5 inches when notched, and a minimum thickness of 4 inches under. On the Narrabri-Moree line the sleepers were supplied on the butty-gang system, and cost from 2s. 3d. to 2s. 6d. each. They were delivered to the contractor at Narrabri, and he had to cut them down to a uniform 8 feet length, and adze them for the rails. On the running track they are spaced fourteen to the 30-feet rail, or about 2,500 per mile, and the minimum bearing surface on the ground or ballast is 15,000 square feet. On the type country section the bearing area is 12,000 square feet, so to some extent the absence of ballast is compensated for by the closer sleepering. On the Narrabri to Moree and Parkes to Condobolin ironbark is used for the sleepers, and on Jerilderie to Berrigan chiefly red gum.

The rails on the running track are of the flanged type, steel, and weigh 60lbs. per yard. They are laid with an inner cant of 1 in 20, to suit the coned tyres of the rolling stock. The joints are suspended between sleepers 1 foot 9 inches apart; fish-plates weigh 20½ lb. the pair, and are bolted together with four ¾-inch steel bolts, the holes in rail being slotted to provide for expansion. The rails are fastened to the sleepers with wrought-iron dog-spikes, ¾-inch dia., weighing ⅞ lbs. each, four spikes to each sleeper. Wood screws are used only in longitudinal bearing timbers, or where a series of fastenings are made on the same line of fibres. On bridge-spans 71½ lb. steel rails are used, and on sidings 70 lb. iron rails, all of the flanged type.

Appended is a detailed cost of the running track per mile, taking average prices:—

Item.	Quantity.	Rate.	Cost.
Rails	95 tons ...	£6 0 0 ..	£570
Fishplates	3·2 ,, ...	8 10 0 ...	27
Fishbolts	·7 ,, ..	16 0 0 ...	11
Spikes	4·0	11 0 0 ...	44
Sleepers	2,500 ...	0 2 6 ...	312
Ballast (earth)	80 chs. ..	0 5 0 ..	20
Laying Perm. Way ...	1760 l. yds. ...	0 0 7 ...	56
Carriage of Material ...	103 tons ...	1 10 0 ...	154
		(1d. per mile)	——
Say £1,200 per mile.			£1,194

Prices vary slightly. Sleepers were 3s. 3d. on Jerilderie to Berrigan and Parkes to Condobolin, and cost of laying permanent way on former line 1s. per lineal yard. On the other hand, the permanent way materials cost less for carriage.

The most striking feature in the section of the running track is the absence of ordinary ballast, and the substitution therefor of earth ballast. The success of this material in fulfilling its primary purpose, which is to throw off all water from the track and keep the sleepers on a dry base, will depend largely on its character. The best soil is probably a sandy

or gravelly loam, or even clay, as the harder material works to the top and forms a firm skin, practically watertight. The material on the Jerilderie-Berrigan is of this character. On the Parkes to Condobolin a firm red soil is found which answers very well. The black soil on the Narrabri to Moree is, however, too soluble in water, so to speak, and too friable, though it occasionally cakes up hard enough for anything. A clear way is left under the rails for the water to escape. Considerable stability is, of course, imparted to the sleeper through being bedded in the material. The cost on all three lines was 5s. per lineal chain.

It has been already stated that the earthworks are of very light character. It is here, in fact, that the great cheapness of the pioneer lines has been secured. Taking, for instance, the Narrabri to Moree line, the average cost per mile for earthwork, including cuttings, banks, forming, side ditches, mitre drains, deviation of watercourses, etc., only amounts to £190 per mile.

Bridges—.The waterways, which are numerous, but mostly of a shallow type, run to £225 per mile. The most difficult crossing was over the Namoi River. This is liable to sudden flood, and spreads considerably over the banks. Viaduct spans of 24′ 0″ and 14′ 0″ form approaches to the trussed spans, three in number, over the river. These latter are of 61-feet span, and braced on the Howe system, with ironbark chords, struts, floor beams and stringers, and steel suspension bolts with wrought iron nuts and washers. They are wind braced on the lower chords with 9″ x 3″ timbers spiked on, and have lateral stiffeners in the form of steel angle-bars fastened to top-chords and overhanging ends of floor beams, with adjustable joints.

The depth, centre to centre, of chords is 10′ 3″, and clear width of roadway 14′ 0″. These spans and a single span over Narrabri Creek were tendered for in a lump sum, amounting to £1,320, including cost of the trestle piers, or £5 8s. per foot run, a very low price for a bridge of this character. The river bed is of a soft nature, and piling had to be driven from 28 feet to 38 feet below surface to obtain a firm bearing. This necessitated the use of piles from 60 feet to 70 feet long, with 18 inches minimum diameter at the head. Considerable difficulty was experienced in obtaining suitable timber of these dimensions, but it was finally procured at Wyong. The piles were driven to a test of ⅜″ to ¾′ set, for a blow of 25 cwt. falling 8 feet.

Staging was erected between the piers, consisting of 14″ x 14′ oregon, stiffened by struts from piers reaching to one-third the span on each side. The trusses were first assembled on the ground alongside the southern approach, and put together on the flat, properly fitted and cambered. They were then dismembered, and the individual pieces lifted on to approach by a jib crane, and run out on the staging to

place. The floor beams were first laid in position, properly spaced, and the lower booms laid upon them, the rest of the truss then being built up on top. The booms consist of timber varying from 34 feet to 45 feet in length, and of 12″ x 7″ and 14″ x 7″ scantling. These sizes were also difficult to get, but good timber was eventually obtained from the coast at Hawkes Bay. It may be noted in passing that, in the construction of truss spans for cheap railways, this colony is at a disadvantage compared with America, where suitable timber is generally to be obtained close to the site of bridge. The test load for the spans consisted of two engines, 205 B. class, placed head to head. These weighed 69 tons each, over a wheel base of 39 feet 4 inches, the max-axle load being 13.4 tons. The deflection was only ½″, no appreciable difference being noted between high and low speeds. The floor beams deflected ·11 inch. The spans may, therefore, be considered eminently satisfactory.

The whole length of the viaduct is 972 feet, divided up into 48 14′ 0″, 2-14′ 9″, 2-23′ 8″, 2-61′ 1″, and 1-61′ 10″ openings. The writer is indebted for most of the above interesting particulars to Mr. Wade, assistant to the supervising engineer.

Fencing.—Pioneer lines are mostly unfenced, except in the vicinity of stations, where a cheap post and wire fence is used. As trains are only run in the day, at low speeds, there is but little risk from collision with straying animals, which at night are fond of sleeping on the cool ballast. Where the line crosses a boundary fence, cattle-stops are used, consisting of timber grids laid longitudinally and spanning excavated ditches. These have proved effective. Occasionally rabbit-stops have been found necessary. Cattle-stops are also placed at level crossings in the vicinity of stations.

Stations.—The station arrangements are usually of a simple character, and designed to meet the expected requirements of traffic. The terminal stations are, of course, the most important, and are provided with passenger accommodation and landings, goods sheds and platforms, wool loading banks, turntables or triangles in lieu thereof, wrought-iron tanks of 10,000 to 20,000 gallons capacity on brick towers, with pumping machinery where necessary, jib water-cranes, and engine and carriage sheds. As good traffic in live stock is expected, sheep and cattle yards and races are provided at points on the line where convenient to assemble the stock. Metalled approaches are made on the lines of traffic in the enclosures. A stationmaster's cottage is constructed where necessary. The passenger landings are only six inches above rail-level, steps being provided on the carriages. Turnouts from the main line are 12 chains radius, and from the sidings 10 chains. Solid steel crossings are used, there being a large number in stock. Catchpoints are provided whenever necessary.

Sidings are constructed at points along the line to catch cross traffic, or to form points of concentration. They are of sufficient length generally to accommodate from 15 to 45 trucks, requiring about 5 to 15 chains of rail. At Woolabra and Moree the water supply is taken from artesian bores in the vicinity. At other places, such as Gunningbland Creek, for instance, on the Parkes to Condobolin, the water has to be impounded and stored in reservoirs.

The total cost of a terminal station, such, for instance, as Moree or Condobolin, would be from £4,000 to £4,500. The final cost of the completed line may be taken at £2,000 per mile as an average.

Rolling Stock.—Three trains, mixed goods and passenger, run per week each way on the Jerilderie to Berrigan and Parkes to Bogan Gate (first section of the Parkes to Condobolin, the second section being not quite completed). On the Narrabri to Moree a daily mixed runs through from Werris Creek. The engine is of class C. (79), and weighs in full steam 61 tons, being 39 tons on the engine and 22 tons on the tender. The max. load per axle is 12·7 tons. The engine has four coupled driving wheels, 5′ 6½″ diameter, and a bogie truck, while the tender has three wheels on a fixed base of 11′ 0″. The engine wheel-base is 19′ 6″, and total length of wheel-base 38′ 7¾″. The tender has a water capacity of 1,800 gallons, and coal capacity of 4½ tons. This engine has the following haulage power under varying circumstances :—

Grade.	Tons.	Speed per Hour.
1 in 40	88	20 miles
1 in 60	118	25 miles
1 in 75	115	30 miles
1 in 100	106	35 miles

It has not been specially designed for pioneer lines, but selected from the existing rolling stock as suitable for the purpose. Excluding tank engines, which are wholly unsuitable, it is one of the lightest in stock. Most of the types of the ordinary goods rolling stock are used—from the heavy bogie wagon weighing 11·35 tons and capable of carrying 25 tons, to the common four-wheeled type, carrying 9 tons for a tare of 5·65 tons. The former has a composite trussed underframe, and the latter a metal one of simple character. Sheep and cattle vans of the four-wheeled type, and also a cattle van of the bogie type, are in use. This latter will carry 20 head of cattle, while the sheep van will accommodate 100 head of sheep. The passenger car resembles the suburban American type, with intermediate partitions dividing the car into three compartments, first, second, and smoking, accommodating 16, 28, and 16 passengers respectively, or a total of 60.

Most of the above information, and exhibited drawings of the rolling stock, have been kindly supplied by Mr. Thow, Chief Locomotive Engineer, to whom the writer is much indebted. In their last

report the Commissioners spoke favorably of the prospects of the lines then open, and seemed to anticipate little, if any, loss from the working thereof when the full year's results had been obtained. During the heavy rains in the early part of the year, some washaways occurred on the Narrabri to Moree, and a few more waterways were provided. This line is likely to cause more trouble than either of the other two, which traverse drier country, but has, on the other hand, better prospects of traffic.

Summary.—Summarising results, it seems justifiable to assert that the introduction of pioneer railways into this country marks an important epoch in its commercial progress. True, it is rather early to form an opinion of the thorough success of this class of construction, as it is largely experimental, and sufficient time has not yet elapsed to fully test the working, but a critical examination of its leading features should satisfy most engineers that the pioneer line is eminently adapted for the particular work it has to do. The rails are of substantial weight, and well supported on close sleepers (of good quality, even if rough), to which they are firmly attached. This is the primary element of a good railway, and in no other way can strength and stability be more economically obtained. With a light traffic and low speeds such a road is safe and workable, even with an uneven yielding foundation and defective maintenance. Moreover, it lends itself admirably to improvement when traffic exigencies require it. By lifting and packing with good ballast the track is brought up to the standard of the average country line, as hitherto constructed. The grades so far are good, (though it is not to be expected that they will always be equally so in future lines), and the curves are moderate. Even where sharper curves may be found necessary, they may be eased off at the ends, and the bogie rolling stock of New South Wales is quite competent to negotiate curves down to 6 chains radius. On the Tamworth to Manilla, for instance, there are numerous 12 chain to 15 chain curves, all of which have lengths of generally four chains transition on to the tangents. On this line the ruling grade is 1 in 66, and the earthworks much heavier than on the lines dealt with in this paper.

Most of the country traversed by the pioneer lines is devoted to pastoral purposes, and but little to agricultural. This is not the fault of climate or soil, but simply the absence of facilities, and inaccessibility of large markets for produce. The black soil country round about Narrabri and Moree is described as being exceedingly rich and fertile, the rainfall is ample, and the climate generally very favourable to the growth of wheat and other cereals. Nevertheless, the farmer has avoided this portion of the colony owing the absence of any market for his produce, and has accepted less promising country with better facilities. The advent of the pioneer railway should change this, and give the oppor-

tunities that are being asked for to settle on the land. The pastoral industry absorbs but little labour, and thus our cities are congested, our country settlements deserted. Agriculture, on the contrary, gives employment to a proportionately great number of men for the same area of land. Thus, it may be expected that where the country is favourably blessed with good soil and climate, population will follow in the wake of the pioneer railway—and there is abundance of such country. Former deserts have been made fertile by the consolidation of the ground from the trampling of animals, so that the water that once escaped through it to mysterious depths is now held and conserved for vegetation. Where rainfall is scarce, artesian bores have supplied its place. Agricultural prospects are therefore good, but without railways they cannot develop. That these facts are generally recognised is made evident by the energy with which the construction of pioneer lines is being pushed forward by the present Government.

So far, 147 miles have been practically constructed, 55 miles are, or will be shortly in course of construction, and proposed lines involving an additional 171 miles are before the Works Committee for consideration. The more recent lines are being constructed by day-labour, under departmental supervision.

The railway system of a country has been compared to the artery system of the human body, forming, as it does, channels of circulation. It is, moreover, a nerve system, whereby the various portions of the community are kept in touch with each other, and mutually enlightened. The back-blocks settler has hitherto, however, had to cut himself adrift from the world and bury himself in the weird gloom of the Australian bush. To him the pioneer railway comes as a linking thread with the busy centres of life in the world, and brings with it a warm thrill from the great heart of humanity. This is the moral aspect of the question, intangible, perhaps, and sub-conscious, but not the less real.

In conclusion, the writer wishes to acknowledge his indebtedness to the Engineer-in-Chief for Railway Construction for the use of drawings to illustrate the paper, and to the other gentlemen connected with the Department who kindly volunteered information on many points.