sand or sandstone, which is scarcely strong enough perhaps to stand under very heavy traffic. Nevertheless, it makes an excellent road, as experience in wet weather has shown. Should it, however, prove necessary, later on, when the traffic from the mines increases to a large amount, to obtain ballast of a superior character, the Chief Commissioner for Railways, whom I interviewed on the subject, has promised to supply broken metal from Tarana.

Observations of the flow of water across the line during storms have indicated the fact that, with few exceptions, it mostly soaks into the soil and passes under ground, and that little provision in the way of culverts is necessary.

Substantial and well constructed log culverts have, however, in all cases, been put in. On the steep sidlings overlooking the Wolgan Valley, special arrangements have been made to divert the water into culverts crossing the line on the solid ground, so as on the one hand to avoid lengthy and sometimes impossible construction along the course of the water, and on the other hand to minimise the possibility of scour.

The design of the tunnels adopted is similar to that of the Railway Construction Department in this State, with the exception that in view of the sharp curves used, the haunches have been widened so as to permit of the passage of the longest carriage in the possession of the Railway Commissioner's Department. No lining has been done, as owing to the soundness of the rock, it was found to be quite unnecessary.

The earthworks at the Junction end of the line were, it may be said, commenced in November, 1906, and considerable strength concentrated on these, but before Christmas, 1906, a start was made with the line at 26 miles 50 chains, working back towards the tunnel. Gangs were also located as soon as possible on the heavy grades from 20 miles towards the valley, and a commencement was made with No. 2 Tunnel at both ends. A junction between the two headings was effected on June 9th, 1907.

The permanent way was brought along as rapidly as the completion of the formation ahead would permit, and at the end of November, 1907, the rails were laid up to 31 miles 50 chains, when further progress was for the time blocked by a large cutting. As, however, the said cutting is within the works area, the railway may be taken to have reached its terminus within the time mentioned, and I may be permitted to point out that the completion in so short a time as 12 or 13 months of a railway involving so many difficulties is one for congratulation.

WATER SUPPLY AT DEANE.

Considerable difficulty was experienced in obtaining a water supply at or near this part of the line, as the latter follows the top of the spur. A fair supply was eventually obtained at about a mile from Deane Station, where a swamp exists. The gully here has been dammed, and an excavation added to hold a good supply of water. The reservoir thus formed is 200 feet below the level of the engine tank at Deane, and the water has to be pumped up. The plant erected for this purpose is as follows: At the station there is an 8 horse power Cundell Oil Engine, driving by means of a belt a Siemens Dynamo, which produces current at 500 volts. At the dam there is a three throw pump, direct driven by an electric motor. Between the engine house and pump current is conveyed by copper cables, and there is another pair of wires by means of which, with the aid of a starting switch in the engine house, the pump can be set in motion.

In this way the pump can be started without the necessity of any man visiting the pump. Labour is thus saved, and the water in the tanks can be replenished without delay. At both station and dam the machinery is housed in a small building. A line of 3 inch pipes conveys the water from the pump to the engine tank.

In connection with the water supply, an elevated stage has been erected, carrying six 400 gallon tanks as at the Junction, and there is also a coal stage to carry 50 tons of coal.

Engine sheds have been provided at the Junction, and near the bottom of the steep incline. At the first of these, water is obtained by pumping, at the second by gravity. Triangles for turning the engines are provided at both places.

A separate telephone line has been provided for railway working, and in accordance with the conditions laid down in the lease, namely, that traffic is to be conducted to the approval of the Chief Commissioner, steps have been taken to install the staff and ticket system.

It may be interesting here to state that the earthworks in the open cost, on an average, 1s. 6½d. per cubic yard, and that the tunnel excavation was got out for 8s. 6d. per cubic yard, also that the sleepers sawn at the mill, which were chiefly stringy-bark, cost 1s. 8½d. each.

On the completion of the deviation works, which are now being carried out to cut out the Great Zigzag, the position of the Junction with the Western Line will be shifted about a quarter of a mile towards Sydney, and the Commonwealth Oil Corporation's trains will have to traverse part of the old line, which will be left in to form the connecting link.

I will now give a short description of the several types of locomotives above mentioned with some of the advantages and disadvantages possessed by each.

SHAY TYPE.

The cylinders are, except in the largest engines, three in number, placed vertically on the right hand side, and the driving power, instead of being applied direct to the driving wheels, is conveyed through a horizontal crank shaft running from end to end of engine and tender. The cranks are placed at equal angles round the crank shaft. In order to allow of flexibility there are universal joints, and as in traversing curves the length of the shaft requires to be shortened and extended according as the curve is to the right or to the left, there are sleeves permitting of this. On the horizontal shaft are placed cone pinions, which at each wheel on that side of the engine and tender engage the teeth of a bevel spur casting bolted on to the outside of the wheels. The front part of the engine is supported on a four-wheeled bogie, and the fire-box end is also supported on a similar bogie. The tender in the smaller locomotives is carried on one bogie, but on the largest types there are two bogies. All the wheels of both engine and tender are driving wheels. In order that the loading may be equally distributed on both sides, and to allow for the additional weight due to cylinders, shaft and gearing on the right hand side, the boiler is placed to the left of the median line of the locomotive, so that when viewed from the front it has a lopsided appearance.

Advantages of Type.

Great hauling power, due to the fact that the weight of tender as well as engine is available for adhesion.

In the ordinary two-cylinder engine the number of impulses for one revolution of the driving wheels is four. In the Shay type there are six impulses to each revolution of the horizontal or driving shaft, and the gearing being as 45 to 20 or as 9 to 4 the number of impulses per revolution of the wheels is 6 x 9-4 equal $13\frac{1}{2}$, by which means a very even turning force is applied, and the effect on heavy grades is this, that a locomotive with maximum load behind and coming to a stand on the ruling grade is able to start off again without difficulty.

The rigid wheel base is 4ft. 4in. only, in consequence of which the Shay locomotive is able to traverse very sharp curves.

The tube length being 11 feet only, the difference of level of the water in the boiler on a heavy grade is not serious.

The wear of the flanges of the different pairs of wheels varies according to position; for instance, the leading wheels of the bogies, particularly those of the front one, wear faster than the rest. As all wheels and axles are exactly similar in design, the different pairs of wheels can be changed in position, a pair that is less worn for instance being put in the place of one that has suffered a good deal. In this way the operation of turning up the wheels may be considerably postponed.

Disadvantages—Slow speed on level and undulating country.

The maximum speed at which locomotives of this type will travel without excessive vibration is about 17 miles per hour, but probably a speed of from 12 to 15 miles per hour should be looked upon as sufficient. With greater speeds than these wear and tear begins to be excessive.

The wear and tear of the gearing is often stated to be excessive. I have not found it to be so. Facts are better than theory in a case like this. No. 1 Engine has worked for 3½ years without a complete overhaul, and it is only now found necessary to renew the pinions.

The following are some of the particulars of the locomotives owned by the Commonwealth Oil Corporation:—

70 Ton Shay Locomotive.

3 cylinders, 12in. x 15in.
Boiler pressure, 200lb. per sq. in.
Weight, empty, 111,000lb.
Weight, in working order, 141,000lb.
Tank capacity, 2500 imperial gallons.
Gear, 20 to 45.
Driving wheels, 36in. diameter.
Total wheel base, 40ft. 3in.
Tube length, 11ft.
Rigid wheel base, 4ft. 4in.
Tractive power, 29,800lb.
Grate area, 22.5 sq. ft.

These locomotives have hauled behind them 215 tons gross up the 1 in 30 grades from the junction towards Newnes, and have taken behind them up the 1 in 25 grade from the valley 180 tons gross.

In accordance with general American practice, the fireboxes are constructed of steel, but as the water on the mountains does not produce scale no trouble from that source has arisen. On the contrary, slight pitting was at first observed, which tendency, however, was obviated by the addition of a small quantity of lime to the water.

90 Ton Shay Locomotive.

3 cylinders, 14½in. x 15in.
Boiler pressure, 200lb. per sq. in.
Weight, empty, 152,000lb.
Weight, in working order, 185,600lb.
Tank capacity, 2916 imperial gallons.
Loading—Front truck, 70,000lb.; middle truck, 67,000lb.; rear truck, 56,000lb.
Gear, 20 to 41.

Driving wheels, 36in. diameter.
Total wheel base, 44ft. 1in.
Rigid wheel base, 4ft. 10in.
Tube length, 12ft.
Tractive power, 40,400lb.
Grate area, 23 sq. ft.

MALLET TYPE.

This type of locomotive has long been used on the Continent of Europe, especially in the more mountainous parts of Switzerland, but until six years ago it has not found favor in America. Since that time many locomotives of large size have been built by the American Locomotive Co. and the Baldwin Locomotive Co., the first that was manufactured having been produced by the former company and exhibited at the St. Louis Exhibition in 1904. It weighed in steam nearly 500,000 lb., and since that time even larger locomotives have been built. While this expansion of the use of the type is going on in America it is curious to observe that it is being abandoned in Europe.

The boiler is carried on two four or six wheeled trucks, the hind one carrying two high-pressure cylinders, being rigidly fixed to the boiler. The front one with the low-pressure cylinders is pivoted and is arranged for lateral movement. In this way sharp curves can be negotiated.

Advantages of type:—Ability to negotiate sharp curves; large hauling power, for although the weight of the tender cannot be utilised, the whole of the weight of the engine is available for adhesion, and there is no loss due to bogie or trailing axle, as all the wheels of the engine are drivers.

Disadvantages:—Conveyance of steam through flexible connections, though in the case of the Mallet it is only the low-pressure steam that is thus treated. On sharp curves the front end of the boiler shifts over very considerably towards the outside rail, and heavy additional loading is thereby placed upon the latter.

The boiler tubes are 14ft. to 16ft. long, which is by some considered too long, as the front end of such long tubes is not effective as heating surface.

The following are the particulars of an engine of this type offered to the Commonwealth Oil Corporation:—

Mallet Type (Baldwin Locomotive Co.)

Cylinders, 15in. x 22in., and 23in. x 22in.
Boiler pressure, 200lb.
Drivers, 40in. diameter.
Boiler, 54in. diameter.
Tube length, 15ft. 6 in.

Total wheel base, 22ft. without tender.
Rigid wheel base, 7ft. 6in.
Weight, in working order, 132,000lb.
Weight of tender, 70,000lb.
Total, 202,000lb.
Tank capacity, 3500 gals.
Tractive power, 32,917lb.

MEYER TYPE.

This type of locomotive differs from the Mallet chiefly in the fact that the boiler is supported by two bogies, in both cases resting on pivots, so that the load on each bogie is evenly distributed on the rails. The cylinders are four in number, high pressure, two to each bogie. The wheels of each are four or six wheeled coupled according to the size or weight of the locomotive.

The advantages are the same as in the Mallet, with the additional one that the boiler being pivoted at each end, the load is always central to the permanent way. There is this disadvantage, however, that flexible high-pressure steam connections are required at each end.

The following are some particulars of a locomotive offered by Kitson and Co., of Leeds, to the company, and I give them as an example:—

Meyer Type (Kitson and Co., Leeds).
Class C with Tender.

4 cylinders, 15½in. x 23in.
Boiler, 4ft. 9in. diameter.
Tube length, 13ft. 4in.
Boiler pressure, 165lbs. per sq. in.
Drivers, 3ft. 6¾in. diameter in groups of 6 on two bogies.
Total wheel base, 33ft. 9in.
Rigid wheel base, 8ft. 6in.
Weight in steam, 113 tons 5cwt.
Tank capacity, 3250 gallons.
Tractive force, 35,200lbs.

FAIRLIE TYPE.

This design of locomotive is now of very old standing. It was first designed for the Festiniog Railway in North Wales, which has a gauge of about 2 feet. The chief feature is that there are two short boilers placed back to back, on a continuous frame, the funnel end of each boiler being support by a bogie, four or six wheels coupled, carrying last a pair of cylinders.

The double boiler has the advantage that the variation of its water level on steep grades does not cause inconvenience;

but there is the disadvantage that there are two fires to attend to, and as is the case of the Meyer locomotive, flexible connections are necessitated to each pair of cylinders.

Engines of this type are built by the North British Locomotive Company, and I furnish some particulars of a locomotive offered to the Commonwealth Oil Corporation:—

Fairlie Type (North British Locomotive Co.)

Four cylinders, 16in. x 22in.
Boiler pressure, 165lbs. per sq. in.
Drivers, 3ft. 9in. diameter.
Weight in steam, 73 tons.
Tank capacity, 2000 gallons.
Tractive force, 35,600lbs.

There are several other types of the so-called articulated or flexible locomotives, one of which, Hagans, may be known to my hearers, besides which there have been various methods adopted, such as the Gölsdorf system of the Hanoverian Locomotive Co., already mentioned, to enable the locomotive to traverse sharp curves. The very commonly used bogie or pony truck, which carries the front end of the majority of locomotives at the present day, and the trailing axle with lateral action are attempts in the same direction.

I will confine myself to mentioning one other type of locomotive of recent design, emanating from the workshops of Beyer, Peacock and Co., namely:—

THE GARRATT TYPE.

This type differs from the Meyer and the Mallet, inasmuch as the centres of the two bogies are situated beyond the ends of the frame. The pivots at the ends of the frame rest on the bogies between the near and middle pairs of wheels, that is, in the case of the six-wheeled bogie. A tender is dispensed with, and the water is carried in two tanks, one of which, that at the front end is the larger, while that at the fire-box end is less capacious, as room for coal has to be provided as well. The weights have been very carefully worked out, and the loading of the axles is thus remarkably uniform. The boiler is of large diameter, and very short, it being maintained by the makers that the best results are thus obtained.

The advantages of this type are obvious; it is very flexible; all the wheels are driving wheels, and the whole weight is available for adhesion, and although it can scarcely compare with a geared locomotive, such as the Shay for stopping and starting on grades, it has the advantage on easier grades, and on the level in being able to run at high speed.

I give below some particulars of an engine which was offered to the Commonwealth Oil Corporation, and I have no doubt that had the price been a little nearer that of the Shay, one would have been now working on the Wolgan Valley Railway.

Garratt Type (Beyer, Peacock and Co.).

Four cylinders, 17in. x 22in.
Wheels (6 pairs) 3ft. 9in. diameter.
Total wheel base, 42 feet.
Rigid wheel base, 9ft. 6in.
Boiler, 6ft. 3in. diameter.
Tube length, 9ft. 6in.
Boiler pressure, 160 lbs. per sq. in.
Tank capacity: Smoke box end, 1350 galls.; Firebox end, 650 galls.; Total, 2000 galls.
Tractive power, 38,400 lbs.
Weight, in steam, 82 tons.

All the above are very serviceable types of locomotives which traverse with ease curves of sharp radius. There can be no doubt whatever of their suitability where it is desirable to save expensive earthworks in very rough country. There are many districts in New South Wales, especially along the coast, which want opening up by railway, but where the cost of a line with curves of large radius and easy gradients would be prohibitive. It is better to put up with the disadvantages of sharp curves and steep grades than languish altogether for the want of a railway. The Wolgan Valley Railway is an example of what can be done with the standard gauge. The average cost of the line without rolling stock was about £4000 per mile, whereas if only 12 chains' curves and 1 in 40 grades had been insisted on, the expenditure must have run into £16,000 per mile, and probably much higher.