MAIN ROADS

A month to month account of the activities of

THE MAIN ROADS BOARD OF NEW SOUTH WALES

Issued by and with the authority of the Board

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The Principles of Transport Co-ordination.

By T. H. Upton, M.C.E., M.Inst.C.E., M.I.E.(Aust.)

THE need for the co-ordination of transport is becoming increasingly recognised. For the time being, attention is largely focussed on the problem as it concerns road and rail transport, but the subject is larger than this. All forms of transport—sea, river, road, rail and air—are bidding for their share of the world's transport and in due course have to be considered. Already in this Commonwealth, parallel service has arisen between rail and air along the East-West route connecting Adelaide and Perth. At a later stage we may expect to see airships as well as aeroplanes claiming their part of the work to be done.

Is each form of transport to be allowed to compete indiscriminately for its portion? Formerly the answer was "Yes." Now it is more generally "No." Unrestricted competition means loss and inefficiency. In a young country such as Australia, where the utmost efforts of the community are required to develop its resources and the greater proportion of the transport system is either Government owned or Government subsidised, such losses must be avoided if we are to play our proper part in the business of the world. To do this, some measure of Government or semi-Government control is necessary. How is this to be done?

There are doubtless many methods which will be tried in the Commonwealth before a generally accepted procedure is adopted and it is moreover outside our purview to pronounce officially in favour of one or another. But it is thought that there are certain common principles on which any scheme of co-ordination must be based to be successful, and if these can be ascertained, suitable machinery can then be developed. What may these be?

This subject was investigated by the Commonwealth Transport Committee which reported to the Governments of the Commonwealth and the States in May, 1929, on the Co-ordination of Transport in Australia, and it is proposed to state and to analyse its conclusions. These were that the following general principles should apply to any scheme for effecting co-ordination:—

"(a) Each transport agency should be regarded as providing a definite link in the chain of transportation. Each has limitations as to capacity, speed or convenience, and should be regulated as far as practicable to its own sphere.

(b) The determination of the respective spheres of action should be made by some authority which can ensure that the operations of all are knit together into systematic whole.

(c) The co-ordinating authority should not be interested in one transport agency more than another. It must have an eye to the whole transportation system.

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(d) Each transport agency should be self-supporting, but if a service is necessary in the interests of the State, which will not be self-supporting, such as for development, then a definite policy of subsidy out of other resources should be laid down.

(e) Co-ordination should not prohibit competition, but should regulate the various services to prevent overlapping and consequent economic waste.

(f) Co-ordination should not involve interference in the administration of any transport agency.

(g) All proposals for a new transport service or facility should be examined by the co-ordinating authority to determine

(i) the necessity for the new service;

(ii) whether the proposed service is the most efficient means of providing the transport facility required, or provides a public convenience which cannot be supplied by existing services;

(iii) the possibility of the new service providing either directly or indirectly a return sufficient to cover interest, sinking fund, and operating expenses."

Let us examine these.

(a) is fundamental to any scheme of co-ordination. If one form of transport is considered all-capable, then obviously co-ordination would consist of scrapping all the rest. If, however, it be agreed that each has its definite part to play in the scheme of transportion, then this is the test which must be applied in considering whether one or the other agency is to perform a particular service.

(b) and (c) enunciate the principle of the necessity of an umpire to decide between the alternatives, who, if his (or its) decision is to be accepted, must be impartial.

(d) is a business principle which, if complied with, enables a check to be made as to whether each agency is being run on economic lines. It has already been accepted in the legislation of New South Wales in the case of railways by a subsidy of £800,000 per annum being paid from Consolidated Revenue on account of the losses on developmental lines and, in the case of special unemployment relief works, by only portion of the liability for the interest and sinking fund of loan moneys expended thereon being placed on the transport agency assisted thereby. In other words, since unemployment relief is the task of the State as a whole, and frequently involves the undertaking of works for which there is not otherwise an immediate economic need, portion of the liability for them is borne by Consolidated Revenue.

(e) suggests that, providing overlapping and consequent waste do not occur, competition is healthy. Thus the railways and interstate steamers provide means of passenger and goods transport between the various capital cities, and although they cater for somewhat different types of traffic, the fact of alternatives being available ensures that each form of transport must do its utmost to give service. Cut-throat competition between the two services involving an aggregate development much in excess of the total traffic available would not, however, be to the permanent advantage of the community.

(f) is a recommendation that, apart from the regulation necessary to ensure co-ordination, interference with the administration of any transport agency should be avoided. In other words, the co-ordinating body should not be allowed to dictate to the railway administration the type of engines it should use, or the instructions it should give to its staff, nor to the shipping agencies, the size of their ships and the frequency of their service, nor to the road authorities the class of construction or the system of maintenance to be adopted on the roads or what works should be done on already proclaimed main roads.

(g) enunciates the bases which are recommended for the determination as to what new services should be established, *e.g.*, a new railway or developmental road or port, &c. In other words, it suggests that the development of any area should be investigated on the broadest possible lines, instead of separate consideration being given to projects for new railway lines, developmental roads or ports, &c., and that the framework of a general scheme of development should first be determined upon, after which any further steps would be taken in accordance therewith. The advisability, in the Board's opinion, if the public interest is to be conserved, of adopting such a policy was referred to in the Board's Fourth Annual Report presented to Parliament last year.

It will be seen then that the task of co-ordination calls for the widest possible vision, and the broadest possible knowledge. The first step to ensure that it is undertaken rightly is to determine the principles upon which it should be based and it is with the objective of stimulating thought and developing definite views upon these that the above discussion is offered for consideration.

News of the Month.

METROPOLITAN DIVISION.

The widening of the bridge over Duck River, on Parramatta-road in the Municipalities of Auburn and Granville, has been completed by the contractors, Messrs. S. Haunstrup & Co. Pty. Ltd.

More than 3 miles of concrete pavement 20 feet wide have now been laid on the Hume Highway from the Water Race at Carne's Hill towards Narellan.

The contractors for the construction of the ferry docks at Kangaroo Point and Mooney Point, on the Hawkesbury River, have completed the driving of all piles and expect to finish the whole of the work included in the contract during the present month.

The reconstruction in cement concrete of High-street, Penrith, is making satisfactory progress, half the road having now been completed and opened to traffic.

The work of tar surfacing the Hornsby–Galston–Dural road (No. 161) is well in hand. Its completion at an early date will provide a surfaced road for the whole distance between Hornsby and Parramatta, via Galston, Dural, Rogan's Hill, Castle Hill, and Baulkham Hills.

Good progress is being made with the reconditioning of a further length of the Castlereagh-road (No. 155) beyond the 6-mile post from Penrith.

The work of regravelling the Campbelltown–Appin road (No. 177) has been completed.

The whole of the Pennant Hills–Rogan's Hill road (No. 156) has been resurfaced with tar.

The concreting of Gladesville-road and Joubert-street, Hunter's Hill, between Mary-street and Figtree Bridge, is now complete and the road open to traffic. It is anticipated that the sections being reconstructed in Burns Bay road, between Figtree Bridge and Longueville-road will also be completed very shortly. The work has been done under contract to the Board by the State Monier Pipe and Reinforced Concrete Works.

The reconstruction of the Cabramatta-Mulgoa Developmental Road (No. 1,087), from Cowpasture-road towards Cecil Park, is now well advanced. The provision of a 4-inch gravel sub-base has greatly facilitated construction in preventing the red clay, which forms the subgrade in this district, working up into the stone base course during rolling. The work is being carried out under contract to the Nepean Shire Council by Mr. W. J. Donovan.

OUTER METROPOLITAN DIVISION.

The new bridge over Wallarah Creek, on the Great Northern Highway north of Wyong, has been completed and opened to traffic. It consists of 5 spans of 35 feet and 2 spans of 25 feet, providing a total length of 225 feet. The width provided is 20 feet between kerbs. The deck is of reinforced concrete, the girders are of steel and the substructure consists of reinforced concrete piles. The new bridge replaces an old narrow timber structure which had reached the end of its useful life.

Union-street, Adamstown, showing widened roadway and new buildings.

The last stages of the widening and reconstruction of the Great Northern Highway in the Municipalties of Merewether and Adamstown have been completed. For 703 feet south of Glebe-road, Adamstown, the highway, which was previously only 48 feet in width has been widened to 66 feet. The pavement is of 2 inch asphaltic concrete on a 6 inch concrete foundation. The widening necessitated the demolition of buildings on the western side, but these have been replaced in a number of instances by new structures, resulting in a considerable general improvement as shown in the accompanying illustration.

The Nattai Shire Council has completed the reconstruction of the Hume Highway in the Municipality of Mittagong, between Pioneer-street, Mittagong, and Gibbergunyah Creek, a lengh of 4,831 feet. The wearing course is of premixed bituminous macadam on a broken stone base course. The work is an extension of the length north of Mittagong constructed by the Nattai Shire Council last year.

The construction of 3 miles of the North Coast Highway terminating at the northern boundary of the Port Stephens Shire has been considerably delayed by unfavourable weather conditions. The work is now well forward. A further contract has been let for an additional length of 2 miles 3,380 feet extending southward from the previous work. The construction throughout consists of a 3 inch bituminous penetration wearing course upon a 6 inch broken stone base course, with culverts and subsidiary works.

In the Shire of Erina, the Council has completed the resealing of 13 miles of the Great Northern Highway between Gosford and Wyong, and will shortly commence widening and superelevating the roadway at several of the sharper bends.

On the Singleton-Denman road (No. 213) in the Shire of Patrick Plains, two low-level timber beam bridges, one at the old Maison Dieu Crossing and the other at Bowman's Crossing, are being erected over the Hunter River.

Two high-level timber beam bridges are being constructed by contract over the Allyn River at Sale's and Kenny's Crossings on the Gresford-Eccleston Developmental road (No. 1,128), in the Shire of Wallarobba.

For many years, travellers proceeding from Mittagong towards Bowral and Moss Vale have been compelled to negotiate a heavy grade, which includes two sharp curves, in approach to a subway under the Great Southern Railway on the ascent of the Gib Range. Visibility in the vicinity of the subway is very poor. To remedy this, a deviation has been adopted, involving the construction of an over-bridge on a good alignment and a length of 1 mile of waterbound macadam pavement surfaced with tar. The erection of the bridge has been completed by the Railway Department, and a tender for the road work has been accepted by the Mittagong Municipal Council.

UPPER NORTHERN DIVISION.

Between Coff's Harbour and the beginning of Korora deviation, on the North Coast Highway in the Shire of Dorrigo, 4½ miles of the highway have been bitumen surfaced by the council under its current maintenance programme.

The Maclean Municipal Council has completed and opened to traffic 2,700 lineal feet of bitumen penetration macadam in River-street, Maclean (North Coast Highway). A further length of 2,982 lineal feet of a similar type of pavement is being constructed by Messrs. Model Homes, Limited, under contract with the municipality.

The contractors, Messrs. M. R. Hornibrook, Limited, have completed a two-span timber bridge over Hoffman's Creek, on the Great Northern Highway, in the Shire of Tenterfield. This is one of the minor works, referred to on page 164 of the April number of *Main Roads*, in connection with the reorganisation of the Amosfield-Mt. Lindesay section of the highway.

A reinforced concrete causeway, in lieu of a stone crossing, has been constructed over Hell Hole Creek, on the Cobbadah-Narrabri road (No. 133) in the Shire of Gwydir.

Contractor R. B. Haydon is making good progress with the reconstruction of 4¾ miles of gravel pavement betwen Glen Innes and Deepwater, on the Great Northern Highway in the Shire of Severn.

The Inverell Muncipal Council has constructed, by day labour, a short deviation of 8.55 chains, together with a 7 ft. 6 in. by 3 ft. 6 in. reinforced concrete box culvert, on the Inverell-Bundarra road (No. 115).

On the Gwydir Highway at Gravesend, in the Shire of Yallaroi, the Foundation Company, Limited, the contractors for the erection of the bridge over the Gwydir River, which was described on page 40 of the November number of *Main Roads*, have placed in position the girders for the 70-feet span and are erecting the truss for the 140-feet span at the Warialda end.

LOWER NORTHERN DIVISION.

On the Wee Waa-Pillaga road (No. 127) in the Shire of Namoi, a further section of nearly 2 miles of gravel pavement on black soil country is practically complete. Gravel is not readily obtainable at this point, the material for this length having had to be hauled 32 miles by rail and 10 miles by road. With a view to trying out a less expensive road, a short section of the road in extension of this work is being treated with an experimental surfacing of red soil.

Main Road signposting has recently been completed in the Shire of Namoi, 103 posts having been erected on a total length of 155 miles. Signposts are particularly important in this shire, where there is so much unformed black soil and habitations are scattered.

The Wood's Reef deviations, extending over 2¼ miles of the Barraba-Bundarra road (No. 132) in the Shire of Barraba, have been completed by Contractor White. The deviations eliminate two creek crossings included in the former bush track. Further works on this road, which are under consideration and will, when completed, make it possible to cater for traffic for some years to come by maintenance and minor formation work, are the erection of a low-level bridge over Ironbark Creek and the construction of 1 mile of road above the creek beyond Wood's Reef.

After consultation with the Armidale Municipal Council, the Board has notified the council that the approved route of the Great Northern Highway has been fixed so that traffic will not have to negotiate the level crossing at Butler-street, but will cross the railway line by the overhead bridge in Dangar-street. To connect to this bridge, approximately 65 chains of roadway have to be constructed in Kentucky-street. The adopted route is the most direct available, gives a good connection with the Grafton-Kempsey road (No. 121) and, from Kentucky-street, affords a fine view of the city.

On the North Coast Highway in the Municipality of Port Macquarie, Contractor McLean has completed a short deviation 712 feet long, which eliminates a dangerous bend and at the same time permits improved drainage of the swampy flat crossed by the road. The pavement is 18 feet wide, of broken stone and will later be surfaced with bitumen.

Under its 1929 Maintenance Programme, the Dumaresq Shire Council has carried out effective work on the Armidale-Grafton road (No. 121). At Armidale, where traffic is heaviest, the road has been widened to standard, strengthened and tar-surfaced. Farther out, widening has been carried out and the existing pavement reconditioned, while nearer Ebor the existing road has been smoothed out and drained pending further improvement under future programmes.

On the North Coast Highway between Kempsey and Frederickton, 3 miles of the road parallel to the Macleay River has been raised from 18 inches to 30 inches, and surfaced with an 8-inch broken stone pavement which will shortly be surface treated. To avoid the inundation of this road during freshes in the river, an earth embankment is being constructed across Verge's drain, 1 mile north of Kempsey, to replace a bank destroyed by floods in 1927.

CENTRAL WESTERN DIVISION.

The Mid-Western Highway through the Municipality of Grenfell has recently been considerably improved by systematic maintenance by the council. The length of the highway in the Shire of Weddin, from Grenfell towards Cowra, has also been improved by the shire council. Both sections present a good surface throughout.

The gravelled length of the Mid-Western Highway in the Municipality of Blayney has been subjected to maintenance under the direction of the Lyndhurst Shire Engineer, who supervised the work on behalf of the Board.

Progressive maintenance has greatly improved the surface of the North-Western Highway between Molong and Wellington. The section, with the exception of the last 3 miles into Wellington where a deviation is under consideration, is now in good order.

The Belar Creek bridge, on the Nyngan-Colane road (No. 204) in the Shire of Bogan, has been re-decked and painted, and the approaches have been re-gravelled.

A single span concrete bridge has been completed and opened to traffic at Wattle Creek, on the Orange-Forbes Trunk Road (No. 61) in the Shire of Amaroo, in replacement of an old timber bridge which was rendered untrafficable in 1926. On the North-Western Highway, in the same shire, a concrete box culvert has been erected at the site of an old timber bridge which was washed away in 1927.

SOUTHERN DIVISION.

On the Federal Highway, of the works described in the January number of *Main Roads*, earthworks and culverts between 12½ miles and 18 miles have been completed by Contractor W. D. McDonald; a 7-inch gravel pavement is being constructed by Contractor J. Dunn between 12½ miles and the Federal Territory boundary at 27¾ miles, the work being the greatest length of paving yet let by the Board in one contract, and the McLean Construction Company has commenced operations on the Yass River bridge. The new highway will be available for traffic upon the completion of these three works.

A further section of 2 miles of the Monaro Highway, between Bega and Tathra, in the Shire of Imlay, has been reconstructed with a 7-inch waterbound macadam pavement, surfaced with a tar primer and a bitumen seal coat. This important length of the highway has now been reconstructed for a distance of 7½ miles from Bega.

On the Prince's Highway in the Shire of Clyde, the Board has undertaken by day labour the reconstruction of a further length of 3 miles in premixed bituminous macadam. The work will extend from the previous section terminating north of Tomerong to the commencement of the second deviation south of that town. Local sandstone is being utilised for both base and surface courses.

The surfacing with asphaltic oil primer and bitumen seal coat of two sections, totalling 6 miles 2,500 feet of the Hume Highway between Cullerin and Gunning, has been completed by the contractors, Messrs. John Fowler & Company.

On the Hume Highway between Yass and Bowning there will shortly be a continuous length of more than 9 miles of new bituminous penetration macadam. Commencing at Kirkton, and extending to the Yass River bridge, a section of 2 miles is under construction by Messrs. N. H. Jones & Company. The next 3¾ miles extending westerly are under construction by Mr. F. H. Stewart, and a still further 3½ miles adjoining this has just been completed by Australian Roads, Limited.

A two-span concrete bridge is being constructed over Hume Creek on the Goulburn-Dalton road (No. 201) in the Shire of Gunning. The original timber bridge was washed away during a flood, since which time traffic has used a ford.

RIVERINA DIVISION.

The construction by the Chas. Hardy Contracting Company Limited of 2 miles of gravel pavement, with culverts, on the Lochhart-Urana Trunk Road (No. 59), crossing Brookong Plain in the Shire of Lockhart, is nearing completion and will shortly be available for traffic.

In the Municipality of Murrumburrah, a length of 1 mile 900 feet in Albury-street (No. 243) is being resurfaced with tar by the council.

One mile of the Monaro Highway in the Municipality of Wagga Wagga, commencing at the railway level crossing and extending to the municipal boundary, has been reconditioned, and semi-penetrated and sealed with tar. The whole length of the highway within the municipality is now tar-surfaced and in good order.

Arrangements are in hand for the improvement of 3 miles of the Mid-Western Highway in the Municipality of Balranald. This work will open up the approach to the town from the direction of Hay.

At the western end of the Mid-Western Highway, a length of 24 miles between Goolgowi and Rankin's Springs, in the Shire of Carrathool, is at present being improved. The existing clearing is being widened and the whole length is being formed and drained. This work, apart from effecting an improvement for through traffic, is developmental in character and should be of value in assisting to open up the rich wheat area west of Rankin's Springs.

Messrs. Connolly & Sons have practically completed the construction of 1½ miles of gravel pavement on the Urana-Corowa road (No. 131), in the Shire of Urana. This was the only unconstructed length of the road in the shire and its opening to traffic will make available a continuous length of all-weather roadway.

Personal.

On 25th March, 1930, Mr. S. L. Luker, B.Sc. (Civ. Eng.), Assoc. M. Inst. C.E., Metropolitan Maintenance Engineer, left with his family by the s.s. *Ceramic* on an extended tour which will embrace Great Britain, Europe and Northern America. Mr. Luker's journey is primarily in connection with private business, but he proposes also to make enquiries into methods of road construction and maintenance abroad. The Board has therefore taken advantage of his intention so that, in conjunction with Mr. H. M. Sherrard, M.C.E., Assoc.M.Inst.C.E., Assistant Chief Engineer, who will also shortly be leaving for the United States of America, he shall attend, as one of its official representatives, the Sixth International Road Congress, which is to be held at Washington, D.C., in October next. The Board and its staff wish Mr. Luker and his family "bon voyage," and look forward with pleasure and interest to his return towards the end of the present year.

Expenditure from 1st July, 1929, to 31st March, 1930.

	Expenditure to 28th February, 1930.	Expenditure for month of March.	Total Expenditure to 31st March, 1930.
	£ s. d.	£ s. d.	£ s. d.
COUNTY OF CUMBERLAND MAIN ROAD FUND—			
Construction of Roads and Bridges	344,608 7 6	35,834 12 9	380,443 0 3
Cost of Land Resumptions	108,659 12 11	5,368 18 6	114,028 11 5
Maintenance of Roads and Bridges	177,569 11 1	20,295 12 10	197,865 3 11
Repayment of Loans	157,034 8 2	7,896 4 11	165,020 13 1
Survey, Design, Supervision and Administration	36,563 15 3	3,685 17 4	40,249 12 7
Purchase of Stock and Assets	14,729 6 1	432 9 7	15,161 15 8
Miscellaneous	7,978 14 0	205 7 8	8,184 1 8
Total	847,143 15 0	73,809 3 7	920,952 18 7
COUNTRY MAIN ROADS FUND—			
Construction of Roads and Bridges, including Resumptions	589,641 1 6	48,127 18 5	637,768 19 11
Maintenance of Roads and Bridges	734,877 19 6	71,898 16 2	806,776 15 8
Repayment of Loans	18,020 13 1	.....	18,020 13 1
Survey, Design, Supervision and Administration	90,646 5 7	11,651 8 8	102,297 14 3
Purchase of Stock and Assets	*28,963 5 11	596 1 6	*28,367 4 5
Miscellaneous	26,952 18 1	2,190 15 5	29,143 13 6
Total	1,431,175 11 10	134,465 0 2	1,565,640 12 0
FEDERAL AID ROADS FUND—			
Construction of Roads and Bridges, including Resumptions	685,425 19 8	90,605 13 7	776,031 13 3
Purchase of Stock and Assets	12,111 5 7	9 13 2	12,120 18 9
Miscellaneous	6,220 2 6	0 0 3	6,220 2 9
Total	703,757 7 9	90,615 7 0	794,372 14 9
DEVELOPMENTAL ROADS FUND—			
Construction of Roads and Bridges	187,026 6 1	17,899 3 4	204,925 9 5
Survey, Design, Supervision and Administration	2,965 15 7	1,053 0 3	4,018 15 10
Miscellaneous	6,279 4 10	*120 10 0	6,158 14 10
Total	196,271 6 6	18,831 13 7	215,103 0 1
SUMMARY, ALL FUNDS.			
Construction of Roads and Bridges, including Resumptions	1,915,361 7 8	197,836 6 7	2,113,197 14 3
Maintenance of Roads and Bridges	912,447 10 7	92,194 9 0	1,004,641 19 7
Repayment of Loans	175,055 1 3	7,986 4 11	183,041 6 2
Survey, Design, Supervision and Administration	130,175 16 5	16,390 6 3	146,566 2 8
Purchase of Stock and Assets	*2,122 14 3	1,038 4 3	*1,084 10 0
Miscellaneous	47,430 19 5	2,275 13 4	49,706 12 9
Grand Total £	**3,178,348 1 1**	**317,721 4 4**	**3,496,069 5 5**

* Credit.

Maintenance in the County of Cumberland.

By S. L. Luker, B.Sc.(Civ.Eng.), A.M.Inst.C.E.

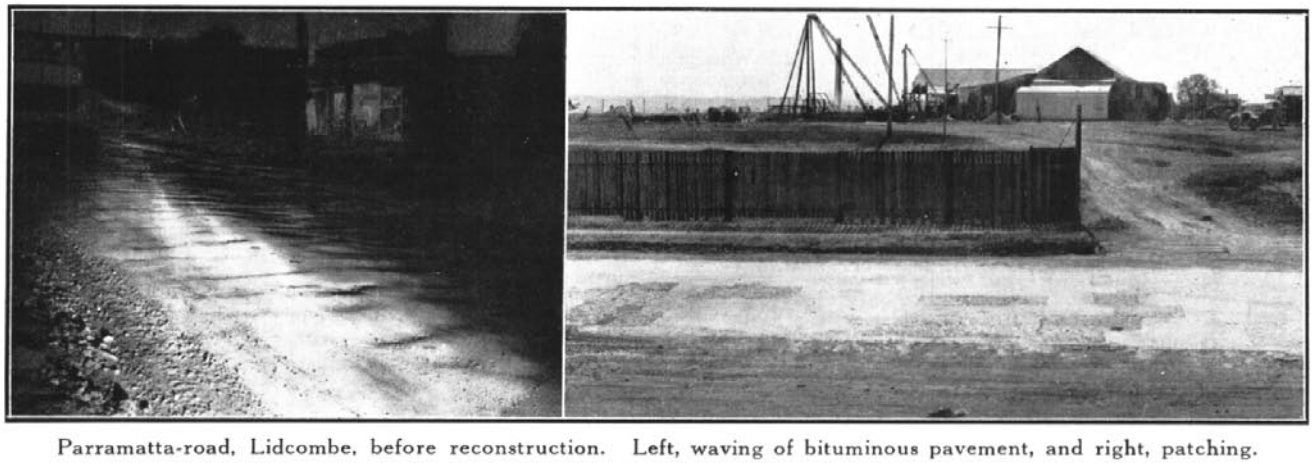
Metropolitan Maintenance Engineer.

WHILE there remains much that could, and will be done, as time and funds allow, in the way of still further improving the condition of the main roads in the County of Cumberland, it is generally conceded that in the five years since the Board's inception, a very considerable change has been wrought in conditions of road travel in this area. At that time, except for a comparatively small mileage of then recently constructed cement concrete and asphalt pavement, the main roads of the County of Cumberland within a radius of ten or fifteen miles of the City of Sydney were generally in other than satisfactory condition; the Lane Cove road through Willoughby and Lane Cove, and the Cook's River road through St. Peters, for instance, two of the most important outlets from Sydney, were remarkable for their defects. Parts of the Parramatta-road and of the Prince's Highway in Rockdale had, a year or two before then, been reconstructed in tar or bituminous macadam with a sandstone base, but under the phenomenal growth of traffic, had begun to show signs of serious deterioration. The remaining main roads of various types within this area were also generally inadequate in standard of condition for the rapidly increasing volume of traffic. Those of waterbound macadam were suffering severely from the abrasive and disruptive effect of fast rubber-tyred traffic, while the tar and bituminous macadam roads were becoming uncomfortably corrugated.

condition but there was a certain want of system in their arrangement, cross-connections or circumferential routes being lacking.

Beyond the area of ten to fifteen miles radius to which the above remarks apply, the main routes, viz.: the Great Western road, the Windsor road, Great Southern road and Prince's Highway, had benefited from comparatively recent reconstruction (in waterbound macadam surfaced with bitumen) by the Public Works Department, and these stretches of road had become popular routes for traffic. The sections of these roads not then constructed, and the remaining less important roads, were either earth, gravel or metal and were uniformly bad. Some were practically impassable after rain, and in dry weather were uncomfortable owing to dust. The Great Western road, between the Nepean River and Mount Victoria, for instance, was continually falling into disrepair despite the efforts of the local councils to maintain it with the funds at their disposal. The Prince's Highway, south of Sutherland, was of loose gravel and subject to rapid corrugation under traffic. Sections of the Great Southern road beyond Liverpool were extremely rough and the same description applied to the Wiseman's Ferry road north of Pitt Town.

Arrangements for the continuation of the work already carried out by the Public Works Department and the reconstruction of the worst sections of the roads, were at once instituted by the Board, but while



Parramatta-road, Lidcombe, before reconstruction. Left, waving of bituminous pavement, and right, patching.

A few councils had, prior to the Board's inception, constructed cement or bituminous concrete pavements within their areas—and due credit must be given to the enterprise of such bodies and to the engineers who carried out the work—but beyond these outstanding cases, the majority of roads suffered from the effect of traffic of an altogether heavier and more destructive character than that for which they had been built. Moreover, not only were the roads generally in poor

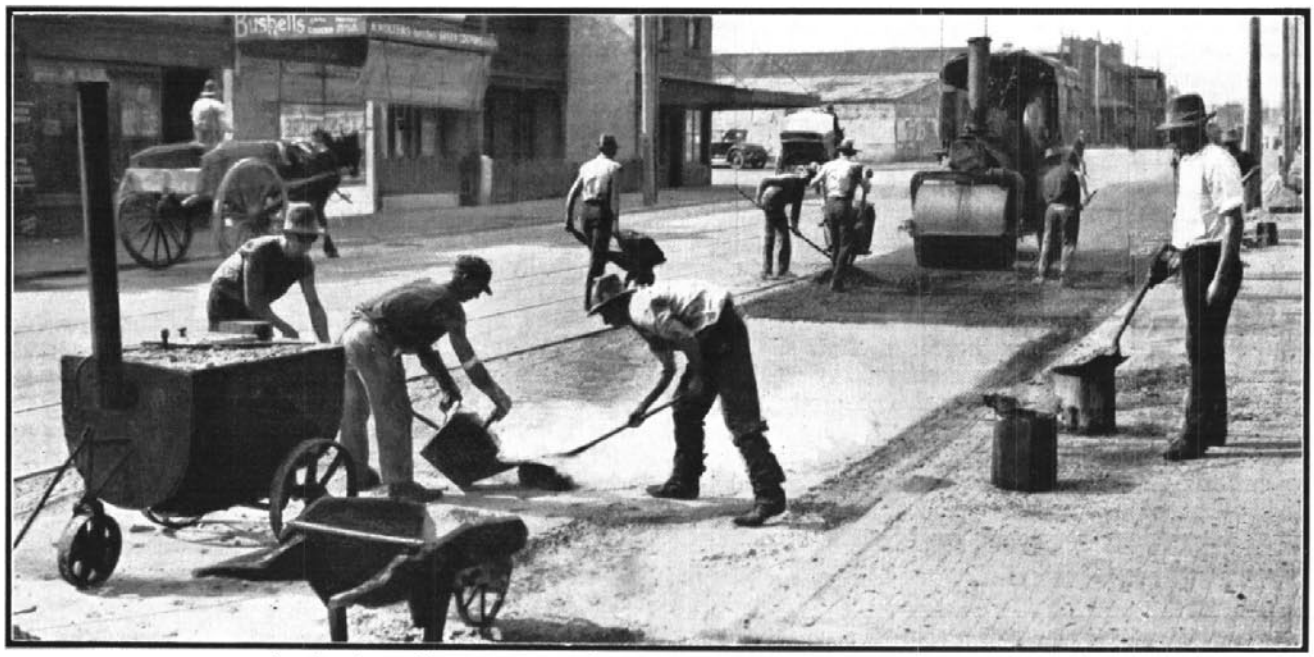
these were being brought to fruition, and to meet the needs of the large number of roads which, though possibly in need of reconstruction, could not, with the funds available, be rebuilt during the earlier years of the Board's operations, it was necessary to put in hand an extensive programme of maintenance. In many instances, work of a comparatively heavy nature was found to be essential; the existing pavements which were either worn out or inadequate in strength had to

be completely resheeted with either waterbound macadam (later to be surfaced with tar or bitumen) or with tar or bituminous macadam, either mixed before being laid or penetrated when spread. In other cases, extensive patching was resorted to, to hold the road together until such time as it could be reconstructed. Some reshaping of earth and gravel sections was put in hand, but in the main, little could be done on roads of this nature until the second and third year of the Board's operations.

Such measures naturally had their beneficial effect on travel conditions, but this was to a large extent counteracted by the fact that the growing number of motor cars, buses and lorries used the roads to an increasing extent as the urgently required repairs were effected. This process of comparatively heavy maintenance has therefore had to be continued throughout the whole of the five years period, as additional stretches of road began to suffer in one way or another by the severe treatment to which they were subjected. When it is considered that in the time mentioned the number of motor vehicles in use has more than doubled, and the distance run by a majority of the vehicles has largely increased, it will be appreciated that in spite of the extensive construction programme carried out by the Board, the task of maintaining the main roads in the County of Cumberland has become a heavier one each year.

As affecting the amount of work undertaken in this direction, the increase in the total length of main roads should also be mentioned, the majority of newly proclaimed main roads having required comparatively heavy expenditure to bring them into full use as a part of the system of main roads.

A great part of the maintenance work has been carried out by councils under grants made by the Board after examination and approval of councils' proposals, and while naturally in some cases there have been initial difficulties in securing maintenance work to the desired standard, it should be recorded that in the great majority of cases councils have shown a commendable desire to achieve the standard aimed at. As the result of their efforts the funds granted were, in the main, spent economically and well. Furthermore, while the plant available for road maintenance at the time of the Board's formation consisted of little more than rollers, tar and bitumen boilers, and light horse-drawn graders—and these machines by no means possessed by all councils—many of the latter have in the five years of the Board's work, purchased up-to-date machinery and plant, such as power graders and machinery for mixing tar and bitumen macadam (in the case of two or three councils, even the more expensive weighing and grading machines necessary for mixing bituminous concrete), so that high-class work is becoming possible—to the benefit of the road user and the still greater economy in funds.



Application of bituminous surfacing to concrete pavement, Botany-road.

In spite of the best efforts of co-operation on the part of councils, however, one of the essential requirements of a satisfactory system of highway maintenance was lacking. A due degree of uniformity in the nature and condition of the surface is needed for any such complete system, as a section, however short, in an otherwise good road, which is very much below the general standard, seriously detracts from the value of that road. Similarly, from the view point of the road-maintaining authority, to have one section of road differing in class of material, or in any other respect, from the remainder of the road gives rise to difficulty, not only in providing the plant and materials required for the particular type of road, but also in supervision of the work done. Such conditions were encountered by the Board on several of the more important main roads in the County of Cumberland. The Great Western road, for instance, traversed or formed the boundary of thirteen separate municipalities in the

fifteen miles between the city and Parramatta. The Main Southern road, likewise, was in charge of a number of councils, and, adding to the difficulties which would thus arise in securing uniformity of condition and methods of work, was the fact that a number of the councils concerned did not possess the plant required for effecting repairs, much less the heavier reconditioning required for preserving the condition of the main road through their areas.

The natural outcome of these conditions was that many of these councils either requested the Board to take over, or, upon having the position explained to them, concurred in assumption by the Board of direct responsibility for maintenance. Provision of staff and plant for the complete maintenance of all classes of road was thus entailed, and a start having been made in this direction on a few sections of any particular road, it became necessary for convenience and economy in working to take over intervening sections which had to be traversed by the Board's gangs, patrolmen, &c. Thus, practically the whole of the main routes (now State Highways) came under direct maintenance by the Board, and considerable economy has resulted from this process.

expiration of the respective contract periods, and of the newly constructed pavements of other types (cement concrete, &c.), will in the main be carried out by the Board's staff.

The following table sets out the mileages of proclaimed main and secondary roads in the County of Cumberland in each year since the commencement of the operations of the Main Roads Act and the expenditure incurred in maintenance:—

Year.	Mileage of proclaimed or declared roads at the end of each financial year.		Maintenance Expenditure.		
	Main.	Secondary.	Through Council.	By Board's staff direct.	Total.
			£	£	£
March 1925-30th June, 1926 ...	548	.....	123,075	24,455	147,530
1926–27 ...	550	12·0	108,707	97,132	205,839
1927–28 ...	554	19·5	111,939	127,155	239,094
1928–29 ...	599·3	42·6	64,076	122,271	186,347
1929–30 (estimated) ...	605	48·7	100,000	146,000	246,000
		Totals	507,797	517,013	1,024,810

Left, power scarifier-grader. Right, patrol maintenance equipment.

In its efforts to afford that degree of continuous inspection and attention so essential for keeping a system of highways in proper condition, the Board has had in view not only the safety and comfort of the travelling public and the aggregate saving in the cost of transportation made possible by the improvement in the condition of the roads, but also the conservation of the money invested in their construction—for if there is one failure in road policy worse than another, it is to spend money in constructing roads and to allow the assets to be destroyed for lack of adequate maintenance. It is the desire to avoid the lastnamed error that has very largely governed the Board's policy in respect of the maintenance of the roads which it has itself constructed either by contract or day labour. A number of these have been built in bituminous concrete by contractors who specialise in that particular type of construction, and, partly as a guarantee of satisfactory work, but mainly in order to ensure that repairs, &c., are done in a proper manner by experienced skilled workmen, the contracts for the construction of the pavements have in all cases to date embodied a provision for maintenance for a period of five years. The maintenance of these bituminous pavements at the

Thus at the end of the current financial year (30th June, 1930), more than one million pounds will have been spent on maintenance during five and a half years that will have passed since the commencement of the operations of the Main Roads Act. This includes not only maintenance in the ordinary way, *i.e.*, keeping the road in trafficable order to its original width and condition, but also substantial improvements, such as the tar surfacing of roads which were previously either of waterbound macadam or gravel, heavy resheeting with tar or bituminous macadam, either by premixing or the penetration process, incidental work such as minor widening of pavements, improvement of corners, and replacement of faulty sections of foundations, &c., the restoration of street openings and the repair of bridges. The bulk of the expenditure, however, has been incurred in the normal processes of maintenance, such as surface treatments with tar and bitumen, patching, light resheeting with premixed tar or bituminous macadam, in making good the wearing away of the earth and gravel shoulders of the rural-type roads (*i.e.*, those having a central strip of pavement only) and (on the same type of road) in that very important work of keeping watertables and culverts in order.

Reconditioning of Old Waterbound Macadam

By David Craig, M.Inst.C.E., M.I.E.(Aust.)

Chief Engineer.

(Note.—The following is a statement which has been prepared for the guidance of and issue to the Board's Divisional Engineers. It deals with a class of work which, in view of the wide and ever growing spread of road transport throughout the State, on ordinary roads as well as proclaimed main roads, must receive increasing attention. It is a subject, therefore, of great importance to all Councils as well as to the Board.—*Editor.*)

OLD waterbound macadam roads requiring treatment usually have to be reshaped, and sometimes widened also. Cases do occur, however, where the road presents a satisfactory shape, and reconditioning or improvement of the running surface is necessary. As in all country roadwork, the local materials available are the dominating factor in determining what method should be adopted in reconditioning.

For light traffic conditions, the most suitable method is to reshape the existing road and surface with gravel, if available. For this purpose, gravel of good binding quality is necessary, as the underlying layer of metal has the effect of preventing to some extent the rise of capillary moisture. On account of the very satisfactory results that can be obtained with gravel, the use of this material should always be given first consideration.

Where suitable gravel is not available, reshaping alone is generally only a temporary palliative. If the reshaped road is of adequate thickness, and contains a high percentage of stone, it is possible to surface treat it with tar or bituminous materials. In some cases a reshaped road may be brought to suitable condition for surfacing by blinding with ¾-inch screenings (excluding material passing ⅜-inch ring), and rolling and watering. In cases of this nature, two coat tar or bituminous work is essential, and the first coat should be tar, preferably Priming Tar, at the rate of from 1/6 to 1/4 of a gallon per square yard. The seal coat may be bitumen or tar, depending on local conditions, applied at the rate of .3 gallons per square yard. If tar is used, it should be No. 1 grade, and if bitumen, it should be of penetration at least 85—100, and consideration might well be given to the use of 100–120, or 175–225 grades, especially in cooler parts of the State.

There have been placed on the market recently various grades of liquid bitumen. These are claimed to be extremely adhesive, especially the 85/80 grade (*i.e.* containing 85 per cent. of 80-penetration bitumen). The liquid bitumens are intermediate between road oils and ordinary bitumens, and have no measurable penetration. The least liquid of the liquid bitumens approximates to 200 penetration, however. Under most favourable conditions, 85/80 liquid bitumen might be applied direct to a reshaped road. It is suitable for application after a light tar primer in all cases where surfacing is admissible.

Should the road be too thin or contain insufficient stone for surface treatment, and gravel surfacing is impracticable or undesirable, it becomes necessary to add new metal. What thickness of existing metal may be considered too thin is a matter for local determination. If the foundation is sound and dry, three or four inches (thickness after reshaping) may be satisfactorily surfaced, but if unsound, then a new wearing course will be necessary. There are a variety of methods by which this may be done, and in some cases the construction of trial sections and close attention to costs will be necessary to determine the most suitable types. The following indicate some of the methods:—

(1) Addition of 2½ inch or 3 inch thick penetration surface course using 1½ or 2½ inch gauge stone respectively. A 3 inch layer would have 1¼ gallons per square yard grouting and 1/3 gallon per square yard seal. The grouting for the 2½ inch layer would be 1 gallon per square yard.

(2) Addition of 2 inch thick penetration course using 1½ inch metal. Grout with ¾ gallons per square yard and seal with ¼ gallon per square yard. In some cases, seal coat may be omitted.

(3) Retread construction, 1½ inch–2 inch thick, using 1½ inch metal. This method eliminates most or all of the rolling necessary in penetration work, and may thereby enable a fair quality local stone to be used instead of importing first-class metal. It results in a smooth running surface. Seal coat may be omitted.

(4) "Semi-penetration." This name has been used to describe several differing processes. Among these are:—

(*a*) A layer one stone thick of 2½ inch, or even 1½ inch metal is added and rolled so that the stones are partly pressed into the resltaped roadway. Bitumen—85–100 or softer—or a suitable grade of tar, is then applied at a rate between ¼ and 2/3 of a gallon per square yard, and followed with ¾ inch screenings and rolling. Seal coat may be omitted where bitumen is used for penetration.

(*b*) "Puddle Macadam" as used in West Virginia. In this "semi-penetration" method, soft sandstone is spread 4 inch loose and rolled. It is then filled to about ¼ inch above surface of stones by addition of fine stone and dust and further rolling. Surplus material is then swept off until a mosaic surface is exposed. This is then

(*Concluded on page* 186.)

The Organisation of Road Works in the Shire of Boree.

By Lloyd W. Morris, C.E., L.S., *Shire Engineer,*
and S. D. Stables, Stud.I.E. (Aust.), *Assistant Shire Engineer.*

(In the February issue of "Main Roads" an account was given by Mr. C. W. Williams of the organisation of road works in the Shire of Tumut, and an invitation extended to other Shire Engineers to contribute similar articles. In this issue, Messrs. Morris and Stables describe the position in the Boree Shire. These statements as to the manner in which various engineers are endeavouring to cope with the problem of road improvement within their areas should prove of great value to others engaged in similar work. The Board would welcome further contributions from other engineers, arranged somewhat along the lines adopted by Messrs. Williams and Morris.—*Editor.*)

General Topographical and other Conditions of Shire.—The Shire of Boree, covering an area of 800 square miles, is situated in the Central-western Division and on the western slopes of the Canobolas Mountain. The country generally is undulating and fertile, except for the Nangar Range and isolated granite outcrops in the north and south-west. The general altitude lies between 700 and 1,500 feet above sea-level, and the topography is such that easy road grades, with practically no side-cutting, are readily obtainable.

The higher hills adjacent to Canobolas, an extinct volcano, are capped with basalt. The underlying Devonian and Silurian strata are noted more or less for their abundance of roadmaking materials, consisting of limestones, quartzites, conglomerates, red sandstones and gravels. The soils commonly met with are sound and capable of carrying heavy traffic when covered with a light layer of gravel, but they are such that scouring action readily takes place in side drains.

A moderate climate is experienced, extreme variations of temperature being exceptional.

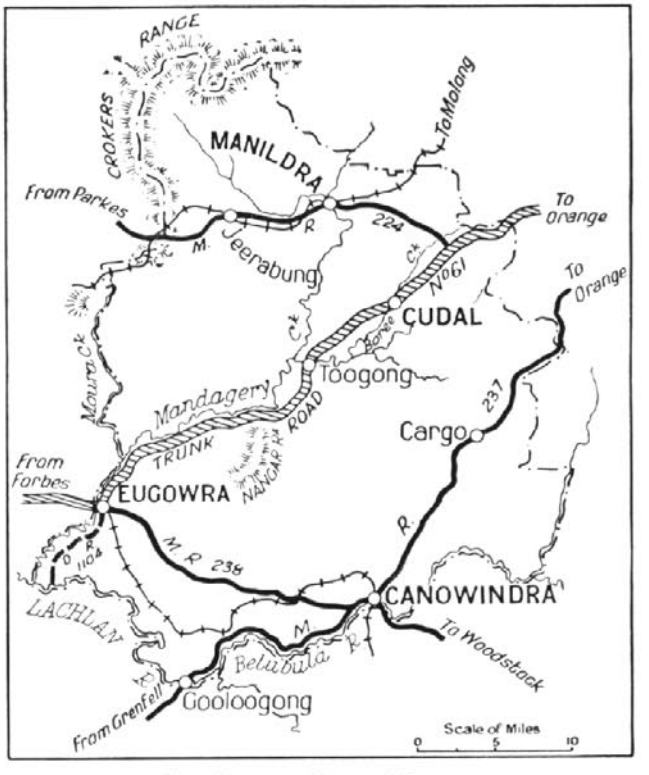
The principal roads of Boree and the adjoining shires form part of that system which radiates towards Orange, so that the main roads run in a general east to west direction. The shire headquarters are centrally situated at Cudal, which is on the most important road in the shire (Trunk Road No. 61).

The total mileage of trunk road in the shire is 37½. There are also approximately 80 miles of main roads and 4½ miles of developmental road. Of the remaining roads of the shire, 34 miles carry a certain amount of through traffic, 80 miles carry heavy local traffic, while there are 200 miles of by-roads and many miles of lanes.

Gravel and other surfacing materials used on these roads are taken an average distance of 3 miles, but specially selected material is carted up to 18 miles.

Formation of a Policy.—In order to overcome the rapid deterioration of the principal roads of the shire, the council, at the end of 1928, entirely reviewed its road policy. As a result it was decided to increase the general rate from 2d. to 2½d. and to spend two-thirds of the available revenue on the maintenance of main roads for a period of two years. The general policy since then has been to allocate money for this work according to its urgency. The relative urgency of the work to be done was considered to be as follows:—

(*a*) Obligatory maintenance of existing good lengths, consisting of grading, dragging, application of "loose blanket" of selected gravel and cleaning and aligning water-tables and side drains.



Sketch map, Shire of Boree.

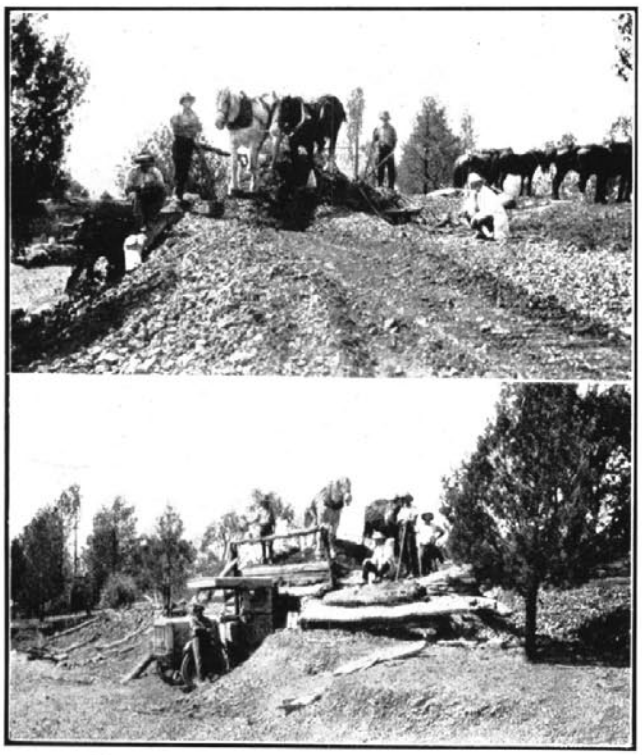
(*b*) Heavy maintenance of worst lengths, consisting of scarifying, reshaping, and widening existing pavement and resheeting with gravel, the building of shoulders and drainage work generally.

(*c*) Resheeting fair to bad lengths, without scarifying and reshaping unless absolutely necessary, and the cleaning of water-tables and side drains.

(*d*) General light maintenance of the remaining portions. This work includes only patching pot-holes and attention to longitudinal drainage where necessary.

It was decided that no new construction on main roads was warranted until the total length of such roads already constructed was placed in good condition.

The Yearly Programme.—A flying survey of all roads in the shire is made towards the end of each calendar year. With the information obtained from this the complete programme for the coming year is prepared and the part dealing with main roads is submitted to the Main Roads Board for approval. Sufficient time is allowed to permit of this being obtained before the New Year in order to permit of an early commencement of the work being made. After such approval is secured, any variations introduced are only of a very minor character. Care is taken to have the whole of the work completed within the year.



Views showing method of loading gravel.

The Conduct of the Work.—Both day-labour and contract methods for the carrying out of works are used, although wherever possible, the former is preferred, as it is found that, carried out with proper organisation and supervision, supplemented by a bonus system, it is cheaper and more satisfactory. This does not apply to large bridges or other works of a similar nature.

During the holiday season the plant is overhauled and any necessary repairs made. Before operations are commenced on a large scale the permanent employees are re-selected from those engaged during the previous year. Two complete large gangs are organised and each commences work in a different district. All work, as set out in the programme, is done by these two gangs, the work on main roads being done in conjunction with that on the less important roads. The gangs proceed in a definite direction and do all necessary work as they go, so that no re-traversing of an area once covered is necessary, except in cases of extreme urgency or for carrying out the systematic maintenance described elsewhere.

Method of Carrying out the Work.—Maintenance and construction plant is kept up to date, as it is considered that the greatest economy can be obtained only by the use of the most suitable machinery and the exclusion, as far as possible, of all kinds of hand work. Drays are hardly ever used, except for shifting camp, motor trucks for this purpose being, in general, preferred. Plant in use in the shire includes the following:—Two 10-ton steam rollers, two complete portable crushing and screening plants, driven by a Robey tractor and oil engine, two scarifier-graders (light type), one 8-foot grader, all complete with back slopers, eight baby graders, two 5½-yard, one 3-yard, and one 1½-yard motor trucks, a large number of drag and wheel scoops, four rooters, twelve No. 66 and 64 mouldboard ploughs, and several light ploughs, one motor water cart and spray, one horse-drawn water cart, besides bitumen kettles, a large number of heavy and light road drags, &c. Such spare parts as are most likely to be required are always kept in stock.

A close attention has been given to detailed administration of road work in order to obtain the most economical results. All work is carried out on a unit cost basis and detailed unit costs for different classes of work, under varying conditions, together with methods to be employed and details of organisation, have been prepared. Responsible employees are given these figures from which they daily check the actual cost, which must not in any case exceed those which are applicable to the given conditions. If they do so and the ganger is unable to rectify the matter, it is immediately reported to the engineer. All employees are closely watched and those not giving satisfaction are immediately dismissed; while those showing a marked aptitude for any particular class of work are kept on such work as far as practicable.

Special attention has been given to economical methods for the handling of road materials, &c. For loading gravel at the pits, the following method is employed:—A loading stage, consisting of two hinged doors of 2½-inch oregon about 10 feet long by 2 feet wide, is constructed. These doors are supported by three catches on a centre bar which are controlled by a single lever and are counter-weighted. The gravel is tipped on the doors with two-horse scoops and the motor trucks are driven into an excavation made beneath them. The lever is then pulled over, which releases the catches and allows the doors to open and the gravel to fall into the truck. If the loading device is properly constructed, this takes place without undue jarring to the vehicle beneath. The average time taken to load a large truck is about 20 seconds and the average quantity of gravel loaded by one man in a day with a two-horse drag scoop is 60 to 70 cubic yards, the record being 132 cubic yards. The total cost of such a loading device, exclusive of the portable doors, seldom exceeds £10.

Actual average unit costs per cubic yard of gravel, when handled as described, are as follow:—

	s. d.	s. d.
Ploughing gravel with rooter	0 4	to 0 6
Scooping and loading	0 9	to 0 10
Total loaded on trucks	1 1	to 1 4
Hauling 1 mile	0 9	to 1 3
Spreading, harrowing and grading	0 4	to 0 5
Net cost spread on road	2 2	to 3 0
Overhead expenses—		
Loading stage	0 0½	to 0 1
Supervision, &c.	0 2	to 0 3
Total cost spread	2 4½	to 3 4

Property-owners rarely require the council to pay compensation for gravel obtained from their land.

Contract rates for haulage are as follows:—

1 mile, 1s. 3d. per cubic yard.
2 miles, 2s. per cubic yard.
3 miles, 2s. 6d. per cubic yard.

The rate is increased by 6d. per mile for each additional mile. When carried out by the council by day labour the cost averages, over all hauls, about 6d. per cubic yard less than this.

The following is taken from the result of an actual day's work:—

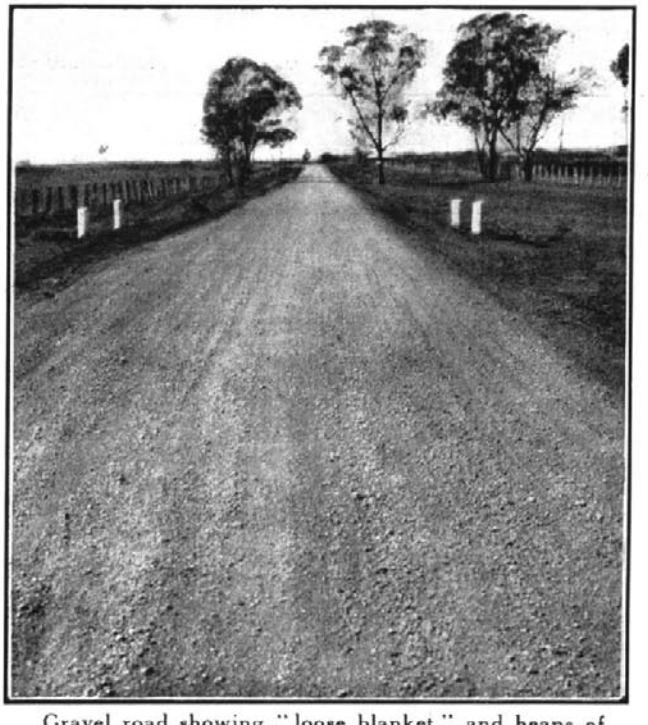
One Leyland truck (capacity—level full, 5½ cubic yards) made 40 trips on a lead of about 1 mile on a good road.

	Per day. £ s. d.		Rate per cub. yd.
Ploughing gravel (2 men and 3 horses) half day			2d.
Loading and scooping			9d.
Loading in trucks			11d.
Depreciation on Leyland	@ 3 7 0		
Driver and greasing	@ 1 10 0		
Petrol and oil	@ 2 10 0		
Total	£7 17 0	*or*	8d.
Spreading, harrowing and grading (3 men and 2 horses, half time)			4d.
Net cost spread on road			1s. 11d.
Ganger (part time)			1d.
Loading stage, &c. (life 4,000 cub. yds.)			1d.
Incidentals, shifting camp, wood and water and contingencies			2½d.
Total cost spread on road			2s. 3½d.

The scoopmen are paid a bonus of 5s on loading 60 cubic yards in one day and 9d. for each additional cubic yard. This has been found to produce very good results, not the least of which is a reduction in the rates paid for contract haulage, due to the fact that no time is lost at the pit as was formerly the case.

All minor repairs to motor trucks are carried out before or after working hours, and the drivers work right up to knock-off time in order to enable the scoopmen to do so.

Considerable trouble has been experienced in the past from the occurrence of corrugations on gravel roads. This has now been practically overcome by the use of scarifier-graders and heavy drags shod with steel plates. These have been found to produce highly satisfactory results when used immediately after rain. A "loose blanket" covering of specially selected gravel reduces their formation to a great extent. Light maintenance on the principal roads is carried out by first stacking selected gravel in heaps of 1 cubic yard each at 1 chain intervals along the road, the trucks being divided into compartments of 1 cubic yard for the purpose. These are placed on the shoulders close to the road, but out of the way of traffic. The heaps are spread after dragging as required, two men with a drag scoop doing about a mile a day.



Gravel road showing "loose blanket" and heaps of maintenance gravel.

Supervision and Administration.—The results described above could not have been achieved without careful and thorough engineering supervision, and the same interest by the engineer in day-labour working costs as would be taken by a contractor. The great assistance rendered by the council in giving the engineer a free hand to organise the carrying out of the programme of works, after it has once been approved, has also been a most important contributing factor and is greatly appreciated.

A single-seater Chevrolet car, owned by the council, is used in supervision work. It has been found very useful, on a small scale, for the transportation of the less bulky stores and materials. Last year 20,000 miles were covered in supervision and inspection work at a unit cost of approximately 3½d. per mile.

The employees are paid fortnightly. The time-sheets are sent in on Saturdays and the men paid during the following week. Formerly it was the practice for the men to fill out these forms during the week up to the Friday night. This system was found to be unsatisfactory in view of the fact that it made accurate allocation of the expenditure unduly difficult.

Developmental Roads Policy.

IN the March issue of *Main Roads* reference was made to the Board's proposals for an investigation to be made with a view to determining, so far as it is practicable, the economic result of the expenditure of State funds on Developmental Roads since the commencement of its operations. To assist in this direction, a statement of expenditure on the various roads assisted in the Upper Northern Division has been published in the preceding issue of *Main Roads*, to which the following table, dealing with Developmental Roads in the Lower Northern Division is now added.

LOWER NORTHERN DIVISION.

STATEMENT of Works undertaken and completed from 1st July, 1923, to 28th February, 1930, and expenditure of Developmental Roads Funds to 30th June, 1929.

Dev. Road No.	Date of Proclamation.	Shire or Municipality.	Location of Work. At	Location of Work. From	Class of Work.	Length.	Amount of Grant.	Source of Funds.	Completed Cost. Council's Contribution.	Completed Cost. Total.	Expenditure to 30th June, 1929.
						m. ft.	£ s. d.		£ s. d.	£ s. d.	£ s. d.
1003	22/1/26	Mandowa	4½ m. to 9½ m. ...	Manilla, towards Boggabri.	Gravel, culvert and causeways.	5 0	5,000 0 0	C.C.S. 1925–26	151 3 6	5,151 3 6	5,000 0 0
		,, ...	9½ m. to 12 m. 1,000 ft., 13 m. 1,220 ft. to 14½ m.	,, ...	Gravel and culverts.	3 5,060	6,805 9 0	Vote 1926–27	.....	6,805 9 0	6,805 9 0
		,, ...	14 m. 4,160 ft. to 15 m., 13½ m.p. to 14½ m.p.,	,, ...	,, ...	1 1,120	2,000 0 0	Vote 1928–29	.....	2,000 0 0	1,000 0 0
		,, ...	12 m. 1,000 ft. to 13 m. 1,220 ft.	,, ...	Gravel ...	1 220	2,000 0 0	Fed. Aid Grant, 1926–27.	.....	2,000 0 0	1,900 0 0
						11 1,120	15,805 9 0		151 3 6	15,956 12 6	14,705 9 0
1030	1/7/27	Hastings	0 ft. to 4,700 ft. (paved to 3,500 ft.)	Telegraph Point North.	W.B.M. and culverts.	0 4,700	2,500 0 0	Vote 1927–27	327 5 0	2,827 5 0	2,500 0 0
		,, ...	4,700 ft. to 2m. 1,140ft.	,, ...	W.B.M. ...	1 1,720	7,338 14 8	Vote 1928–29	.....	.....	2,000 0 0
						2 1,140	9,838 14 8		327 5 0	2,827 5 0	4,500 0 0
1032	22/1/26	Cockburn	1¼ m. to 3 m., 3 m. to 5¾ m.	Limbri	Clearing and formation.	4 2,277	5,812 0 0	C.C.S. 1925–26	644 0 5	6,456 0 5	5,812 0 0
		,, ...	Limbri Bridge	,, ...	Bridge and culvert, inc. approaches.	.....	2,777 17 4	Vote 1926–27	200 0 0	2,977 17 4	2,777 17 4
		,, ...	Swamp Oak Creek and Taylor's Creek.	,, ...	Bridges ...	.....	2,228 1 10	Vote 1926–27	200 0 0	2,428 1 10	1,900 0 0
		,, ...	18½ m. to 19½ m. ...	,, ...	Earth formation.	1 2,354	2,614 8 5	Fed. Aid Grant, 1926–27.	200 0 0	2,814 8 5	2,000 0 0
		,, ...	9 m. 1,770 ft. to 10 m. 2,640 ft.	,, ...	Deviation and formation.	1 870	369 0 10 2,000 0 0	Vote 1926–27 Vote 1928–29	....	....	....
						7 221	15,801 8 5		1,244 0 5	14,676 8 0	12,489 17 4
1034	22/1/26	Peel ...	5 m. to 6 m. 51 ch., 8 m. to 9 m. 72 ch., 14 m. 72 ch. to 15 m. 32 ch.	Westdale Railway Siding.	Gravel, culverts and causeways.	4 462	2,400 0 0	C.C.S. 1925–26	.....	.....	2,400 0 0
		,, ...	0 ch. to 65 ch., 65 ch. to 135 ch., 135 ch. to 142 ch., 191 ch. to 207 ch.	,, ...	Gravel, culverts and causeways.	1 3,069	5,000 0 0	Vote 1926–27	0 9 6	5,000 9 6	5,000 0 0
		,, ...	83 ch. to 273½ ch. ...	Winton	Gravel ...	2 2,013	5,144 6 0	Fed. Aid Grant, 1927–28.	.....	5,144 5 5	3,000 0 0
						8 264	12,544 6 0		0 9 6	10,144 14 11	10,400 0 0
1037	22/1/26	Wyaldra	0 m. to 0 m. 1,200 ft., 0 m. 2,700 ft. to 1 m. 60 ft.	Goolma	,, ...	0 3,840	1,800 0 0	Vote 1928–29	.....	.....	.....
		,, ...	37 ch. to 51 ch., 2 m. 22 ch. to 2 m. 53 ch., 3 m. to 3 m. 55 ch., 4 m. 14 ch. to 6 m. 34 ch., 1 m. 6 ch. to 1 m. 26 ch., 1 m. 39 ch. to 1 m. 65 ch.	,, ...	Clearing ... Gravel ...	3 2,640 0 3,036	1,000 0 0	C.C.S. 1925–26	135 6 11	1,135 6 11	1,000 0 0
						4 4,236	2,800 0 0		135 6 11	1,135 6 11	1,000 0 0
1044	Extended 29/6/28	Manning	8 m. 2,000 ft.	Gloucester and Manning Shire boundary, towards Krambach.	Timber bridge, Brown's Creek.	.....	5,000 0 0	Vote 1928–29	.....	.....	.....
	12/3/26	Gloucester	3 m. 3 ch. to 4 m. 10 ch.	8 m. 67 ch. from Gloucester towards Krambach.	Formation and culverts.	1 462	750 0 0	C.C.S. 1925–26	867 3 5	1,617 3 5	750 0 0
		,, ...	4 m. 10 c. to 6 m. ...	,, ...	,, ...	1 4,620	5,000 0 0	Vote 1928–29	.....	.....	.....
						2 5,082	10,750 0 0		867 3 5	1,617 3 5	750 0 0

LOWER NORTHERN DIVISION—*continued.*

Dev. Road No.	Date of Proclamation.	Shire or Municipality.	Location of Work. At	Location of Work. From	Class of Work.	Length.	Amount of Grant.	Source of Funds.	Completed Cost. Council's Contribution.	Completed Cost. Total.	Expenditure to 30th June, 1929.
						m. ft.	£ s. d.		£ s. d.	£ s. d.	£ s. d.
1048	22/1/26	Macleay...	6 m. to 6 m. 62 ch. ...	Comara	Formation and culverts.	3 198	6,000 0 0	C.C.S. 1925–26	422 14 9	6,422 14 9	6,000 0 0
			8 m. to 8 m. 35 ch., 10 m. 10 ch. to 12 m. 26 ch.	Bellbrook							
		,, ...	6 m. 62 ch. to 7 m. 10 ch., 5 m. 60 ch. to 5 m 76 ch. 7 m. 10 ch. to 8m	Comara	,,	1 2,244	3,252 19 6	Vote 1926–27	.....	.....	.....
		,, ...	6 m. to 6 m. 2,713 ft.	Bellbrook ...	,,	0 2,713	1,329 3 6	Fed. Aid Grant, 1927–28.	.....	.....	.....
						4 5,155	10,582 3 0		422 14 9	6,422 14 9	6,000 0 0
1056	1/7/27	Hastings	0 m. to 4,940 ft., 5,840 ft. to 8,300 ft.	Kendall ...	Gravel and culverts.	1 2,115	4,994 12 8	Vote 1926–27	.....	4,994 12 8	4,994 12 8
		,, ...	4,940 ft. to 5,840 ft., 8,300 ft. to 11,600 ft., 3 m. 1,900 ft. to 3 m. 4,200 ft.	,, ...	W.B.M. ...	1 2,520	5,212 2 6	Vote 1928–29	.....	.....	1,500 0 0
						2 4,635	10,206 15 2		.....	4,994 12 8	6,494 12 8
1073	5/8/27	Bellingen	0 m. 60 ch. to 1 m. 52 ch.	Bonville, towards Bonville Stn.	W.B.M. and culverts.	0 4,861	2,200 0 0	Vote 1926–27	332 5 8	2,532 5 8	2,200 0 0
1075	5/8/27	Nambucca	0 m. to 3 m. 4,768 ft. ...	Macksville ...	Gravel and culverts.	3 4,768	8,000 0 0	Vote 1926–27	119 0 0	8,119 0 0	8,000 0 0
		,, ...	29 m. 786 ft. to 31 m. 4,067 ft.	,, ...	Formation...	2 4,281	370 0 0	Vote 1928–29	.....	.....	.....
							6,000 0 0	Fed. Aid Grant, 1927–28.	.....	6,370 0 0	5,000 0 0
		,, ...	31 m. 4,067 ft. to 33 m. 2,046 ft.	,, ...	Formation, and culverts.	1 3,359	6,032 0 0	Vote 1928–29	.....	.....	2,000 0 0
		,, ...	30 m. and 30 m. 68 ch.	,, ...	Gravel and culverts.	0 4,488	1,000 0 0	C.C.S. 1923–24	6 2 10	1,006 2 10	1,000 0 0
						9 1,056	21,402 0 0		125 2 10	15,495 2 10	16,000 0 0
1078	5/8/27	Nambucca	17½ m. to 18 m., 18 m. to 19 m., 21½ m. to 24½ m.	Bowraville ...	Gravel and culverts.	3 4,092	1,500 0 0	C.C.S. 1923–24	296 3 10	1,796 3 10	1,500 0 0
		,, ...	0 m. to 2 m. 462 ft. ...	,, ...	Gravel and bridges.	2 462	6,500 0 0	Vote 1926–27	.....	.....	6,450 0 0
		,, ...	2 m. 462 ft. to 3 m. 2,470 ft.	,, ...	W.B.M. ...	1 2,008	23 9 10	C.C.S. 1923–24	.....	.....	1,500 0 0
							2,822 13 10	C.C.S. 1924–25			
							1,125 5 0	C.C.S. 1925–26			
						7 1,282	11,971 8 8		296 3 10	1,796 3 10	9,450 0 0
1093	3/2/28 Extended 6/7/28	Cockburn	0 ft. to 2,254 ft., 3,300 ft. to 2 m. 2,342 ft.	Attunga, towards Hall's Creek.	W.B.M. and culverts.	2 1,386	6,089 1 3	Vote 1926–27	1,439 1 4	7,528 2 7	6,089 1 3
		,, ...	1 m. (Attunga Creek) ...	,, ...	Bridge ...	.....	1,650 0 0	Vote 1928–29	.....	1,650 0 0	1,500 0 0
		,, ...	2 m. 4,830 ft. to 3 m. 3,850 ft.	,, ...	Earth formation.	0 4,300	525 0 0	Vote 1928–29	.....	502 2 4	350 0 0
		,, ...	1 m. 1 c., to 4 m. 2 ch....	Attunga, towards Somerton.	Culverts (8)..	.....	1,850 0 8	Vote 1928–29	14 12 6	1,864 13 2	1,000 0 0
						3 406	10,144 1 11		1,453 13 10	11,544 18 1	8,939 1 3
1094	3/2/28	Hastings	0 m. 2,200 ft. to 5 m. ...	Kindee	Gravel ...	4 1,440	15,000 0 0	Fed. Aid Grant, 1927–28.	.....	.....	6,000 0 0
1102	6/7/28	Merriwa...	3 m. to 3¾ m. and 5 m. 48 ch. to 7 m. 21 ch.	At Bow, towards Idaville.	,, ...	2 2,150	4,600 0 0	Fed. Aid Grant, 1927–28.	.....	.....	1,500 0 0
	Extended 29/11/29	,, ...	1 m. to 1 m. 35 ch.	,,	.....	.....	3,000 0 0	Vote, 1928–29	.....	.....	.....
			9 m. 33 ch. to 10 m. 25 ch.	,,	.....	2 1,792					
						4 3,942	7,600 0 0		.....	.....	1,500 0 0
1105	6/7/28	Upper Hunter.	16¾ m. to 17¼ m. ...	Aberdeen ...	Gravel, two bridges.	0 4,528	10,000 0 0	Fed. Aid Grant, 1927–28.	.....	.....	1,000 0 0
			15¼ m. (Rouchel) ...	,, ...	Bridge						
		,, ...	11 m. to 12½ m. ...	,, ...	Deviation ...	1 3,930	4,725 0 0	C.C.S. 1923–24	1,695 3 9	6,420 3 9	4,725 0 0
		,, ...	14 m. to 15 m. ...	,, ...	,, ...	0 5,190	2,400 0 0	C.C.S. 1924–25	495 5 6	2,872 11 8	2,377 6 2
						3 3,088	17,125 0 0		2,190 9 3	9,292 15 5	8,102 6 2
1109	29/6/28	,, ...	3 m. to 3 m. 4,025 ft. ...	41 m. from Scone	Formation, culverts.	0 4,025	5,000 0 0	Vote 1926–27	.....	.....	2,000 0 0
1112	20/7/28	Liverpool Plains.	0 m. to 1 m. 8 ch. ...	Dubbledah ...	Gravel ...	1 546	2,000 0 0	Vote 1928–29	.....	.....	.....
		,, ...	1 m. 8 ch. to 1 m. 60 ch., 7 m. to 7 m. 70 ch.	,, ...	Formation, gravel.	1 2,720	3,000 0 0	Vote 1926–27	.....	2,879 5 2	2,000 0 0
						2 3,266	5,000 0 0		.....	2,879 5 2	2,000 0 0
1121	14/9/28	Peel. ...	0 m. to 66 ch., 1 m. 17 ch. to 2 m. 61 ch.	Gidley Siding ...	Crossings. Gravel.	0 693 2 1,386	8,000 0 0	Vote 1928–29	0 1 8	8,000 1 8	6,500 0 0

The Six-wheel Rigid Frame Motor Vehicle.

By J. James, B.C.E.
Engineer.

In the February issue of *Main Roads*, the necessity was pointed out of not only adapting the roads to the vehicles using them, but also of endeavouring to develop types of vehicles which are capable of economic operation and, at the same time, do not require expensive forms of road construction. One of the transport units which have recently come into use with this latter objective is the six-wheeled rigid frame motor vehicle.

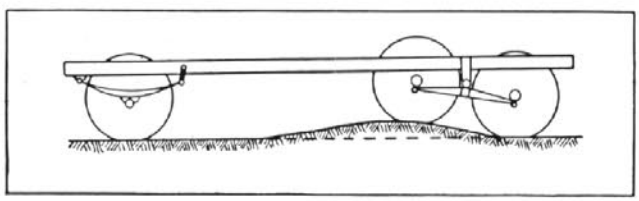


Fig. 1.

The adaptation of pneumatic tyres to commercial vehicles has, in the first place, enabled speeds to be increased from the comparatively low values suitable to solid tyred vehicles, and concurrently, the development of the six-wheel rigid frame chassis (shown diagrammatically in Figure 1) has enabled the gross weight of vehicles, and in due proportion, the pay load

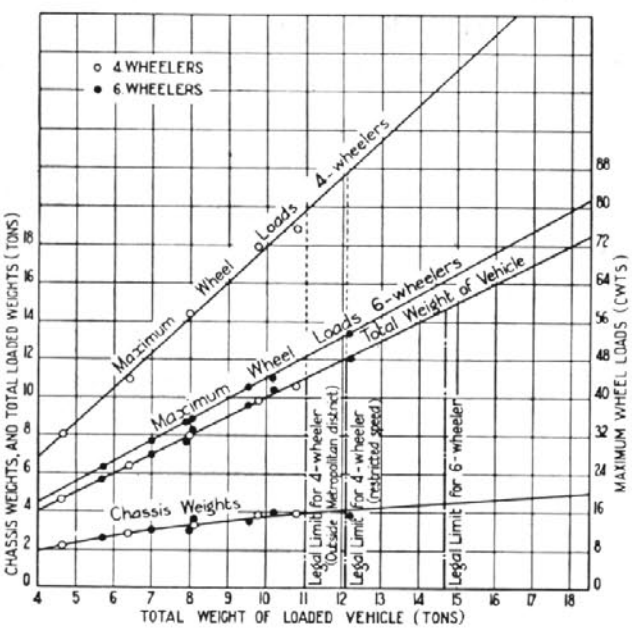


Fig. 2.

also, to be considerably increased without exceeding the wheel load limits fixed in the interests of preventing undue damage to road pavements. The principal type of six-wheeler developed during the last six years is such that several very definite advantages accrue to both vehicle and road, as compared with conventional four-wheelers of similar load-carrying capacity.

As indicated by the diagram, Fig. 1, the six-wheeler, in respect to its front end, is identical with the ordinary four-wheeler. The rear end of the chassis, however, is supported by a bogie of four wheels, each of which is connected by suitable gearing to the engine of the vehicle. Each axle is provided with a differential, as in the four-wheeler, but there is no differential between the two axles. The bogie is free to pivot about an axis at right angles to the length of the chassis, and each axle is spring-connected to this pivot in such a way that very considerable relative movement of the four wheels is possible. It is an essential feature of the construction of the bogie that, under all conditions of load and road, the balanced suspension shall enable the weight of the rear end of the chassis to be shared equally between the four driving wheels.

Figure 2 has been compiled from published data concerning British four-wheel and six-wheel trucks marketed in Australia, and arranged to indicate the relationship between chassis weight and total weight (chassis, body and maker's load rating) and to show the corresponding maximum (rear) wheel loads. In chassis of the same rated capacity there is no practical difference in weight as between four-wheel and six-wheel vehicles. The ratio of "weight of body and load" to "weight of chassis" steadily increases from 100:100 for a vehicle weighing 5 tons loaded to 160:100 for a 10-ton vehicle, and would be approximately 200:100 for a 15-ton vehicle. Throughout the range of the diagram the maximum wheel load of any six-wheeler is approximately 60 per cent. that of the four-wheeler having the same gross weight.

The advantages of the six-wheeler, compared with the four-wheeler, are as follow:—

1. Greatly lessened road-bed pressures.—Figure 3 is a diagrammatic representation of the pressures transmitted through the pavement to the road sub-grade from the rear wheels of six-wheel and four-wheel vehicles of equal load capacity, and has been drawn from the results of actual tests made upon a certain pavement by the United States Bureau of Public Roads. These tests indicate that the maximum subsoil pressure produced by the six-wheeler is only one-third of that produced by the four-wheeler. It follows that a considerably lesser depth of pavement would satisfactorily convey the former vehicle over a given subgrade than would be necessary to adequately support the latter.

2. Reduced impact forces.—The rear wheel loads of a six-wheeler are approximately 60 per cent. of those of a four-wheeler of the same capacity, and consequently the unsprung weights of six-wheeler and four-wheeler are in a similar ratio. The advantages of a lighter unsprung weight, as regards riding qualities, are too well known to need further comment.

To determine experimentally the impacts arising from motor vehicles the United States Bureau of Public Roads has made a number of tests. The details

and results of one series, shown in Figure 4, demonstrated that, of all the vehicles tested, the six-wheeler although the heaviest, caused the least impact, and would accordingly be the most economical vehicle in regard to damage to the pavement. The figure shows that the impact forces in the case of the six-wheeler are approximately equal to those in the case of a four-wheeler with a nearly equal wheel load and similar tyre equipment, indicating that the balanced suspension of the former vehicle is functioning as designed, and all road shocks are shared equally between the two driving axles.

3. Improved traction.—Should one rear wheel of a conventional four-wheeler lose traction it spins and power is automatically cut off by the differential from the other rear wheel. With the six-wheeler, when a rear wheel loses traction it cannot spin so long as the remaining three wheels, or two wheels of one axle, retain their grip of the road (since there is no differential between the rear axles), and power will continue to be applied through one axle at least. The

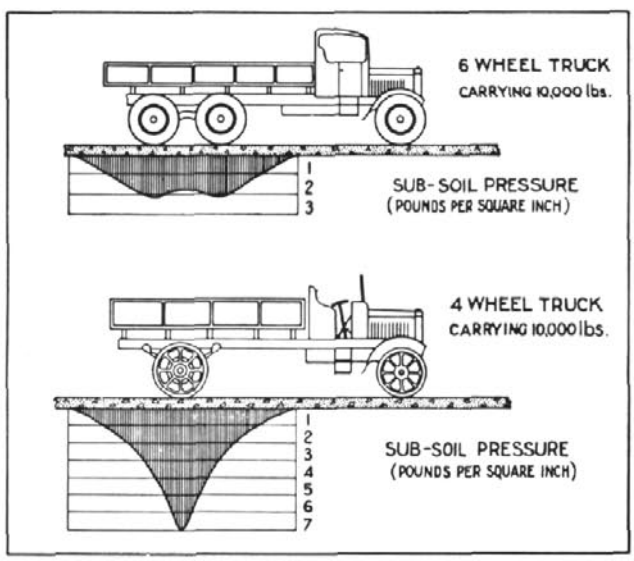


Fig. 3.

degree of improved traction provided by the latter vehicle has been demonstrated conclusively on many occasions during recent years. Conditions such as muddy unmade roads, desert sand, and grassy hillsides are negotiable by the six-wheeler, which, when provided with suitable wide range gearing designed to take full advantage of the improved traction, may be operated on grades quite outside the scope of the four-wheeler.

4. Increased life of tyres.—In Figure 5 it is shown that, in turning a corner with a six-wheeler, and steering by the front wheels only, the difference in the radii of the paths traversed by the two rear wheels on one side is about ¾ inch. This difference is easily compensated by the "give" in pneumatic tyres. In the comparable four-wheeler, which, if of more than moderate capacity, would necessarily be fitted with dual tyres on the rear wheels, the difference in radii of the paths traversed by each tyre would be of the order of 7 inches, which could not possibly be adjusted by "give" in the tyres, and slipping would occur. Should dual tyres be used on the rear wheels of a heavy six-wheeler these will be considerably smaller than the tyres of a corresponding four-wheeler, and would therefore be set closer together. This again would reduce wheel slip, as compared with the four-wheeler.

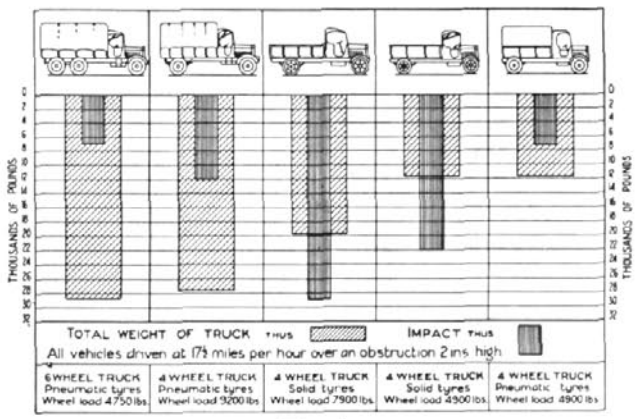


Fig. 4.

Experience has shown the life of tyres on six-wheelers to be from 50 to 75 per cent. in excess of that on four-wheelers, which is due in a large measure to the reduced tyre slippage and wheel spin.

5. Increased safety.—Brakes can be applied easily and conveniently to each of the four driving wheels of the six-wheeler, and the construction of the bogie greatly facilitates the equalising arrangements on the second and third axles. Should the brake on any one wheel be faulty that wheel would nevertheless be locked, since there is no differential between the two axles. The six-wheeler makes four rear tyre contacts with the road, as against two in the case of the four-wheeler, and skidding is practically eliminated.

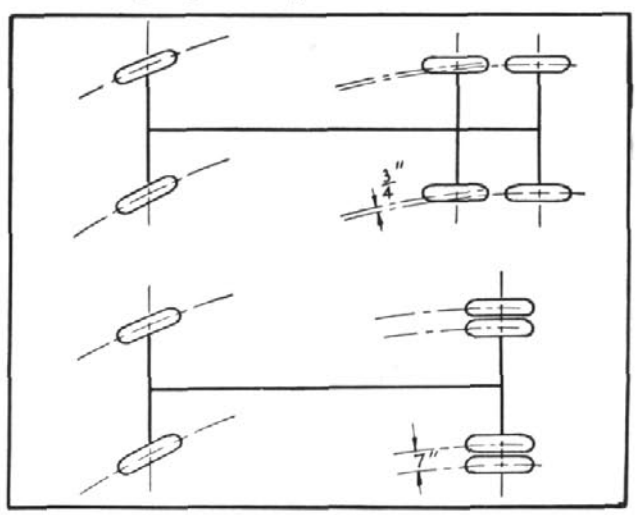


Fig. 5.

6. Increased riding comfort.—The impact forces dealt with by a rear axle of a six-wheeler are approximately one-half those which would occur in a vehicle with a single rear axle. In the former case the road shocks are shared between the two axles by the balanced suspension, and the shocks reaching the body of the

vehicle are thus further reduced, as compared with a four-wheeler of similar capacity operating under similar conditions. Also, as demonstrated by Figure 1, if one of the rear wheels should sink into a hole, or ride over an obstruction, the body and load will fall or rise, as the case may be, only one-half the distance as compared with the four-wheeler. These two considerations explain the increased riding comfort of the six-wheeler.

7. Less road congestion.—With six-wheelers, less vehicles are needed to handle a given tonnage. On account of the reduced wheel loads these vehicles lend themselves to the use of pneumatic tyres, which leads in turn to increased speeds. On account of the ease of applying four-wheel brakes to a six-wheeler the latter can safely be run at a higher speed than a heavy duty four-wheeler.

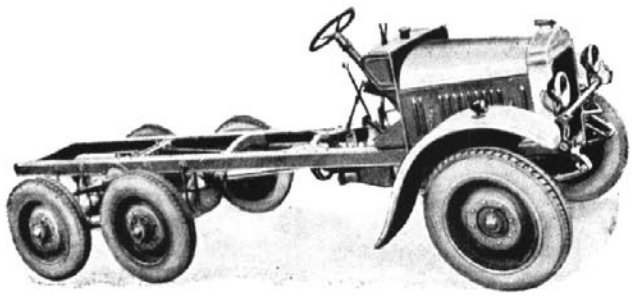


Fig. 6. A medium weight, War Office type, six-wheel chassis.

8. Increased economy of freight transportation.—A six-wheeler complying with the legal gross weight limit of 14 tons 13 cwt. would, as indicated by Figure 2, have a chassis weight of approximately 4 tons 9 cwt. Assuming a body weight of 1 ton 4 cwt. then the net load capacity of the vehicle would be 9 tons, while the dead weight, or non-paying load, would be 5 tons 13 cwt. Thus, for each ton of pay load 12½ cwts. of non-paying load would be propelled. Corresponding figures for other vehicles are given below.

Vehicle and capacity.	Chassis weight.	Body weight.	Total weight.	Pay load.	Dead weight.	Dead weight per ton of pay load.
	tons.	tons.	tons.	tons.	tons.	tons.
Legal limit 6-wheeler (9 tons)	4.45	1.20	14.65	9.0	5.65	.63
Legal limit 4-wheeler (6 tons)	4.0	1.0	11.0	6.0	5.0	.83
4-wheeler (4 tons)	3.5	.8	8.5	4.2	4.3	1.02
4-wheeler (3 tons)	3.0	.7	7.0	3.3	3.7	1.12
4-wheeler (2 tons)	2.2	.6	5.0	2.2	2.8	1.27

These figures indicate that the six-wheeler, by reason of its superior pay load ratio, would show a substantial economy in fuel consumption, tyre wear, and wear of pavements, as compared with any permissible four-wheeler.

Also, one six-wheeler, with one driver, could displace two four-wheelers, each with a driver, thus economising in wages; while the distinctive characteristics of the former vehicle—reduced wheel loads, four-wheel drive, and balanced suspension—lead to still further economies.

The foregoing relates specifically to the three axle, four-wheel drive, balanced suspension type of rigid frame six-wheeler which has been developed under the auspices of the British War Office. There are other types of six-wheelers which do not employ the War Office type of drive or suspension, and some drive on two wheels only. These vehicles, in general, are superior, in respect to the characteristics discussed above, to four-wheelers, but do not necessarily confer all the advantages of the type of vehicle to which the discussion is principally directed.

Acknowledgement is made of information extracted from the following sources:—

"Public Roads."
"Highway Engineer and Contractor."
"Australian Commercial Motor."

Reconditioning of Old Water-bound Macadam.

(*Continued from page* 178)

treated with about ¾ gallon per square yard of tar, and chippings are applied and rolled. Seal in the usual way.

(*c*) Constructing a light surface course as for waterbound macadam, but stopping at the point when water should be applied. Then apply tar or bitumen. This is substantially the same as "puddle macadam."

(*d*) An ordinary light penetration surface course, *e.g.*, 2 inches thick, is sometimes referred to as "semi-penetration." The use of the term in this connection is to be deprecated.

It will be noted above that Priming Tar has been recommended for priming reconditioned roads. In most cases a suitable road oil will be equally satisfactory—such as the Board's specification for Road Oil "A." Both Road Oil "A" (or any oil containing 55 per cent. or less of 80 penetration bitumen) and Priming Tar may be applied cold in warm weather. For National economic reasons however, it will be realised that, provided acceptable local products can be obtained at satisfactory prices, their use is preferable to the importation of materials from overseas.

Grade of Bitumen recommended for Use in Penetration Macadam Roads.

THE following circular was issued on 3rd April, 1930, to all Councils in the Eastern and Central Divisions of the State:—

The Board has had under consideration for some time the advisability of amending its specification for the bitumen used in bitumen penetration macadam roads and in surfacing work, from 60–70 penetration grade to a higher penetration grade.

Experience has now demonstrated that 85–100 penetration bitumen may be substituted for 60–70 penetration bitumen without increased risk of "bleeding" in hot weather, and with the definite advantage in both penetration and surfacing work of greater fluidity at time of application, especially at relatively low temperatures. A further advantage in surfacing work is that

(*Concluded on page* 189)

The Maintenance Organisation of the Prince's Highway Within the Southern Division.

By T. A. Donaldson, M.I.M.&Cy.E., A.M.I.E. (Aust.)

Divisional Engineer.

THE Prince's Highway within the Southern Division extends from Nowra on the north to the Victorian border on the south, a distance of 254 miles, passing in turn through the Municipalities of Nowra and South Shoalhaven, the Shire of Clyde, and the Municipality of Ulladulla, the Shires of Eurobodalla and Mumbulla, the Municipality of Bega, and the Shire of Imlay. For the whole of its length, it closely follows the coast line, frequently being in contact with it, and never more than 15 miles distant. It passes through beautiful scenery and, because of this and the many facilities for bathing and fishing, the road is one of the most popular tourist routes in the State. In addition, it is one of the two Interstate Highways to Victoria and the main avenue of communication between the South Coast and the State Capital, via Nowra, at which point the railway from Sydney terminates. It therefore performs the duties which in other parts of the State are rendered by a combination of rail and road, which makes it singularly important. The country passed through is devoted primarily to dairying, on which account the road facilities must be such as to permit of uninterrupted daily delivery of milk or cream to the factories established at the various centres. The chief points of contact with the coast are at Ulladulla, Bateman's Bay, Moruya, Narooma, Bega (via Tathra), Merimbula and Eden. These places are served regularly by coastal steamers, and hence they constitute, with the rail head at Nowra, the strategic points through which supplies of tools, plant and materials (other than those locally available) must be obtained.

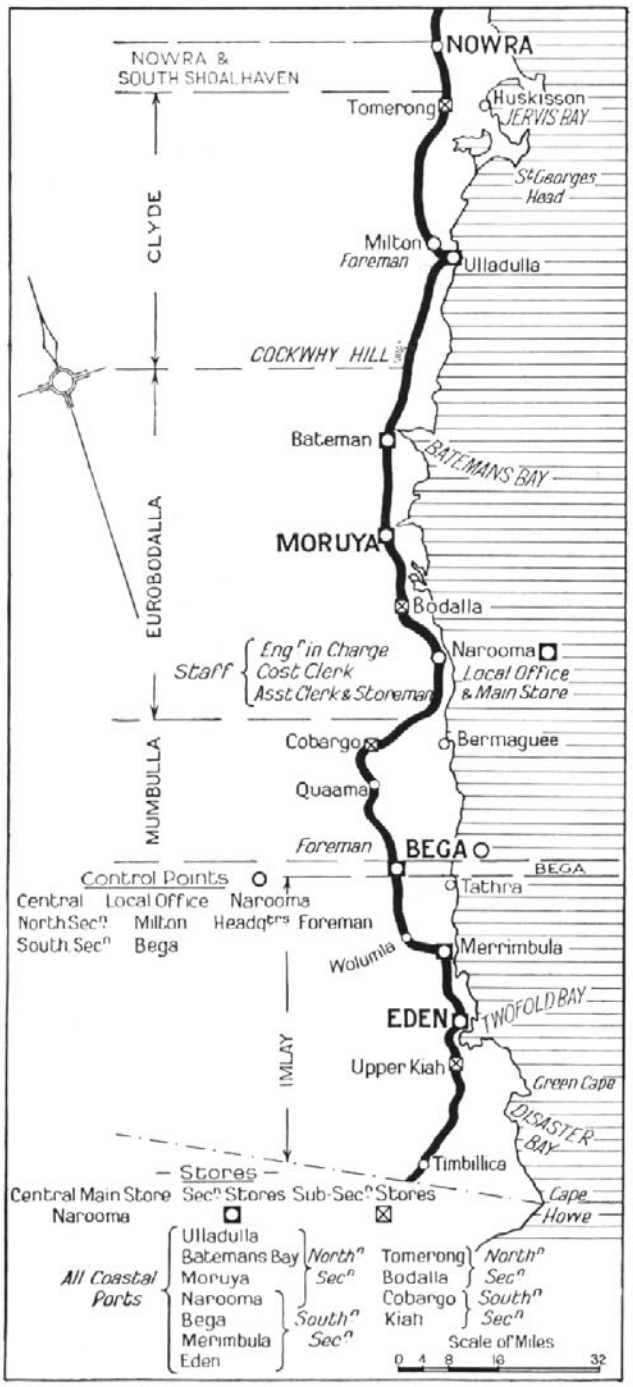
The surface of the Highway, with the exception of about 12 miles of bituminous pavement between Nowra and Tomerong, and short lengths of bitumen or tarred surfaces in the business areas of Milton, Bateman's Bay, Moruya and Narooma, is generally gravel interspersed with lengths of waterbound macadam or earth sections. Suitable materials for maintenance and repair are, especially at the northern end between Nowra and Bateman's Bay, difficult to obtain and of somewhat inferior quality. Towards the southern end, however, the supplies of stone and gravel improve in quality, particularly within the Bega district, where excellent decomposed granite gravel is obtainable at small expense.

As regards alignment and width, it was—and still is in certain parts—(like many other roads in the State which had been located and built before the advent of the present age of fast moving motor traffic) by no means satisfactory, long lengths in the vicinity of Milton and over the Cockwhy Hills between Ulladulla and Bateman's Bay, and from Wolumla to Eden requiring extensive deviation to fit them for modern conditions. In many other places, although the alignment was suitable, the width was insufficient.

The foregoing constitutes the salient points of the road, the bulk of which has, since April, 1929, been in the Board's hands for maintenance. It will readily be appreciated that the opportunity which then presented itself for organising an adequate system of maintenance was somewhat unique and that the problem was given very careful consideration. The works to be done by any maintenance organisation were seen to consist of two kinds—one the routine maintenance of placing and keeping the road in trafficable condition, and the other the continuous improvement of the road as the traffic grew in quantity and speed, as it was bound to do progressively with the improvement of the surface. While the former and a part of the latter could be best attended to by patrols with definite lengths of the road under their charge, a great deal of the second would consist of isolated works and could best be dealt with by gangs specially trained and equipped. Similarly any extensive repairs to bridges could only be efficiently carried out by special bridge gangs. Consequently a combined system of road patrols and gangs was indicated—the former being confined to definite lengths and performing routine work, the latter carrying out the specialised and emergency work wherever it was required. Each patrol would be simply and suitably equipped and given charge of a definite length, the mileage of which would be dependent upon the density or weight of traffic and the class of material forming the road surface. Each gang would be more elaborately equipped and would vary in size, from time to time, according to the nature of the work to be done.

To ensure that the operations of these groups were properly performed, the supervision of a resident Engineer and two resident Foremen was considered necessary. Narooma, as the most central point on the Highway, was selected as the Headquarters of the former, and Milton and Bega, respectively, as those of the latter, these being, in their turn, approximately midway between Narooma and the northern and southern limits of the Division. Thus, three effective and conveniently placed points of control were established. Attached to the main headquarters at Narooma were a clerk and a storekeeper to assist the Engineer-in-Charge with time-keeping, costing, store-keeping, payment of workmen and miscellaneous duties. The two foremen were each placed in control, under the direction of this Engineer, of the lengths in which they were stationed, the disposition of their headquarters making it practicable for them to supervise these with the minimum of travelling. They were also made responsible for the receipt and safe custody of stores arriving at railhead (Nowra only) or wharf, and the delivery to store, depot, or site of work, as required. Further, by equipping them with utility trucks for their conveyance, they were enabled, when reporting to the Local

Office (generally once a week) to deliver to the storekeeper tools and gear for repair by a blacksmith stationed at that point, and to receive new and repaired equipment and light stores for distribution to patrols and gangs along the road.



Sketch map of Prince's Highway, showing maintenance organization.

The general work of maintenance is performed by patrols consisting of a leading hand and one or more labourers. These are each equipped with necessary tools and plant consisting mainly of one two-horse grader, fitted with either a 5 or 6 ft. blade, and road drags. The graders are used for general light reshaping of gravel and earth sections, and the road drags for use after wet weather. For the purpose of obtaining new road making materials, a 30-cwt. or 2-ton motor lorry is provided and paid for at contract rates. In one section, a 2-ton motor lorry fitted with grader blade, operated by the driver, is in use instead of the usual separate horse-drawn grader and lorry. It has the advantage of combining the functions of the two independent machines and has proved very serviceable. With its aid, between 2½ and 3½ miles of road can be satisfactorily reshaped per day. Further improvements are now being tried which, it is hoped, will still further increase its usefulness.

The duties of each patrol are:—

(*a*) To keep the road to its proper shape and cross section by means of graders and drags.

(*b*) To repair the road surface by securing and adding new material when and where necessary.

(*c*) To provide for the satisfactory drainage of the road, side drains, culverts and bridges.

(*d*) To effect minor repairs to bridges and culverts.

(*e*) To keep the approaches to bridges and culverts, and their decks, in good condition.

(*f*) During times of flood, to prevent blockage of bridges by timber.

(*g*) To erect barriers and red lights at washouts and points of danger on the section.

(*h*) To maintain and/or improve the visibility by cutting down and removing scrub on curves and road sides.

(*i*) To repair or restrict the erosion of batters and side drains.

(*j*) To paint bridge and culvert fences, fender posts and sign boards.

(*k*) Broadly, to look after the entire section, and

(*l*) Finally, for the leading hand to forward reports of work done, materials used, from whom secured, times worked by men and plant under his charge.

The average length of road entrusted to each patrol is at present 22 miles.

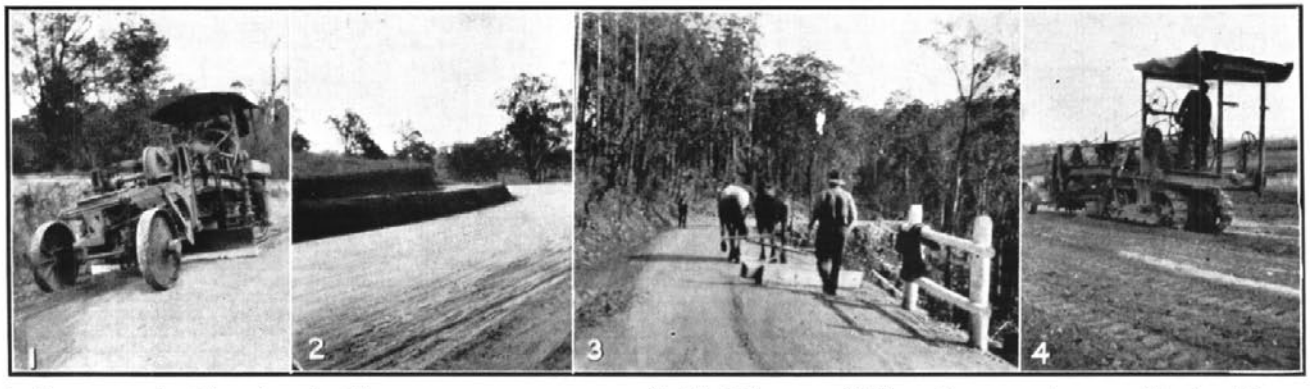
Superimposed on these patrols for still heavier work are three power scarifier graders, which are employed on the scarification, resheeting and partial reshaping of road surfaces where necessary, the final reshaping and consolidation being carried out by the two-horse graders previously mentioned. The lengths patrolled by these machines vary from 70 to 80 miles. Each is driven by a tractor, one unit being of the separate type requiring a driver and a grader operator, the others being of the combined type, operated and driven, except on heavy work, by one man. Assisting each of these machines is a labourer who removes stones and attends to the drainage in the section while the grader is working. To conserve time, caravans are attached to each unit and used by the men for camping.

Two road rollers are also in use for the scarification, reshaping and consolidation of waterbound and tar surfaced pavements, together with the consolidation of new gravel sections.

A considerable amount of improvement has been undertaken by way of widening and/or benching and superelevating curves, increasing the width of narrow sections and eliminating V gutters (*otherwise* causeways or inverts), notably between Wandandian and Milton, Bateman's Bay and Mogo, Bodalla and Narooma, Central Tilba and Dignam's Creek, Cobargo and Bega, and Eden and the Victorian border, but a large amount still remains to be done to bring the Highway up to the standard aimed at. Four gangs are employed on this work, and are making progress at the average monthly rate of 9,400 lineal feet of widening, while

Two ferry services are maintained—one over the Clyde River at Bateman's Bay and the other over the Wagonga River at Narooma. At the former, a twelve-vehicle steam ferry, operated by the Board's staff, is running; while at the latter a six-vehicle oil-driven ferry is being operated under contract. These ferries run day and night on demand, except once each month from 9 p.m. on the fourth Thursday to 6 a.m. the following day, when repairs and necessary overhaul are carried out.

The work which has been undertaken has produced a very great improvement in the condition of the road. This has resulted in attracting an ever increasing number of tourists to the South Coast, and has also enabled the regular passenger service cars to effect a reduction in travelling time, to such a degree that



1. Power grader trimming shoulders.
2. Visibility on a 66 ft. radius curve improved by benching.
3. A road drag working on gravel pavement.
4. Power grader scarifying and re-shaping gravel pavement.

during the six months ending 31st December, 1929, forty-seven turns were widened and superelevated. As a considerable quantity of excavation is in rock, especially south of Bateman's Bay, two portable air compressors are used for drilling purposes. Benching of side cutting on the inner sides of curves very greatly improves their visibility at a minimum expenditure and affords a ready means of improving their safety. It is, therefore, largely availed of where complete widening would be too expensive.

Twenty-three causeways were replaced with reinforced concrete pipe and box culverts during 1929.

The repair and maintenance of bridges and culverts is a most important item of work performed by the organisation. Each structure is closely examined once a year, and any other than minor repairs, which, as already mentioned, are included amongst the patrolman's duties, are carried out by a bridge gang, under the direction of a working foreman. These gangs are equipped with necessary plant, and the services of a diver are made available for inspection and repair of parts of structures below water. All timber used in repairs is obtained from the many local sawmills, supplied and delivered to bridge site at contract rates. Excellent turpentine piles are found between Nowra and Milton, ironbark near Narooma, while box and other suitable hardwoods are available. When new decking is required, steps are taken to provide spiking planks, which are bolted to the tops of girders. This arrangement not only increases the life of the structure but checks the rising of deck spikes.

residents from the extreme southern districts can now reach Sydney in one day. As was stated earlier in this article, however, much yet remains to be done as regards the improvement of alignment and width, and it is the Board's intention to pursue, as funds permit, a systematic policy of removing the present disabilities until the whole length of the Highway is brought into line with the standards required by modern traffic.

Grade of Bitumen Recommended for Use in Penetration Macadam Roads.

(*Continued from page* 186)

the softer bitumen enables the surface to be filled more readily with coarse screenings, thereby tending to prevent "bleeding." The Board has, therefore, decided that for all penetration and surfacing work of main roads in which bitumen is to be used, which will commence after 1st July, 1930, 85–100 penetration bitumen shall be specified, and it is asked that the Council's Engineer arrange accordingly.

In order, however, to allow the suppliers of bitumen to clear their stocks and orders of 60–70 material which they have obtained in anticipation of the old specification being continued, 60–70 penetration bitumen should continue to be specified, unless special circumstances warrant otherwise, for all penetration and surfacing work using bitumen, which will be commenced prior to 1st July, 1930.

No alteration is proposed in the grade of bitumen at present specified in premixed bituminous macadam.

Country State Highway Maintenance and Improvement Programme for 1930-31.

THE Board has requested the Divisional Engineers in charge of the six Country Divisions to prepare maintenance and improvement programmes, including bridges and ferries, on the State Highways for the financial year 1930-31.

his deputy, will traverse the more important Highways in company with the Divisional Engineer and the shire or municipal engineer, with a view to examining councils' proposals on the ground and making any adjustments that are necessary to co-ordinate the whole

MAIN ROADS BOARD OF NEW SOUTH WALES

DIVISION ..... HIGHWAY No. ..... MUNICIPALITY OR SHIRE OF .....

MAINTENANCE AND IMPROVEMENT PROGRAMME FOR YEAR 1ST JULY 19.... TO 30TH JUNE 19.....

	Item No	DESCRIPTION	LOCATION:* FROM	LOCATION:* TO	TOTAL QUANTITY	UNIT.	RATE.	AMOUNT.	REMARKS.
MAINTENANCE	1	General Maintenance of Roadway							
	2	General Maintenance Bridges & Ferries.							
	3	Regular re-forming by grader or drag only							
	4	Scarifying & re-forming by grader and/or roller							
	5	Catch and diversion drains							
	7	Re-Sheeting with gravel.							
	8	Re-Sheeting with broken stone							
	10	Tar re-surfacing							
	12	Bitumen re-surfacing.							
		TOTAL MAINTENANCE							
IMPROVEMENT	6	Forming shoulders & Super-elevating							
	9	Tar Surfacing.							
	11	Bitumen surfacing.							
	13	Construction of small culverts							
	14	Large renewals of bridges & ferries, separately listed							
	15	Erection of Sign Posts.							
		TOTAL IMPROVEMENT							
		GRAND TOTAL							

* Mileages from Municipal or Shire Boundary, measured in direction away from Sydney

These programmes are to be submitted not later than 5th May, 1930, in accordance with the form shown above, a separate sheet being used for each Highway in each shire or municipality, and chainages being continuous throughout the shire or municipality from the boundary nearer to Sydney.

It is proposed, when these programmes have been received at Head Office, that the Chief Engineer, or his deputy, will traverse the more important Highways in company with the Divisional Engineer and the shire or municipal engineer, with a view to examining councils' proposals on the ground and making any adjustments that are necessary to co-ordinate the whole of the programmes, and to fit them to the funds which can be provided.

On this occasion, definite provision has been made for the separation of "Maintenance" and "Improvement." By the latter term is meant definite improvement in the type of pavement (such as the change from gravel to gravel tar-surfaced) or of culverts (such as the replacement of a small worn out timber culvert

by a reinforced concrete pipe culvert), the enlargement or benching of curves, the replacement of causeways by culverts, &c. Previously these works, which can be best carried out in conjunction with the maintenance programme, have not been distinguished from maintenance. As, however, the cost per mile of road under such circumstances does not truly reflect the cost of maintenance, it has been decided to make this distinction as from 1st July, 1930, and to keep the costs accordingly. It will be noted that the item "Forming shoulders and superelevating" has been placed under "Improvement," but where the road has been properly formed, such work will come under the heading of "Maintenance."

The Divisional Engineer of the Central Western Division (Mr. H. M. Baker), in circularising the councils of his Division in preparation for the submission of the programme of that Division, asked that in order that he should be able to appreciate the councils' views as to the urgency of the works which appeared desirable, maintenance should be divided into "Obligatory," "Heavy" and "General" as set out below, and that in the case of the various items under "Heavy" maintenance, an order of urgency should be indicated.

Obligatory Maintenance (of the existing good lengths of pavement, which should include the lengths which were good prior to 30/6/29, and the lengths reconditioned under heavy maintenance under the 1929/30 programme).

(1) Gravel pavements—

(a) Light grading of pavement and shoulders four times.

(b) Cleaning and aligning watertables and catchdrains twice.

(c) Stacking and spreading maintenance gravel at the rate of 1 cubic yard per chain.

(2) Tar or Bitumen pavements (whether premixed, penetration or surfaced)—

Resurfacing in accordance with the Board's standard specification for such work.

(3) Structures—

Repair and repainting of culverts, mile posts and signposts and constructing small culverts.

Heavy Maintenance (of the lengths which at the completion of the 1929/30 programme are still bad).

(a) Scarifying, reshaping, resheeting with gravel at .....cubic yards per chain and rolling pavement and shaping up shoulders.

(b) Clearing and aligning watertables and catchdrains twice.

(c) Subsequent obligatory maintenance, to consist of light grading of pavement and shoulders once and stacking and spreading maintenance gravel at the rate of ½ cubic yard per chain.

General Maintenance (of the bad lengths not provided for under either Obligatory or Heavy Maintenance).

Supply of material (quantity to be specified) for the patching of these sections of the roadway until funds become available in subsequent years for its reconditioning.

Tenders and Quotations Accepted.

The acceptance by the respective Councils of the following Tenders has been approved by the Board during the month of March, 1930:—

Work.			Name of Recommended Tenderer.	Amount of Recommended Tender.
Municipality or Shire.	Road No.	Description.		£ s. d.
Namoi	127	Road construction, 1 mile 4,320 ft.	J. H. Sleeman	6,580 0 0
Oberon	1033	Formation, drainage and pipe culvert	Williams and Burton	362 11 0
Merriwa	1102	Road construction	D. Walmsley	669 12 4
Bibbenluke	288	Widening and gravelling between 23½ and 25½ miles	George Warne	3,851 6 0
Liverpool Plains	11	Forming and gravelling, 800 ft.	T. G. McKay	500 0 0
Do	11	Forming, gravelling and five culverts	D. McGee	1,300 18 6
Do	11	Forming, gravelling and three culverts	J. Sullivan and H. Armitage.	1,631 5 9
Bega	272	Repairs to Tarraganda-lane bridge	W. D. McDonald	767 8 0
Waugoola	1058	Forming and gravelling	J. Bryant	1,697 9 0
Do	1058	Forming and gravelling	J. Bryant	302 11 9
Manning	1044	Construction of timber bridge over Brown's Creek	E. W. Milligan	3,488 3 3
Upper Hunter	105	Construction of bridge over Hunter River, at Bell's Crossing.	J. A. Jackson and Sons	4,100 0 0
Tomki	1047	Waterbound macadam	Murray and Co.	1,104 5 3
Glen Innes	1099	Gravel roadway between 1 m. 600 ft. and 2 m. 1,630 ft.	Model Homes, Ltd.	1,930 19 2
Wyaldara	1037	Formation, gravelling and culverts	W. G. McDonald	834 18 6
Severn	9	Bitumen penetration, 4 miles	A. M. Black and Co.	14,032 8 2
Mittagong	260	Gib deviation, 5,260 ft.	M. Gilroy	8,795 16 4
Stroud	1110	Construction in waterbound macadam, 2 m. 4,280 ft.	McGrath, Caratti and Johnson.	6,128 1 6
Berrigan	1126	Gravel construction, 1 m. 4,220 ft.	C. Snell	2,930 0 0
Carrathool	6	Formation and clearing, 4 miles	Ledwidge and Hurst Bros.	788 0 0
Do	6	Formation and clearing, 4 miles	E. and G. McCau	901 0 0
Do	6	Formation and clearing, 4 miles	L. C. Billing	744 0 0
Do	1071	Clearing and forming, 3½ miles	J. Stokes	687 0 0

The following Tenders and Quotations were accepted by the Board during the month of March, 1930:—

TENDERS.

Work. Municipality or Shire.	Road No.	Description.	Name of Successful Tenderer.	Amount of Accepted Tender.
				£ s. d.
Goodradigbee } Yass } ...	56	Construction of 4 miles of gravel pavement	McGann and Edwards...	9,260 6 4
Apsley	11	Construction of 3 miles of gravel pavement...	Model Homes, Ltd. ...	8,662 14 2
Gunning } Yarrowlumla } ...	3	Construction of 15 miles of gravel pavement	J. Dunn, Ltd.	16,158 9 0
Port Stephens ...	10	Construction in bitumen penetration macadam of 2¾ miles between Raymond Terrace and Stroud.	W. B. Carr Construction, Ltd.	18,859 3 8
Erina	9	Surfacing of 8 miles of gravel pavement between Mooney Creek and Gosford with tar primer and bitumen seal.	J. Fowler and Co. (Aust.) Ltd.	5,193 5 6
Tenterfield	9	Construction of a four-span reinforced concrete bridge over Wylie Creek.	McLean Construction Co.	6,116 17 0
Yarrowlumla ...	3	Construction of a three-span reinforced concrete bridge over the Yass River, near Sutton.	McLean Construction Co.	2,288 16 0
Erina	9	Haulage of 7,500 tons of materials from Wyee railway station to the Board's depot at corner of Wyee-road and Wyong-Swansea road.	Hawkins, Ltd. ...	1 mile @ 1s. 7d. 2 miles @ 2s. 5d. 3 miles @ 3s. 3d.
Hornsby	9	Hire of up to sixteen 2-ton motor trucks with power operated or quick acting tipping gear.	G. A. Rudd.	1 @ 7s. 3d. per hr. 3 @ 7s. 6d. per hr.
			W. J. Donovan ...	4 @ 7s. 5d. per hr. 3 @ 7s. 6d. per hr.
			R. A. Chappell... ...	2 @ 7s. 6d. per hr.
			J. Staines	2 @ 7s. per hr.
			J. Saunders	1 @ 6s. per hr.
Port Stephens ...	101	Caretaking of the Paterson River bridge at Dunmore, for three years from 1st February, 1930.	B. Franklin	£104 per annum.
Ashfield	5	Purchase and demolition of shop near intersection of Parramatta-road and Great North road, Fivedock.	J. H. Brennan and Son	£32 10 0

QUOTATIONS.

No. of Quotation.	Description of Article.	Name of Successful Tenderer.	Amount of Accepted Quotation.
768	.....	Cancelled.	£ s. d.
778	Concrete pipes, 27 ft. x 15 in. dia.; 114 ft. x 21 in. dia.; 158 ft. x 42 in. dia.	State Monier Pipe Works	218 3 4
779	Bridge timber—Hewn girders—106 ft. 6 in., 13 in. x 12 in.; 33 ft. 6 in., 14 in. x 12 in.	E. J. Burnside	40 6 11
780	Deformed metallic jointing, 18,500 lin. ft., 18 gauge, g.i., in 6 ft. lengths.	F. G. Kerr & Co.	334 4 0
781	Mastic jointing, ⅜ in., 800 pieces, type A; 900 pieces, type B...	Ormonoid Roofing and Asphalts Co. ...	90 16 11
783	Concrete pipes, 66 ft. x 18 in.; 32 ft. x 21 in.	State Monier Pipe Works	30 4 0
785	Trachyte sets, 1,200 l. ft. 5 in. x 3 in.; 20, l. ft. 4 in. x 3 in. ...	Bowral Trachyte Quarries Syndicate ...	45 13 4
788	Concrete pipes, 132 ft. x 21 in.	State Monier Pipe Works	39 12 0
782	Blue Metal, 200 tons, 2½ in.	Sydney and Suburban Blue Metal Quarries...	80 0 0
784	Bitumen kettle, 50 gall.	W. N. Stone	37 10 0
786	Blue metal, 500 tons, ⅝ in.	State Metal Quarries	162 10 0
787	Bitumen, 50 tons, 60—70 pen.	Vacuum Oil Co. Pty. Limited.	375 0 0
791	Chain wire, 1,000 ft., 24 in. wide, 2 in. mesh, No. 8 B.W.G. ...	H. Clarke and Sons	17 14 2
790	Specimen cabinet	John Brown	2 18 6
795	Maple cabinet	Brien and Tompsett	8 1 9
793	Blue metal, 300 tons, ¾ in.	N.S.W. Associated Blue Metal Quarries ...	120 0 0
798	(In lieu of 794) Tar, 4,000 galls. No. 2, 4,000 galls. No. 3 ...	Australian Gas Light Co.	241 13 4
800	Firewood, 200 tons, in 2 ft. 6 in. lengths	Brunero Bros.	140 0 0
796	Rowing boat	W. M. Ford	32 10 0
797	Bridge Timber:—Hewn Girders—30 ft. x 13 in. x 12 in., 34 ft. x 15 in. x 12 in., 159 ft. x 14 in. x 14 in. Capwales, 464 ft. x 12 in. x 6 in. . Piles (12 in. small end), 294 ft. Round girders (16 in. small end), 125 ft. Decking, 3,000 ft. super, 7 in.—10 in. wide by 4 in., in 22 ft. 6 in. lengths.	G. and D. Mackay	253 12 10
801	Blue metal, 300 tons, ⅝ in.; 570 tons, 1½ in.	N.S.W. Associated Blue Metal Quarries ...	424 12 6
804	Tar, 5,350 galls., No. 0, delivered hot to Board's sprayers ...	Australian Gaslight Co. Ltd.	189 9 7
802	Blue Metal:— 80 tons, 2½ in.; 27 tons, 1½ in.; 27 tons, ¾ in.; 8 tons, ⅝ in.	N.S.W. Associated Blue Metal Quarries ...	34 19 11

Sydney: Alfred James Kent, I.S.O., Government Printer—1930.