles were used for each pier.

The superstructure consisted of a pair of R.S. joists 20in. x 7¼in. x 89lbs., sleepers being laid directly on them.

The anchor abutment and six spans of the permanent trestle having been built, the temporary bridge was erected, curving off the latter and crossing the river on a parallel line 35ft. distant (between centres). Reverse curves were 600ft. radius without super-elevation, and slow speed of trains was insisted on.

As at the Mitchell River, this structure considerably reduced the cost of placing concrete and steel in the permanent bridge.

Bridge at Tambo River.

The line crosses this river at Bruthen at a point about a quarter of a mile below the existing road bridge, which has 75ft. timber truss spans. Old residents of the district affirm that the river has so silted up in the past 30 years that the original road bridge, which had considerably over 10ft. clearance when built, is now buried under the present sandy river bottom. This is quite probable, for numerous logs were met with from 20 to 25ft. below the river bed, and, in one case, a red gum stump was found 41ft. below the present surface.

At the railway crossing the river has a flat, sandy bottom about 350ft. in width, and generally dry except for a narrow
Within 48 hours this may become a torrent 10ft. deep and 500ft. wide, with a velocity of 7 to 8 miles per hour. Under these conditions it is unknown to what depth the sand is disturbed, but it was evident that foundations for a bridge must be taken well down.

Bores indicated from 25 to 40ft. of drift sand and silt, to a deposit of gravel about 2ft. in thickness, then another 15 to 20 ft. of drift sand to a bed of hard gravel over 20ft. thickness. It was, therefore, evident that piers must be founded about 60ft. below river bed; and the considerations that led to the choice of well piers in preference to twin cylinders for the Mitchell were even more prominent here.

This being a "deck" bridge, the piers were not needed as wide as the Mitchell, and therefore circular well piers 15ft. 6in. diam. were designed, with an 8ft. 6in. shaft. It was computed that these piers would be safe against all probable transverse forces if river bed erodes 36ft. below present level, the whole pier being considered as a vertical cantilever with the bottom 20ft. "fixed," and allowing for no tension in concrete.

The piers on the river banks were founded on piles—the four river piers being sunk 51ft. 4in., 59ft., 60ft. 6in., and 60ft. 6in. respectively below the river bed to the above-mentioned gravel. It was expected that difficulty would be experienced from skin friction when sinking the wells, so each well was supplied with piping, placed in the concrete walls, through which water jets would be forced so as to give an external water skin and facilitate sinking. As it was found possible to overcome the skin friction by jacking up against the loaded staging (as at the Mitchell), this device was never utilised. See Plate V.

The sand proved very easy to sink through, and without the suspension rods it is probable that wells could not have been kept in their correct position. A few feet beneath the river bed the wells were corbelled out to carry cut-waters, the nose of each cutwater was protected by an 80lb. rail, anchored into the concrete, to prevent the edge being chipped by floating logs, etc. Logs were met with while sinking every well. In No. 3 Pier numerous logs were met with at 27ft. below surface, and a red gum stump at 41ft. down. They were all removed by a diver.
Pier No. 4: In No. 4 Pier at 20ft. depth, a nest of logs from 12in. to 30in. diam. was encountered. After the diver had removed the smaller logs and had cut the large one in two, an unsuccessful attempt was made to pull it out of the well with the grab. It was then cut across outside the well by means of the rail chisel on one side, and on the other side it was drilled and blasted. This log now cut or shattered in 3 places was still immovable. (Later on it was discovered that it forked—one branch running partly along and underneath the cutting edge).

Work was suspended here until an air-lock was obtained. As soon as this was placed in position the difficulty was easily surmounted, but much time had been lost, the well being stationary at this level for 27 weeks. It was found necessary to render the inner surface of the well shaft with cement to prevent excessive leakage of air.

For the purpose of attaching the air lock, a ring of angle iron 4in. x 3in. x 3in. was built into the concrete and the air-lock bolted to this. After the removal of the lock, the ring remained in the wall. The air-lock was of simple design, consisting of a cylinder 6ft. 3in. x 3ft. diam., formed of 3/16in. steel plate and rivetted to a steel dome covering the well shaft. A lock 4ft. diam. would have been better, as the doors in this one were inconveniently small for removing material. Air was obtained from the compressor provided for pneumatic rivetters, etcetera.

Method of Sinking, Etc.: Wells were sunk for the most part by grabs, but the hydraulic ejector was found very useful in sinking the lower portion (10ft. to 15ft.) of wells 4, 5, and 6, where they hung up on boulders and cemented gravel underneath the cutting edge. The powerful 1½ in. jets sluiced out the material easily (boulders, of course, were removed by grabs).

The total time occupied in sinking wells 3, 4, 5, and 6, is given in weeks hereunder, the time lost in dealing with logs, boulders, etc., being stated in brackets:—

No. 3—58 weeks (32) No. 4—61 weeks (34)
No. 5—36 ,, (15) No. 6—34 ,, (15)

At a stage where no logs were met with, No. 5 was sunk 25ft. in eighteen working days. Excepting in one instance,
it was never necessary to use the jacks to overcome friction until the wells were more than 45 feet below river bed; the weight of (submerged) well was sufficient to overcome skin friction up to about 230 lbs. per square foot.

*Curbs, Etc.:* All wells were bottomed on hard cemented gravel and (as at the Mitchell) were bonded together from cutting edge to top with four 1½ in. and four 2½ in. diam. tie rods. The cutting edge was formed of steel plates built up to form an angle 8 in. x 8 in. x 8 in., with a timber curb of almost triangular cross section above it, 2 ft. thick and 2 ft. wide on its upper face on which the first course of concrete was placed. The walls of wells were of 7 to 1 gravel concrete.

The actual material passed through by wells was widely different from that shown in preliminary bores, many seams of clay and gravel being met with, but hard gravel suitable for foundations was not found above 51 to 60 ft. depth.

It had been intended to use the river sand for concrete, but it was found to be unsuitable, as all the samples made with it cracked. Sand was obtained by screening the gravel from a ballast pit. After washing out a small percentage of clay and silt and removing stones over 2½ in. gauge, the mechanical analysis of this gravel followed very closely the "Ideal curve" in Fuller's experiments—(Trautwine 1911, page 1089).

*Superstructure:* Preliminary designs were got out for spans ranging from 75 ft. to 170 ft., and with various combinations of cantilevers. The formation level allowed the use of a deck bridge, and the most economical structure was found to be one of five (5) 90 ft. plate girders with a 21 ft. approach span at each end.

With no depth of water to sink wells through, it was not anticipated that any difficulty would be found in building piers accurately (and such proved to be the case). Therefore, the cantilever promised little advantage for modifying span lengths; also, being a deck bridge with a less dead load per foot than the Mitchell, the economic advantage of the cantilever was proportionately less. (The greater the dead load, the greater the advantage of cantilever: with a very slight dead load and a heavy rolling load, there is very little economy in metal). The girders 90 ft. x 7 ft. 6 in. depth are spaced 7 ft. apart and carry 5 in. transverse decking; they are on rocker
bedplates, and were erected by skidding off the temporary bridge. The bottom of superstructure is 20ft. above the river bed and 4ft. above the highest known flood level.

The bridge as constructed was estimated to cost £16,000; a bridge with 75ft. spans was estimated to cost £17,300, and one with 108ft. spans, £17,000.

Temporary Bridge at Tambo River.

A temporary bridge 23 openings 20ft. of the same type as at the Mitchell (log superstructure) was built to expedite the construction of the line. Piles 40ft. length were obtained, but after driving to a satisfactory test at 22ft. depth, it was found that after 48 hours they would not stand up to the same test but drove more easily, so piles in river bed were driven to 30ft. depth and spliced.

Probably at least a third of the cost of each of the temporary bridges should be debited to the adjacent permanent bridge as an offset to the reduced cost of placing materials through their use.

Floods:

Although by good fortune no floods of any magnitude occurred during the period that the Mitchell and Tambo were under construction, precautions were taken to deal with them, and the staging was designed with this end in view. Also a wire rope was stretched across the river above each bridge so that during a flood of high velocity a boat could be warped along for the purpose of keeping piers free from floating timber and avoiding a log jam.

Plant:

The more important items in use at the three (3) river bridges were:

One portable Engine and boiler 20 N.H.P. (78 B.H.P.), 11in. x 16in. cylinders 120lbs. pressure.

One 20 B.H.P. Oil Engine and 5in. Centrifugal Gravel Pump, capacity 400 gallons per minute at 60ft. head.

One Steam Hoisting Engine 7in. x 10in., cylinders with friction drum.

One Worthington Steam Pump, cylinders (steam) 14in. x 10in., and (water) 10½in. x 10in.—capacity, 550 gallons per minute at 340ft. head.
One "Milwaukee" Batch Concrete Mixer, driven by 5 h.p. petrol engine—capacity 10 cubic yards per hour.

One Air Compressor, 100 lbs. pressure, 8 in. x 10 in. cylinders, maximum output 140 cubic feet free air per minute, with receiver 30 cubic feet.

This plant was obtained with a view to flexibility as the three bridges were being built simultaneously. The large portable engine and boiler was useful for supplying steam to pump for hydraulic ejector and jets; and also for air compressor. The latter could be also driven, if required, by the hoisting engine or oil engine.

Several donkey engines with improved friction clutch were also used for pile driving, handling grabs, etc., and an additional small centrifugal pump and engine were hired at the Tambo.

The concrete mixer was seldom worked up to its capacity on the wells, but its use resulted in a better quality of concrete than is usually obtainable by hand mixing.

The air compressor was installed for pneumatic rivetters, etc., but was found sufficient to supply air for wells during the short period an air lock was required. (There was no very serious danger to workmen in these wells during pneumatic sinking from a possible breakdown in the compressor, as the air lock was placed above outer water level).

The designs of these bridges were worked out by Mr. C. H. Perrin, assisted by Mr. Malcolm Moore, Assoc. M. Inst. C.E., B.C.E., B.M.E., Melbourne University, and their erection was carried out by Mr. Malcolm Moore in consultation with Mr. Perrin. Mr. David Craig, Assoc. M. Inst. C.E., was Engineer-in-charge of the works of the whole line. Mr. Moore and Mr. Craig are now engaged at works for manufacture of Munitions of War in Scotland.

**Other Bridges:**

Besides the three river bridges already described, there are 10,960 lin. feet of other bridging, of which 6,520 lin. feet consists of "standard time or bridges 11 ft., 15 ft., and 20 ft. spans."
The most important of the other “special” bridges are those at Boggy Creek, Mundic Creek, Three Mile Creek, and Stony Creek.

**Boggy Creek Bridge:** Here, the line crosses the creek at a picturesque gorge just before the stream enters the North arm of Lake Tyers at Nowa Nowa. The line is at a height of 65 feet on a 15-chain curve, and the central span of 60 feet is on a skew of 55 degrees. See Plate III.

The plate girders, 6ft. depth, were erected by skidding along runways formed of two lengths of 80lb. steel rails 31ft. 9in. long, fished together and supported by a temporary pier at the centre of span. Eight (8) rails were used, bolted together in groups of four (4) at each side, and the “horses” supporting girders were skidded along them.

The Piers of this 60ft. span are of concrete; the effect of centrifugal force, brake pressure, and wind were found to be very considerable as they may all tend to overturn pier in the same direction. This effect was partly counteracted by setting the bed plates 6 inches to one side of the true centre line of pier.

In mountain streams, such as this, with high velocity and in sparsely inhabited districts, it is difficult to get reliable information as to highest known floods. It is reported that flood waters have reached 30 feet above the creek bed, and cutwaters on piers were carried to this height and protected with imbedded 80lb. rails.

The adjacent 30ft. spans have timber piers resting on concrete pedestals, which are carried up to flood level as extreme velocity occurs here, the creek bed being very steep: about 20 chains below the bridge a great number of large trees are to be seen, which have been brought down by the floods.

**Mundic Creek Bridge:** This bridge is of unique design; the line crosses at a very sharp angle of skew, the angle between creek and line being only 30 degrees. See Plate IV.

The importance of this waterway was not sufficient to justify a long span bridge, but it was feared that the ordinary 20ft. spans, with skew piers, would give such narrow openings normal to stream (10ft. width between pile centres) that a log jam would be probable.

The central portion of the bridge as built has 23ft. 6in.
spans along centre line. Each alternate pier is an ordinary 4-pile pier on 30 degree skew; the intermediate pier straddles the stream so that, looking up stream, the bridge openings appear like three letter A's, thus AAA giving 3 openings of 23ft. 6in. span normal to the stream. Each side of each "A" consists of a pair of piles braced together; the horizontal member is well above flood level.

Girders ex. N.E. Line. The 23ft. 6in. spans above-mentioned are formed of steel girders removed from the North-Eastern Line, 4 being used for each span. Although removed (mostly from "through" bridges) on account of being too weak in shear for the heavy A2 engines, when placed 4 to a span they have a large factor of safety, and form an economical superstructure for a deck bridge.

About 400 of them were used on this line for spans ranging from 21ft. to 23ft. 6in.

Three Mile Creek and Stony Creek Trestles: These are the highest timber bridges on the line—Three Mile Creek reaching 66 feet in height.

Stony Creek Trestle consists of 27 spans of 30 ft.—total length 810ft., or 12 chains—piers averaging 55ft. high with a maximum of 63ft. The piles are of White and Yellow Stringybark, very uniform in size: all piers, excepting two (2) at each end, have foundation piles, and are spliced a few feet above the surface.

In both bridges each alternate bay is braced longitudinally with round timber bracing (trussed), and a longitudinal brace, consisting of a pair of 80lb. steel rails, is carried from end to end of the structure. The superstructure consists of four 100lb. R.S. joists with 4in. transverse decking.

Standard Timber Bridges—15ft. and 20ft. An improved type of timber bridge was designed for this line.

In renewing timber railway bridges it is generally found that the chief point of decay in superstructure is at the timber fish-pieces between the beams over the piers. In the new type, these have been omitted; beams are fixed to walings by steel angles, and spaced 4in. to 5in. apart by bolts and ferrules.

The previous practice of spiking all decking to beams, etc., also led to deterioration of the beam, both through mechanical
injury and the entrance of water. In the new type no spikes are driven into top of beam, and all beams and walings are protected by 24-gauge galvanised iron. Decking is fastened to longitudinal cleats which are spiked to sides of outer beams every 2 feet. It is believed that these and some other minor alterations will result in a longer life for the beams, and will also afford greater facility for making renewals.

The longest bridge on the line is one across the Snowy River Flats, near Orbost, the length of which is 2,539ft. It consists of 15ft. and 20ft. spans.

**Timber:**

White and Yellow Stringybark were largely used for piles and beams, etc.; this timber was of superior quality, and local experience showed it to have a life up to 40 years as fence posts. On the last three bridges on the line, Gippsland Mahogany timber, Eucalyptus Botryside, was used for beams, etc. It promises good results. The timber cutters found it very tough and hard to work.

**Temporary Terminus:**

With a view to cutting down the large capital cost of the line, I was asked to advise whether it would be practicable to make a terminal railway station on the flooded flat on the West side of the Snowy River, and so avoid the cost of bridging that river in carrying the railway into Orbost township beyond.

After a study of the local conditions and the available records of floods extending over a period approaching half a century, I was able to advise that a station could be provided at moderate cost, which, on the average of the flood records, would probably be damaged to a small extent by flood about once in 25 years, and to a larger extent about once in 50 years, and this has been constructed.

It is of course likely that the line will be extended within the next 25 years, when the station should be removed across the river to a better and more convenient site.

**Conclusion:**

The length to which this paper has extended is good reason for abbreviating further description of the line.

It is ballasted throughout with gravel obtained from pits near the course of the railway.

The sleepers are of timber from the local forests, 9ft. long x 9in. x 4 3/4in. in section.
The rails, as before stated, are of steel, weighing 60lbs. to the yard. They are not new, but were obtained from older lines where traffic has increased sufficiently to justify relaying the track with heavier material.

The eight intermediate stations are sufficiently equipped for traffic at present in sight. They will be added to as traffic develops. Large quantities of grey marble have already been despatched from Nowa Nowa for the new Commonwealth Offices at London.

Water supplies for locomotive purposes are provided at Bruthen, Nowa Nowa, and Orbost, from perennial streams near by. In each case the water is pumped by a small oil engine, with belt drive, to a geared reciprocating pump. The experience of the Railway Department with small gravitation schemes has been such that they are not now favoured.

LIST OF LANTERN SLIDES.
ILLUSTRATING PAPER ON "THE BAIRNSDALE TO ORBOST RAILWAY."

1. Railway Routes—Melbourne to Sydney.
2. Public Buildings, Bairnsdale.
4. River Scene, Orbost Railway.
5. River Scene, Orbost Railway.
6. River Scene, Orbost Railway.
7. Maize Flats, Bruthen.
8. Map—Bairnsdale to Orbost Railway.
9. Lakes Entrance, Cunningham.
10. American Excavator at Bairnsdale.
11. Sinking Concrete Well, Tambo River Bridge.
12. Sinking Concrete Wells, Mitchell River Bridge.
15. Rail Loading on Concrete Well Pier.
16. Sinking Concrete Well with Compressed Air, Tambo River.
17. Sinking Concrete Wells, Mitchell River Bridge.
20. Piers 1 and 2, Nicholson River Bridge.
22. Temporary Bridge and Steel Sheet Piling, Nicholson River.
24. Temporary Bridge and Steel Sheet Piling, Nicholson River.
27. Road Bridge, Tambo River, Bruthen.
28. Sinking Well Piers, Tambo River Bridge.
29. Temporary Bridge and Well Piers, Tambo River.
30. Curb for Well Piers, Tambo River.
31. Testing Bridge, Tambo River.
32. Building Temporary Bridge, Tambo River.
33. Donkey Engine, with Friction Clutch, for Pile-driving.
34. Boggy Creek Bridge.
35. Mundic Creek Skew Bridge.
36. Mundic Creek Skew Bridge.
37. Trestle, Three-mile Creek.
38. Building Stony Creek Trestle.
39. Stony Creek Trestle.
40. Timber Bridge, 15ft. openings.
41. Timber Bridge, 20ft. openings.
42. Timber Bridge with Iron Girders.
43. Overbridges, Bruthen Township.
44. River Scene, Orbost Railway.
45. River Scene, Orbost Railway.
46. Marlo—Mouth of Snowy River.

The President said they were indebted to Mr. Kernot for his detailed description of an interesting and important national work. He was much struck with Mr. Kernot’s opening remark that in the last 25 years there had been little extension of railways in this State. He could not say whether that was a matter for congratulation or otherwise. Many people were of the opinion that railway construction had not been undertaken in Victoria to the extent that was expedient in a young country such as this. He thought it was one of the problems of the present or near future to provide the people of the country with greater railway facilities, and to open up lands at present unoccupied. Mr. Kernot’s description of this railway was very instructive—the more so because of the numerous obstacles that had to be overcome.

Railway construction was vastly different to most other engineering work in that it could not be always considered from a profit-making point of view. Most of them, in designing engineering works, knew fairly closely the revenue to be derived and the expenditure to be incurred, but railway works had to be viewed, more from a developmental point of view—the opening up of the country. He thought members would agree with him that they had listened to an interesting paper, and he would ask them to express their gratitude to the author in the usual way.

The vote was carried by acclamation.

DISCUSSIONS.

THE INFLUENCE LINE.

(Paper by Prof. H. Payne.)

As there was no further discussion forthcoming, the President declared the discussion closed.
HAIRNSDALE
46 FT
MITCHELL RIVED
ATV HOLLOW CR
MOSSIFACE
53 FT
DEEP CR
BRUTHEN
50 FT
TAMAR RIVER
THREE MILE CR
NICHOLSON
48 FT
NICHOLSON RIVER
BRIDLE CR
HARIINGS
LAUGHTERHOUSE
COSSIPPI
~F
BUMBERRAN
184 FT
COLO/HOUR
420 CT
Dale To ORBOST Railway.
Miniature Section.
Plate II.
Plate III

Bridge Over Nicholson River.

Bridge Over Boggy Creek.
Plate IV.

Trestles at Three Mile Creek.

Bridge Over Boggy Creek.
Plate V.

Sinking Concrete Well Pier, Tambo River.

Hydraulic Ejector.
views. As this discussion had been postponed previously, a resolution would be necessary to postpone it again.

Mr. JAS. ALEX. SMITH moved that the discussion be postponed. Mr. J. S. DETHRIDGE seconded. Carried.

A METHOD OF STRENGTHENING IRON AND STEEL BRIDGES.
(Paper by F. K. ESLING.)

On the motion of Mr. JAS. ALEX. SMITH, seconded by Mr. C. F. LINDBLADE, this discussion was postponed to next meeting, on account of the limited time available.

BAIRNSDALE TO ORBOST RAILWAY.
(Paper by M. E. KERNOT.)

Mr. J. T. N. ANDERSON said, on page 183, Mr. Kernot had referred to the silting up of the Tambo River, to the extent that the old bridge, which originally had a clearance of 10 feet above summer level, was now completely submerged in the sand. He would like to mention that he built the present road bridge 16 years ago. At that time, part of the hand-rail of the old bridge was just showing above the silt, so there was no doubt as to the statement. Of course, he could not say as to whether the old bridge had had a clearance of 10 feet, but when he was there the hand-rail was 2 feet 6 inches above the bed of the river. There was no doubt whatever that was an example of what was going on in a great many of the level stretches where the rivers were getting close to where they debouch to the sea.

An immense amount of valuable land was swept down from the undulating country, and no attempt was being made to protect it. It was simply so much capital lost to the nation. He believed the time would come when it would be found comparatively cheap means could be adopted to prevent that waste.
Also, Mr. Kernot had referred to the use of piano wire in determining the compression made in the limestone in connection with a pier at the Mitchell River. It struck him that that might not give an absolutely true compression, because the piano wire itself might to a certain extent stretch in the time. Would it not be possible to have another wire stretched to the same tension for purposes of comparison? The amount of stretch was so very slight, and the tension on the wire was considerable, it struck him that that wire might have slightly altered. Apart from the strain due to elasticity of the material, it might have altered owing to temperature at the time.

Mr. JAS. ALEX. SMITH said, in connection with the silting of the Mitchell River, clearly that silting must be entirely abnormal. It could not have been the usual condition of things through the centuries. He would like to ask Mr. Kernot if he could account for that abnormal silting. Some condition, which was not a normal, persistent, natural condition, must have arisen to account for it.

The President announced that further discussion would be postponed to next meeting.
Mr. J. A. Smith said he had nothing to add to the discussion, but as a member of the Publication Committee, he had necessarily read the paper closely. The paper impressed one with the amount of work of preparation, and its value as a record. It was a paper that would hardly lend itself to discussion. It was an authoritative record, a type of which they had all too few. Many of the members were doing work of the first national importance, yet from modesty or pressure of work omitted to place their reasons, their methods, the details and the results on record to their own legitimate credit, and for the information of their successors and the profession. But it was pleasing to see that Mr. Kernot had found time to give them a description of the work he was doing so well.

The President said they could all agree with Mr. Smith in appreciating not only Mr. Kernot's paper, but also those that had produced little or no discussion. A paper need not be valued by the amount of discussion it evoked. That most of their papers were able descriptions of important national works was sufficient justification for their being brought forward, and it was a fine thing for their "Proceedings" to have such matters included.

Mr. M. E. Kernot, in reply, thanked the President and Mr. Smith for the kind remarks about his paper. He felt that the work on that line was of sufficient value to place on record, and no institution was more entitled to have the benefit of that record than this one. He had been cautioned once or twice upon his rashness in bringing it forward, but the results so far had given him nothing to repent of.

He had not undervalued the silence of the members, because the work had been the subject of a large amount of local criticism. He did not write the paper so as to lead to discussion, because having been cautioned as to the possible troubles that might arise he was perhaps a little guarded. He thought he could write a more slashing criticism himself than anything that had been offered there. But he thought the placing on record of any new class of work, information that might be of
use to others who had to tackle similar work later on, was one of the objects of the Institute, and sometimes in the discussion more points were brought forward than were in the original paper.

The first point was brought forward by Mr. J. T. N. Anderson, as to the measurement of the compression of the foundation by means of piano wires. The position was that in testing the foundation at a considerable depth below water, they had a plate fixed securely to the bottom, which could not be perfectly “trued” beforehand. They stretched two piano wires and placed them over pulleys and weighted them to get them taut, and applied means of measuring the amount of compression that took place. But the question was, what movement would take place in the piano wires themselves? They stretched another comparison wire with the same load, and found the wire stretched considerably. Mr. Anderson’s question was, would it not be possible to have another wire stretched to the same tension for the purpose of comparison? The answer was they had done so, and were able to judge the amount of stretch in the wires that went down to the foundations. Mr. Anderson had also mentioned the possibility of an alteration in the material through a change in temperature in the time. That was quite possible. He was not there, and the gentleman in charge was now in England on munition work, but he had confidence in the men, and that no ordinary error that could be eliminated would be allowed to remain.

A larger question had been alluded to by Mr. J. A. Smith, that was the silting of the Tambo River. It was the case of a rapidly-running river with a well-defined channel which in the last 20 years had silted up very largely, though the current of the river was quite sufficient to scour out the silt and remove it. He had studied the silting up of rivers more or less at different times. Each case had to be studied under local conditions. In the present case it seemed to him that first of all the question was raised as to why the silting was occurring. The general opinion was that the clearing and cultivation of the country led to a quicker run off of the rainfall with increased scouring action. Many of the Gippsland rivers were scouring away their banks to an enormous extent. The Avon River had extended its banks to the extent of the removal of
hundreds of acres within the last twenty or thirty years. In
the case of the Tambo River he believed that in the course of
a flood the river was scoured out to something like its original
depth, but as the flood eased off the silt was again deposited,
and before the flood was over the river returned to its silted-up
condition. They had provided for that by carrying their
foundations deep enough to allow of the scour taking place
without the piers being endangered. There were many things
in connection with the siltation of rivers that were worthy of
study; and the case of the Tambo was a most interesting one.
Discussion closed.

GASHOLDER CONSTRUCTION.

(Paper by H. E. Grove.)

Mr. C. F. Lindbladé said he would like to ask Mr. Grove
a question with reference to the Brighton gasholder. It
appeared to be totally different from the one described. Could
Mr. Grove give a simple description of that class of gasholder?

Mr. H. E. Grove said the Brighton gasholder was an ex-
cellent example of a Gadd and Mason Holder (so named after
its inventors). Those members who had seen that holder,
would have observed that there was apparently no external
guide framing. The guide framing was there, however, and
consisted of heavy bulb-headed rails rivetted directly to the
sides of the lifts at an angle of 45 deg. with the horizontal.
These rails worked in carriages fixed on the next outer lift, or
the tank as the case might be, and each carriage contained
four grooved pulleys so arranged that two were on each side
of a rail. In action, when the gas was admitted to the holder,
the rails would cause the holder to revolve as it rose; any un-
balanced conditions, such as wind forces, etc., would be
counteracted by the rails locking in the carriages, but the lock-
ing would not prevent the free rise and fall of the holder owing
to the angle at which the rails were set.

The apparent simplicity of this form of construction did
not imply that it had any great advantage over the type of gas-
holder described in the paper. It was obvious whatever type of
holder was adopted, that the forces acting on it were substan-
tially the same, and that sufficient material must be employed
Library Digitised Collections

Author/s:
Kernot, Maurice Edwin

Title:
Bairnsdale to Orbost railway (Paper & Discussion)

Date:
1917

Persistent Link:
http://hdl.handle.net/11343/24599

File Description:
Bairnsdale to Orbost railway (Paper & Discussion)