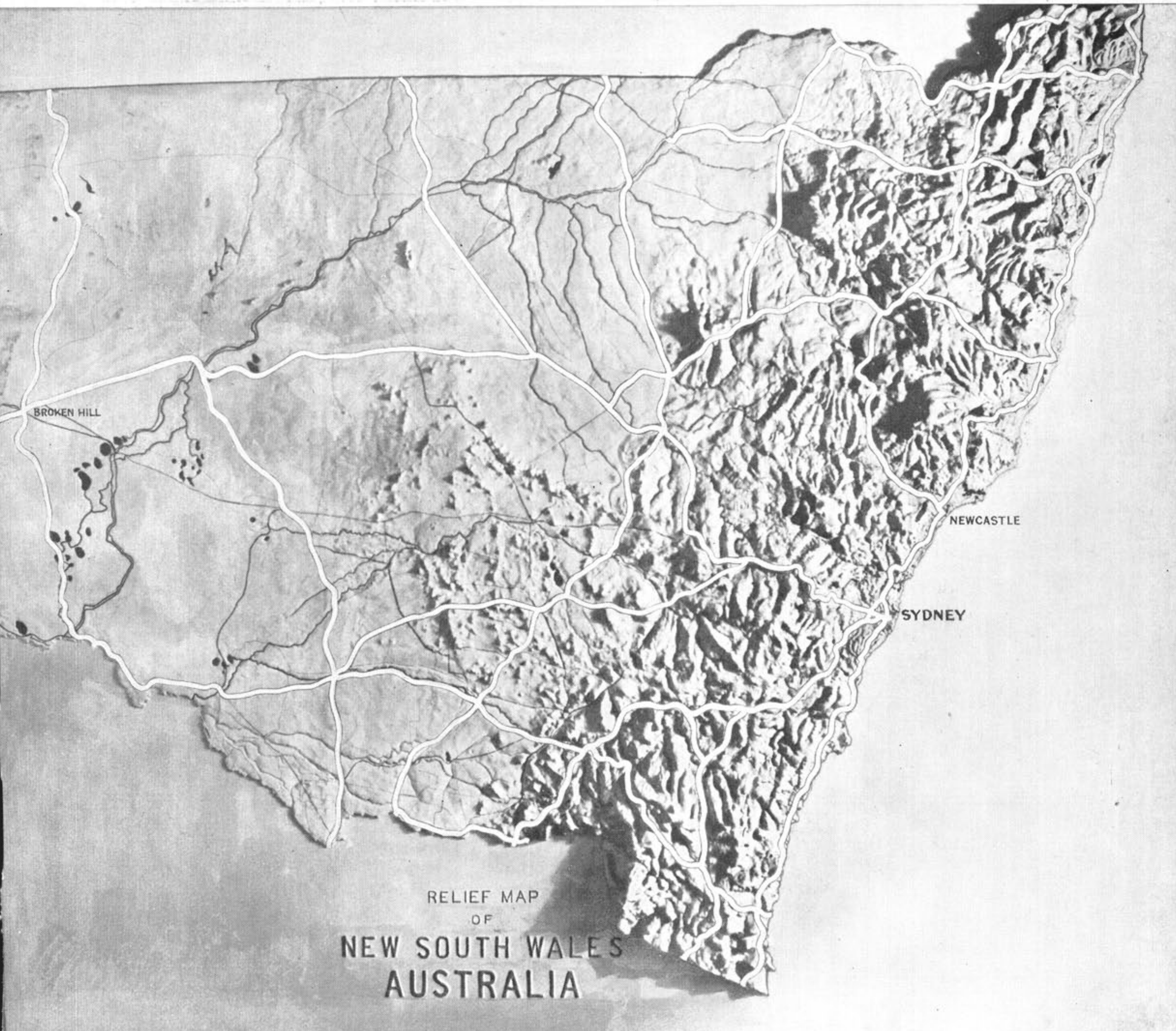
MAIN ROADS

A Record of the activities of the Department of Main Roads, N.S.W.



JUNE 1948

MAIN ROADS.

Issued Quarterly by and with the Authority of the Commissioner for Main Roads.

Vol. XIII, No. 4. *Sydney, June, 1948.* *Price: One Shilling.*

CONTENTS.

Additional copies of this journal obtainable from the—

Department of Main Roads,

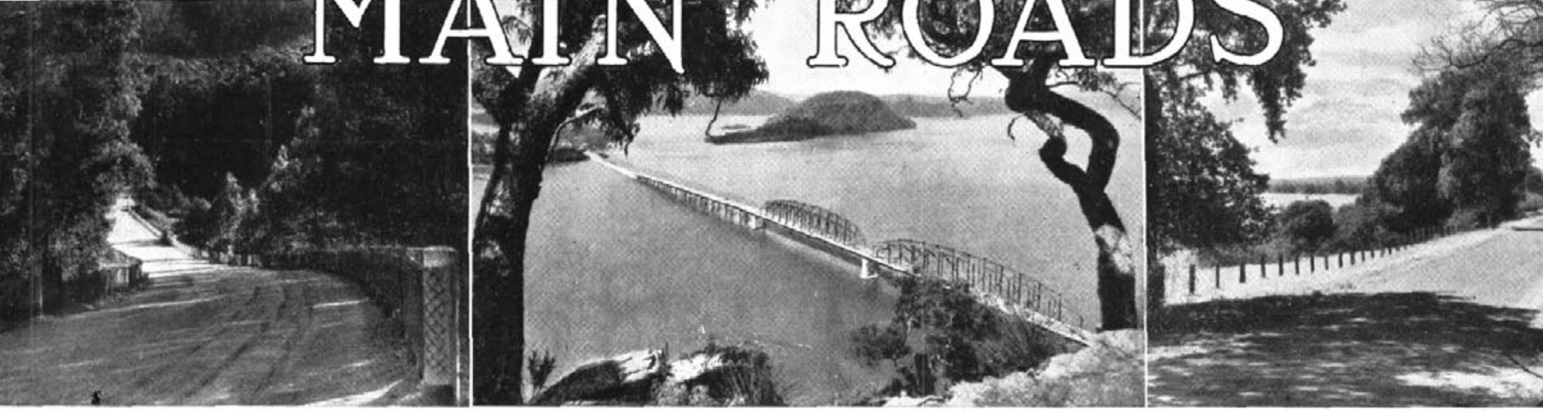
309 Castlereagh Street, Sydney, New South Wales, Australia.

Box 3903 G.P.O. Telephone: M 6231. Telegrams: "Mainroads" Sydney

Annual Subscription, 4/-; Post Free.

Next Issue: September, 1948.

*86756



Vol. XIII, No 4. *Sydney, June, 1948.* 97

Main Roads Administration in New South Wales.

•

A BRIEF ACCOUNT OF THE FUNCTIONING OF THE MAIN ROADS ACT.

The Main Roads Act came into force on the 1st January, 1925, and has thus been in operation for slightly more than twenty-three years. The Act has, since the end of 1932, been administered by a Commissioner for Main Roads and an Assistant Commissioner, and the organisation under their control is named "The Department of Main Roads," the headquarters of which are located in Sydney.

The Department's responsibilities are discharged either by providing financial and technical assistance to the Shire and Municipal Councils or by the Department itself carrying out works on main roads.

THE MAIN ROADS SYSTEM.

Public roads, except those within the City of Sydney and certain other areas minor in extent, may be proclaimed as Main, Secondary or Developmental roads upon the recommendation of the Commissioner for Main Roads.

There are five classes of proclaimed roads which are described hereunder:—

Main Roads:—

State Highways.—The State Highways are the principal avenues of road communication between the coast and the interior, or throughout the State and connecting with such avenues in other States.

Trunk Roads.—The Trunk Roads are the secondary avenues of road communication which connect the State Highways, and with them, complete the framework of the general system of inter-communication by road throughout the State.

Ordinary Main Roads.—The Ordinary Main Roads provide a network of roads connecting towns and important centres of population with the State Highway or Trunk Road routes and with each other.

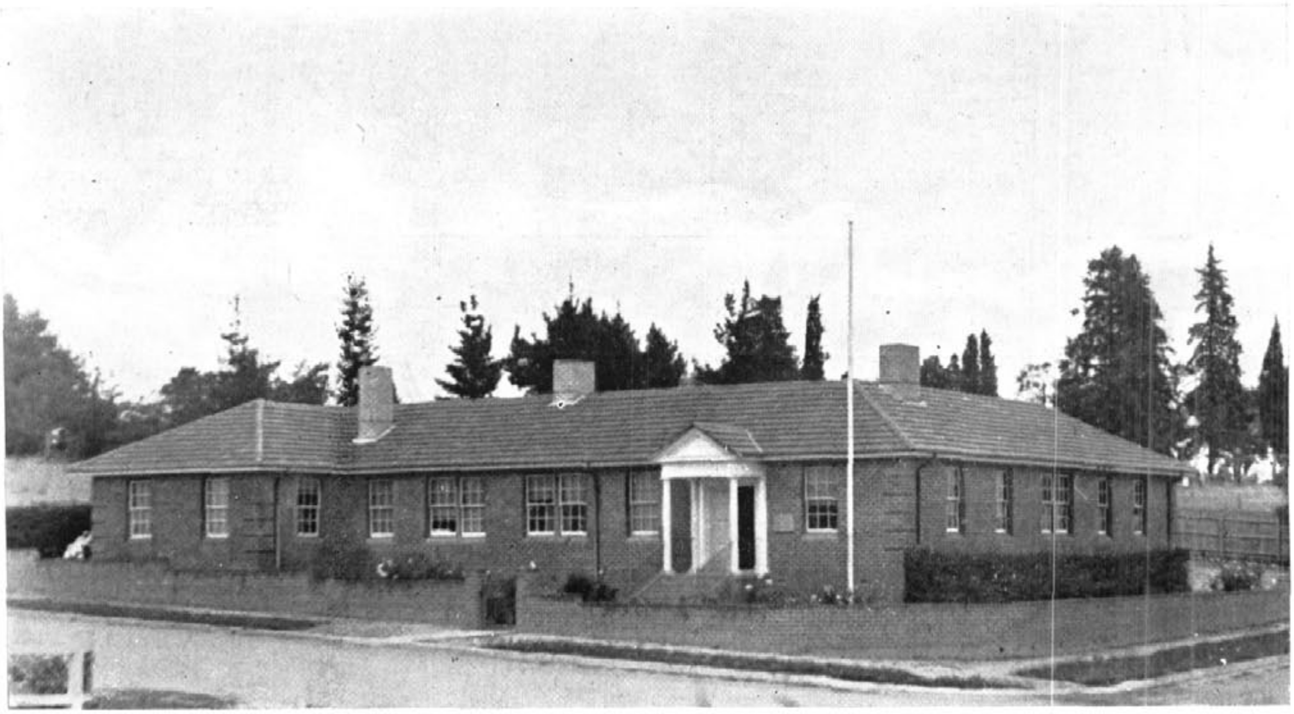
Secondary Roads:—

The Secondary Roads are roads within the County of Cumberland (*i.e.*, the Metropolitan area and rural environs) which carry a substantial amount of through traffic and thereby relieve a neighbouring main road of traffic which it would otherwise have to bear.

Developmental Roads and Works:—

Developmental Roads and Developmental Works are roads or works as the case might be which will serve to develop or further develop any district or part of a district; or will serve to develop any area of Crown or private land by providing access to a railway station or a shipping wharf or to a road leading to a railway station or a shipping wharf. A developmental work generally consists of a short length of road construction, or the construction of a bridge on a road which is otherwise passable but which in the absence of the bridge is impassable after heavy rains.

*86756—2



South Coast Divisional Office, Bega.

The total mileage of public roads in the State is 126,058. The mileage under the assistance of the Department at the 1st July, 1947, was as follows:—

Classification.	County of Cumberland.	Country.	Western Division	Total.
Main Roads—				
State Highways ...	193	4,969	1,339	6,501
Trunk Roads	...	2,378	1,353	3,731
Ordinary Main Roads...	593	9,051	3,009	12,653
Total Main Roads ...	786	16,398	5,701	22,885
Secondary Roads ...	81	...	...	81
Developmental Roads ...	15	2,790	...	2,805
Unclassified	...	...	2,309	2,309
Grand Total—All Roads	882	19,188	8,010	28,080

MATTERS INCIDENTAL TO THE MAINTENANCE AND CONSTRUCTION OF ROAD PAVEMENTS.

The Department's activities in respect of works carried out with its ordinary Main Roads funds are confined, as a general rule, to works for the improvement of the carriageway of the road. In those cases where a country main road passes through a city or town, the Department's assistance is in ordinary circumstances limited to a width of twenty feet of pavement; in all other cases the Department assists in the improvement of the width of pavement required for traffic purposes.

The works towards the cost of which the Department contributes are not necessarily restricted to those carried out on the pavements only, but may extend to ancillary works of value to the road pavements and to the traffic which uses the pavements. Examples of these works are drainage, kerbing and guttering, tree planting, road signs and acquisition of property for road widening purposes.

The Department exercises control over such matters as tree preservation, road openings, overhead wiring, petrol pumps, and also over advertising signs or hoardings whether these are on or in some special cases adjacent to main roads. Having advised the Shire and Municipal Councils of the Department's policies regarding these matters, the Department for the most part relies on the Councils for their implementation, although an over-riding supervision is exercised by the Department.

THE DISTRIBUTION OF WORK AS BETWEEN THE MAIN ROADS DEPARTMENT AND THE SHIRE AND MUNICIPAL COUNCILS.

The objective of the Main Roads Department has been always to work in close co-operation with Shire and Municipal Councils. The work of constructing and maintaining the main roads is, to a large extent, in the hands of the Councils. From time to time, however, major works are undertaken directly by the Department. It is only on the State Highway System that the Department directly controls any considerable length of road and as at the financial year ended on 30th June, 1947, the position was that 85 per cent. of the main roads system was under the control of local authorities and the remaining 15 per cent. under the direct control of the Department. These percentages exclude roads in the Western Division, all of which are directly controlled by the Department, mainly through Public Works Department District Engineers.

A feature of this form of distribution of responsibility has been the transfer of officers between the engineering services of the Department and local authorities. Young men have been trained in Departmental practices, both in the office and in the field and, after a few years, have secured employment as Engineers or Assistant Engineers with Councils. It has been possible for them to gain experience of special phases of road work by transfer from branch to branch within the Department and this has well fitted them to fulfil their responsibilities for the general engineering supervision of council works.

For the greater part of works undertaken on main roads the preliminary surveys and designs are prepared by engineers to the local councils. These are submitted for examination by the Department's technical officers and when agreement has been reached as regards the designs, specifications and estimates, works are authorised to proceed. For maintenance works there are undertaken each financial year programmes which include the regular routine maintenance of roads and bridges and minor improvements. All works calling for detailed design or involving substantial reconstruction expenditure are dealt with independently as construction items. As each work is approved the Department advances to the Council responsible for the work sufficient funds to meet the expenditure for two months. At the end of each subsequent month recoupment is made of the expenditure already incurred upon the submission of certificates giving particulars of expenses and costs and following periodical engineering inspections of the works in progress.

DECENTRALISATION OF ADMINISTRATION.

Divisional offices under the charge of Divisional Engineers have been established throughout the country so that responsible officers may keep continuously in touch with the local Councils and their officers and secure an intimate knowledge of requirements in individual areas. These officers are authorised to finalise conduct of work as far as possible without reference to the Head Office in Sydney. Administration is thus decentralised and the volume of correspondence between local and central authorities is kept to a minimum. At the present time there are twelve Division with headquarters at the following centres:—

Metropolitan Division—Sydney.
Outer Metropolitan No. 1 Division—Petersham.
Outer Metropolitan No. 2 Division—Chatswood.
Upper Northern Division—Glen Innes.
North Western Division—Tamworth.
North Eastern Division—Grafton.
Lower Northern Division—Newcastle.
Central Western Division—Parkes.
South Western Division—Wagga Wagga.
Southern Division—Goulburn.
South Coast Division—Bega.
Central Murray Division—Deniliquin.

It is usual for local offices to be established on the site in the case of the Department's day labour works and for engineering and clerical officers to be stationed at these offices for the purposes of supervision and administration. The number of local offices varies from time to time according to the location and volume of works in hand.

The Department maintains a central workshop and store in the Metropolitan area where employees are engaged in the repairing of plant, etc., required in connection with the Department's works.

North Eastern Divisional Office, Grafton.

SYDNEY HARBOUR BRIDGE.

The Department is responsible for the administration of the Sydney Harbour Bridge, the finances of which are by statute separate from the Main Roads funds.

The cost of maintaining the bridge as well as the cost of interest and sinking fund payments is met from the proceeds of toll charges. Road tolls are collected directly by the Department, while rail, tram and omnibus tolls are collected and remitted to the Department by the authorities which operate the services concerned.

FINANCE.

Provision is made for the establishment of three funds for the purposes of the Main Roads Act. These are:—

The County of Cumberland Main Roads Fund, for expenditure on Main and Secondary Roads within the County of Cumberland. (The County of Cumberland embraces an area within approximately 40 miles of Sydney including the Metropolis, but for the purposes of the Main Roads Act it excludes the City of Sydney.)

The Country Main Roads Fund, for expenditure on Main Roads in the area outside the County of Cumberland. The expenditure on all roads, whether proclaimed Main Roads or otherwise, in the Western Division of the State is also financed from this Fund.

The Developmental Roads Fund, for expenditure on the construction of Developmental Roads and Developmental Works as distinct from Main Roads.

The Financing of Works on Main and Secondary Roads.

A different system of administration, principally in relation to finance and rates of assistance for works, is provided for in the County of Cumberland as distinct from the rest of the State. This will be referred to later.

The principal sources of the Department's regular revenues for works on main and secondary roads are the proceeds of motor vehicle taxation collected by the State Department of Road Transport, and of petrol taxation collected by the Commonwealth Government.

The proceeds of the motor vehicle tax is, at present, paid into either the County of Cumberland or the Country Main Roads Funds. The Country Main Roads Fund receives the complete amount of tax paid by those residents outside the County of Cumberland. Half of the motor taxation levied in the County of Cumberland is also paid into the Country Main Roads Fund, the remaining half being appropriated to the County of Cumberland Main Roads Fund.

The proceeds of the annual motor registration fees and the motor vehicle drivers' and riders' license fees are used in the first place to meet the cost of the administration of motor vehicle registration, etc., by the Department of Road Transport, the cost of the provision of certain traffic facilities, and the cost of police control of traffic. The balance then remaining is allocated to the Country Main Roads Fund, although the amount is a minor one at present.

The proceeds of 3d. per gallon taxation on imported petrol and 2d. per gallon on locally refined petrol (excluding in both cases petrol used for aviation purposes) are paid to the States for expenditure on roads, provided that not more than one-sixth of the amount may be expended on such other works connected with transport as the State thinks fit. The amount received by New South Wales and devoted to roads is allocated between the County of Cumberland and the Country Main Roads Funds in the same proportion as is the amount received from the motor vehicle tax.

In addition to the two principal sources of revenue of the County of Cumberland and Country Main Roads Funds (motor and petrol taxation), provision is made in the Act for the proceeds of a regular annual levy on Councils in the County of Cumberland to be paid into the County of Cumberland Main Roads Fund. This levy is based on a maximum of ½d. in the £ on the unimproved capital value of all lands ordinarily rateable under the Local Government Act, and situated in the councils' areas, except that the levy in the case of lands used principally for rural primary production is reduced by one-half. The maximum rate was levied from 1925 to 1932, since when a rate of 7/16d. (reduced to 7/32d. for primary production lands) has been adopted. The Department then meets the full cost of approved works carried out on all main roads in the County of Cumberland, irrespective of their relative importance.

The Main Roads Act does not provide for a rate to be levied by the Department on the Councils in the area outside the County of Cumberland area. In that area, that is the Country area, the main roads are divided into three classes, viz., State Highways, Trunk Roads and Ordinary Main Roads, according to their relative importance. The Councils' contributions in the country are made by means of a direct payment towards the cost of approved works. The Department meets the full cost of works on State Highways in the country, and the Councils' contributions are usually at the rate of one-quarter in the case of Trunk Roads and one-third in the case of Ordinary Main Roads. The present rates of contribution by the Department which are applicable to all works on main roads in the country, are, broadly, as follows:—

	Construction and Maintenance of Roads and Maintenance of Bridges.	Construction of Bridges.
	%	%
State Highways	100	100
Trunk Roads	75	100
Ordinary Main Roads ..	66 2/3	75

Provision is made in the Act for such loan moneys to be appropriated for the use of the Department as

Parliament may decide should be spent on specified works on main roads. Loans of this nature are made available, as required, to the Department by the State Government, and it is usual for the interest, exchange and repayment of the loans to be made a charge against the Department's revenues. The outstanding loan liability of the Department in respect of main roads works at the 30th June, 1948, will be approximately as follows:—

County of Cumberland Main Roads Fund	157,000
Country Main Roads Fund ..	3,678,000
Total.. ..	£3,835,000

It is competent under the Act for money to be received into the two Main Roads Funds for the carrying out of special works. Defence Works and Unemployed Relief Works are examples of the larger special works executed by the Department.

Reference has so far been made to State Highways, Trunk Roads and Ordinary Main Roads. There is, however, another type of road provided for in the Act called a Secondary Road, which may be proclaimed as such in the County of Cumberland only. These roads are those which carry a substantial amount of through traffic and thereby relieve a neighbouring main road of traffic which it would otherwise have to bear. The Department meets one-half of the cost of approved maintenance and construction works on this type of road.

The Department is required to meet the full cost of all approved works on roads in the Western Division of the State other than those in the six municipalities in that Division. The classified roads in those municipalities are subsidised on the same basis as are the classified roads in the country portion of the rest of the State.

The main features of the financing of main roads expenditure may be briefly summarised as follows:—

(1) The sources of the Department's revenue are motor vehicle tax, petrol tax, loan moneys, special funds which are not regular or statutory provided from Government sources and, in the case of the County of Cumberland, a direct levy on Councils which is met by the owners of the land in that area.

(2) Half the motor vehicle tax collected within the County of Cumberland is spent in the County of Cumberland. The remaining half, together with the whole of the amount collected outside the County of Cumberland is spent in the country. The proceeds of the petrol tax received by the State and devoted to roads are allocated between the Cumberland and Country Main Roads Funds in the same proportions as are the proceeds of the motor tax.

(3) Contributions by Councils in the country are made by way of direct payments towards the cost of works carried out, other than by way of a uniform levy as in the County of Cumberland.

(4) The full cost of approved works in the County of Cumberland is paid for from the funds available to the Department.

(5) The Department's subsidy for approved works in the country varies generally according to the classification of the roads on which the works are carried out.

The Financing of Works on Developmental Roads.

Funds for developmental roads and works are received by way of loan moneys provided by the State Government, moneys provided usually by the State Government for special purposes such as Unemployment Relief Works, and moneys paid to the State by the Commonwealth Government. The amounts received are not regular or statutory. The Department's assistance in respect of developmental roads and works is restricted to approved construction works in respect of which it usually meets the full cost, the matter of maintenance being the responsibility of the Councils.

Total Receipts and Payments, 1946-47.

The Receipts and Payments in respect of principal items for the year ending on 30th June, 1947, were as follows:—

	County of Cumberland Main Roads Fund.	Country Main Roads Fund.	Developmental Roads Fund.	Total Main and Developmental Roads Funds.	Sydney Harbour Bridge Account.	Total.
	£	£	£	£	£	£
RECEIPTS—						
Motor Taxation, Fees and Licences.	498,000	1,583,000	......	2,081,000	......	2,081,000
Petrol Taxation	308,000	1,002,000	......	1,310,000	......	1,310,000
Contributions by Councils.	237,000	7,000	......	244,000	......	244,000
Loan Moneys ...	......	300,000	100,000	400,000	......	400,000
For Special Works.	......	30,000	......	30,000	......	30,000
Toll Charges ...	40,000	......	......	40,000	481,000	521,000
PAYMENTS—						
Maintenance and Minor Improvement Works.	362,000	1,861,000	......	2,223,000	54,000	2,277,000
Construction Works, including Land Resumptions.	375,000	749,000	40,000	1,164,000	......	1,164,000
Loan Charges ...	92,000	196,000	......	288,000	420,000	708,000
Administration and Cost of Toll Collections.	39,000	133,000	2,000	174,000	15,000	189,000

Reconstruction of Pacific Highway (S.H.10) from Frederickton to Eungai Creek.

The reconstruction of the Pacific Highway between Frederickton and the village of Eungai Creek, a distance of twenty miles, on the Kempsey-Macksville section of the highway, within the Shires of Macleay and Nambucca, is one of the most important road improvement projects undertaken since the end of the war.

Frederickton is situated five miles north of Kempsey, with which it is connected by bitumen surfaced pavement. The highway both north and south of Frederickton traverses the highly fertile alluvial Macleay River flats which are closely settled with dairy and grazing pastures varying in size from about forty to one hundred acres. At Clybucca, eight miles north of Frederickton, the country rises in low ridges and the road passes through State Forest and flood refuge areas to the village of Eungai Creek, twenty miles north of Frederickton. The northern end of the work links up with the approaches to a new bridge under construction at Allgomera Creek and with a section of highway previously reconstructed to modern standards.

The road alignment on the Macleay River flats consists of short straights and right-angle bends. Flooding on the flats had gradually raised the adjoining land above the level of the road pavement so that drainage was largely concentrated along the road, softening the silty subgrade and causing frequent failure of the gravel pavement. The width of road reserve was in some places only three-quarters of a chain, leaving little room off the pavement for travelling stock, public utilities, drains, etc. On the higher ground, the holdings being larger, there were longer straights between bends. Sharp vertical curves where sight distance over crests fell below safety limits, occurred at ridges. The pavement was narrow with little or no shoulder.

On this section of the highway traffic density is about 200 vehicles per day.

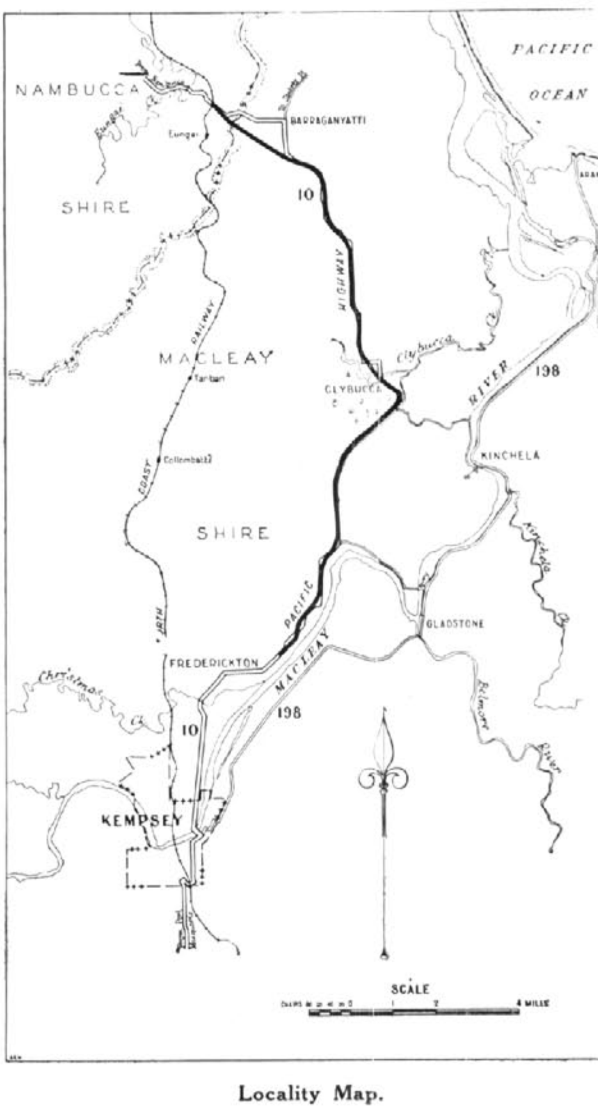
Design.

New work has been designed on a speed standard of 50 m.p.h. with minimum radius of curvature of twelve hundred feet, and minimum sight distance of six hundred and fifty feet, a formation width of twenty-eight feet with a twenty-two feet wide gravel pavement to be subsequently surfaced with bitumen to a width of twenty feet.

The section on the Macleay Flats is covered during high floods to a depth of five feet, and upwards, and it is important that flood waters be cleared from the pastures as quickly as possible. The new pavement has been designed, therefore, to conform generally to the level of the adjoining paddocks, thus providing for adequate drainage of the pavement without checking passage of flood waters. This entailed extensive filling to raise the old road.

Drainage structures in the form of concrete pipe and box culverts have been provided to replace and augment the existing timber culverts.

It was decided to adopt a minimum road width of one and a half chains across the Macleay River flats, widening to the normal two chains for new work, on the ridge country.



Locality Map.

Grader spreading and Tractor-drawn Cleated Roller breaking up shale.

Materials Survey.

There are no deposits of ridge gravel in the Frederickton district the only pavement material available being shale of varying quality in low ridges near Frederickton and Clybucca. Samples of subgrade soil, soil for filling and shales for pavement material were tested before the work was commenced. Suitable shale filling was obtained from ridges near each end of the flat section, but some difficulty was experienced in selecting pavement materials owing to the variable nature of the shale deposits. A quarry was eventually opened at Frederickton, near the Macleay Shire Council's pit, and an old quarry north of Clybucca was reopened and extended. Some pavement material was also obtained from a deep cutting at Clybucca Creek. Prior to sealing with bitumen the material in the pavement will be again tested and if necessary strengthened to support a bituminous seal.

Equipment.

On completion of the materials survey it was decided that the filling and pavement shale could best be handled by ripping and scooping over loading platforms. The following plant was then assembled to commence construction:—

- Three Tractors 85/90 h.p. all fitted with Power Control Units.
- One Trailbuilder attachment.
- Two 6 cu.yd. Scoops.
- One Tractor 60 h.p.
- One Heavy Duty Power Ripper.
- One Heavy Duty Manual Ripper.
- One Pneumatic Tyred Drawn Grader—10 ft. blade.
- One Double Sheepsfoot Roller.
- One Cleated Roller.

A light power grader was supplied as the work proceeded, and a heavy one is loaned intermittently by the maintenance organisation. A 3/8 cu.yd. excavator was later added to load shale at the northern end of the work.

Workshop equipment set up in a Fitter's Shop at the Frederickton Depot included:—

- One Electric Welding Set on Trailer.
- One Oxy Welding Set and Acetlyne Generator.
- One Air compressor receiving set with power greasing attachment for pumping tyres, greasing plant, etc.
- One Electric Drill and stand.
- One Battery Charger.
- One Hydraulic Press.
- One Valve Grinding Machine.
- One Electric Vulcaniser.

Construction.

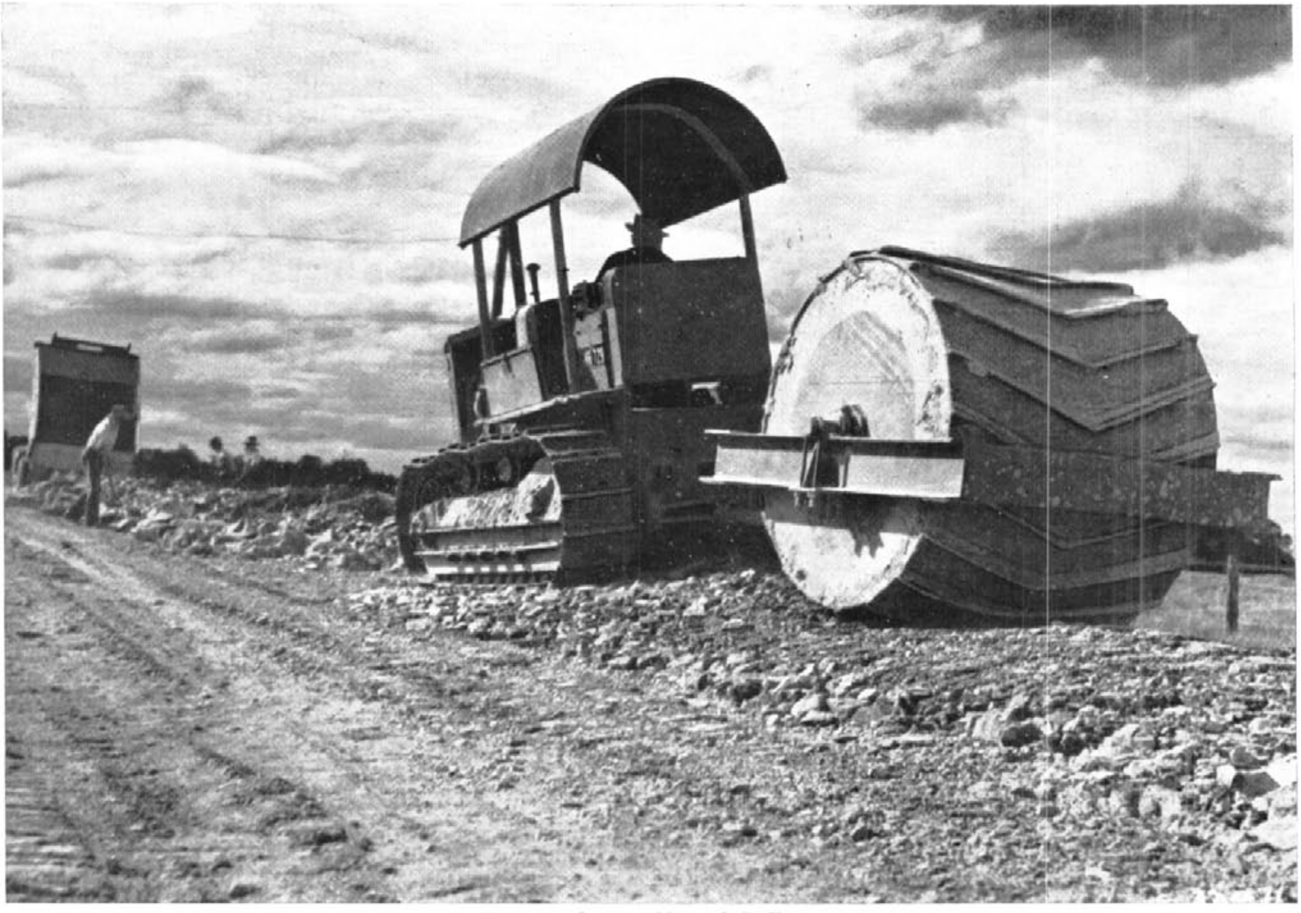
Work commenced in June, 1946, with the construction of a side loading ramp on a hillside at Frederickton, from which about thirty thousand yards of filling material was borrowed. Lorries were loaded under this ramp by the trailbuilder working alone for the most part and doing its own loosening by power ripper. As the lead in the borrow pit extended, another tractor and scoop assisted by transporting filling material to the mouth of the loader. The filling stood up well under traffic and wet weather so that it was not necessary to cover it immediately with paving material. The fill was completed for half the distance to Clybucca from this pit. Later, a second borrow pit was opened on another ridge near Frederickton, where a "Chinaman" was built so that lorries could be loaded by either tractor and scoop or by trailbuilder.

The shale used in the pavement was too hard to rip as hard bands defied the ripper tynes and these bands had to be drilled and blasted, whereupon ripping loosened the remainder. The shale reached the road in boulders sometimes exceeding one cubic foot in volume, and these had to be broken up by hand spalling, by rolling with cleated roller or by a combination of both.

The cleated roller was a feature of the work and proved very successful in the fracture of hard shales. The roller itself is a tractor drawn unit and consists of a steel drum five feet in diameter five feet wide with cleats of 2 inches by 3/8th inch angle iron welded on at ten-inch centres in a herringbone pattern. It is fitted with a manhole at the side, into which was loaded about five tons of the heaviest material available, scrap iron, screenings and sand. The knife edge loading causes fracture of the shale under the cleats.

The method adopted to break up and consolidate the shale was to spread it on the subgrade and roll it continuously and as thoroughly as time would allow. Before closing down for the night and as provision for traffic was necessary, the grader brushed the larger stones from the pavement into a windrow on the shoulder at each side of the pavement. These windrows were left until the pavement had consolidated when they were brushed back onto the hard surface where they cracked readily under re-rolling. This method necessitated spreading pavement for the full width of the formation so that in brushing windrows from the shoulder there was no risk of admixture of inferior shoulder material with the pavement. Scarifying and re-rolling was found to be necessary to break the shale up to uniform gauge and so guard against larger stones remaining and punching through the surfaced pavement on completion of the work.

The remainder of the filling and paving material required on the section over the flat was done with



Tractor-drawn Cleated Roller.

Tractor and 9 cu.-yd. Scoop on formation work.

material from a cutting at the northern end of the bridge over Clybucca Creek. This cutting was designed so as to yield sufficient of each material and to do this it was widened 11 ft. on each side. In order to improve the appearance of the cutting Kikuyu grass was planted in the sides and a row of trees planted on each side of the formation. 40,000 cubic yards of material were taken from this cutting without recourse to drilling and blasting. All loosening was done by the trailbuilder blade or by the heavy-duty power-ripper using three tynes. Loading was done over a "Chinaman."

Earthwork in the ridge country north of Clybucca averages 7,000 cubic yards per mile which is mostly short haul trailbuilder or scoop work in balanced cut and fill. Clearing is fairly heavy through a State Forest where the new alignment deviates from the old on a length of two miles.

Surface and base course material for the section north of Clybucca were obtained from a roadside quarry approximately 15½ miles north of Frederickton, loading being by power shovel. The material is a white sandy shale which shatters well with gunpowder and breaks down well under the cleated roller. The quarry was worked in a face eighteen feet high. The deposit is again very variable and greater selectivity is possible under power shovel operation as against scoop loading.

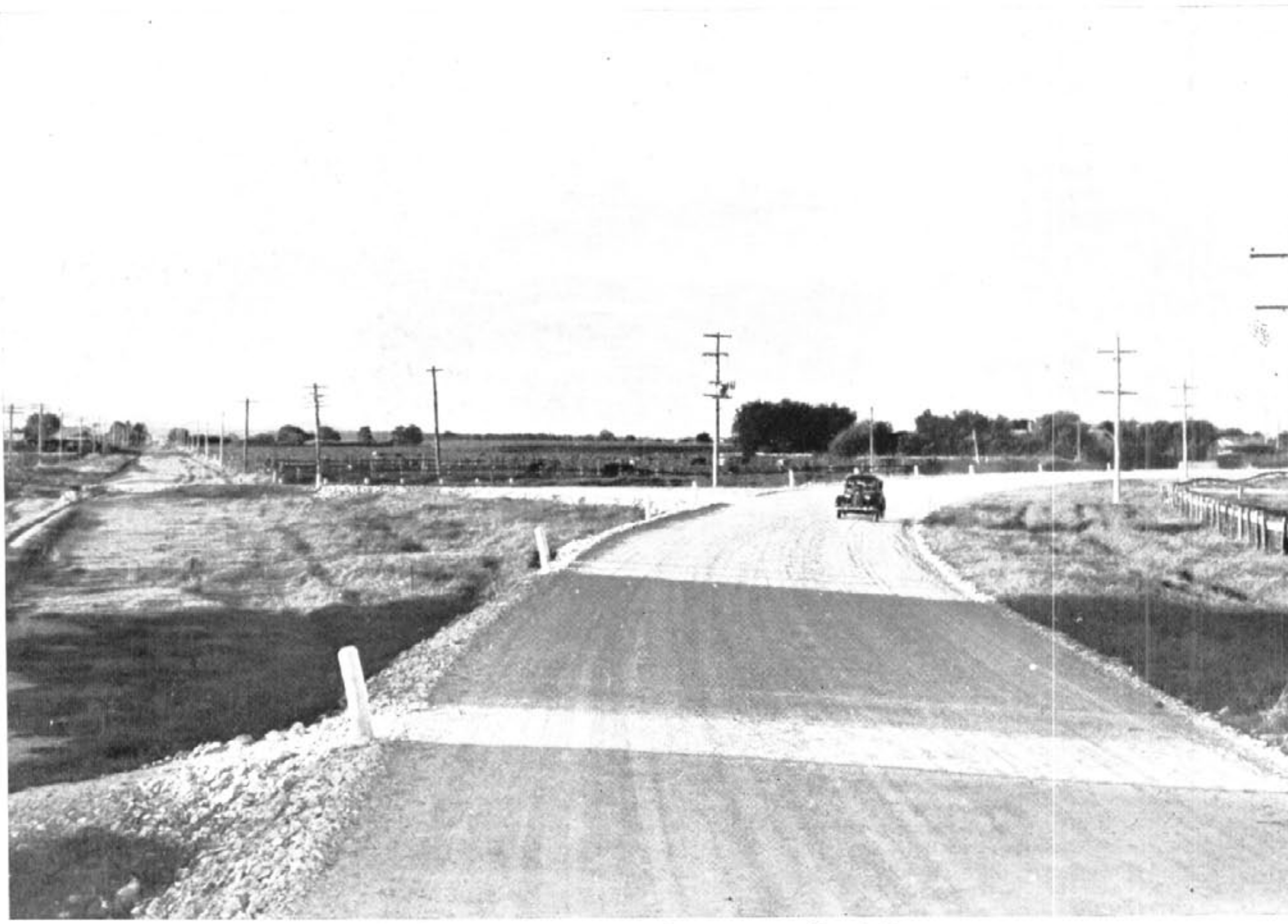
Fencing.

Along the river flats the moving back of fences on account of road widening and the provisions of new fencing on minor deviations proved a major item of the work. All existing fences were of post and rail construction and the landowners showed a distinct preference for this type of fence. All posts in the existing fences had been placed three feet into the ground for additional strength against the pressure of flood waters and debris.

A contract was let for the supply and delivery of mortised posts and adzed rails and the erection was carried out by day labour. A mobile crane was used for lifting the old posts out of the ground for subsequent re-erection. This proved a considerable saving as it would have been necessary otherwise to dig down alongside each post to loosen it.

Interference with Properties.

Interference with improvements on properties was kept to a minimum but in some cases it was unavoidable. Several new wells were dug where properties were severed from water. Log troughs were moved successfully by the mobile crane. Concrete troughs and tanks and windmills were moved back to the new alignment. One complete milking shed consisting of engine room, creamery, bails and covered yards was lifted back in sections onto a new concrete floor.



Completed section approximately 8 m. north of Kempsey.

Some bails encroach slightly within the new road boundaries but have been allowed to remain on the understanding that on re-building the structure it must be moved back within the property.

Where the new alignment deviated from the old and when the existing road reserve was granted to adjoining landowners as part or whole compensation for land resumed, the disused pavement was scarified and scooped away onto access roads. The whole area between the old road boundaries was levelled and the pavement area backfilled with loam and the whole sown with grass seed. The old road area has thus been incorporated in paddocks and is serving a useful purpose.

Structures.

All pipe culvert headwalls and concrete box culverts have been constructed using formwork of closely spaced inch hardwood on normal sized studs, and faced with painted three-sixteenth inch composition sheeting. A clean smooth finish was obtained on the concrete. The forms have now been used three times and will be used many more times on further sections.

General.

The reconstruction has been substantially completed between Frederickton and Clybucca. With present progress it is anticipated that the whole of the work with gravel pavement will be completed to the village of Eungai Creek by June, 1949, a total distance of 20 miles. The provision of a bituminous surface will be effected later.

Statistical Data.

Length of section of work at present in hand, 15M. 2,500 l. ft.

Quantities over this length.

Earthworks (solid measurement), 121,500 cu. yds.

Pavement (shale), 203,900 sq. yds.

Concrete pipe culverts, sizes 15" to 42" dia., 2,400 l. ft.

Concrete in box culverts, 390 cu. yds.

Fencing.

Unit Costs for Main Items.

(Direct costs only, exclusive of Workers' Compensation Insurance, Pay Roll Tax, Holidays and Camp, Depot, General Engineering and Clerical Supervision Costs).

Earthworks, including trimming and consolidation, 2s. 10d. per cu. yd. (solid measurement).

Pavement, base and surface courses, variable 8" to 9" consolidated thickness, 3/2 per sq. yd.

Concrete pipe culverts, including concrete headwalls, average for all sizes, 22s. 5d. per l. ft.

Concrete in box culverts, £9 14s. 5d. per cu. yd.

Some Aspects of Highway Practice in the United States of America.

(From reports by the Department's Materials and Research Engineer, Mr. A. T. Britton, B.Sc., B.E., who visited the United States of America during 1947. Mr. Britton's inquiries there related mainly to Materials and Methods, particularly in relation to pavements and subgrades.)

A. EARTHWORKS.

1. *Soil Survey and Exploration.*—The Public Roads Administration and most States visited conduct a detailed soil and materials survey where a bitumen or concrete pavement is to be constructed. Where not to receive such a surface, the cost of this work cannot be justified, but aerial photographic identification is making headway for such work as a cheap and rapid means of getting approximate information.

Even where high-class pavements are to be used, and a full soil and materials survey undertaken prior to construction, the air photo method is widely used to compare alternatives and select routes traversing sounder country, to assist in search for materials, and to pre-select sampling points to give the best return for the effort expended.

Considerable use is also being made of geophysical methods, especially that of electrical resistivity, for sub-surface and foundation explorations. This method could probably be used with advantage in New South Wales in selecting routes and/or bridge sites in swampy or soft areas.

Technique for securing undisturbed samples from depth, for investigation of embankment or foundation stability, has now been mastered.

2. *Embankments on Swampy and Soft Soils.*—In various parts of the United States, cases were seen of serious settlement of embankments on soft and swampy areas. This has resulted in heavy losses of pavement, and in many cases structures were also involved.

Two types of trouble occur:—

(*a*) Wet clay soils consolidate slowly by expulsion of water as loading is increased till a new condition of equilibrium is reached. This takes many years and, owing to the natural variations in water content and nature of clay from point to point, the settlement is frequently not uniform.

(*b*) Extremely soft wet clays under high embankments, or peat or muck soils under most embankments, fail by shear or flow and considerable settlement results. Such movements are more rapidly completed than the consolidation type, but are more severe and generally disastrous.

In cases where shear or flow failures are anticipated, there are only two resources:—

(i) To remove the inferior material down to a sound bottom that will safely carry the proposed embankment, or

(ii) To construct a pile trestle in lieu of embankment.

If consolidation is the danger, the same two methods apply, but there is also a third method:—

(iii) To accelerate the consolidation by overloading and, if soft layer is of any appreciable thickness, providing sand drains to allow of rapid escape of water.

The important features noted were the general failure of embankments built without precautions on soft or swampy areas, and the adoption now of suitable preventive measures as standard construction in every State visited. Such measures are applied to all embankments over a few feet in height on poor foundations, the choice of method depending on the particular conditions to be met.

3. *High Embankments.*—In California, banks over 300 feet in vertical height were seen under construction. In such high embankments it is necessary to check in advance the shear strength of the soil to be used and to control the compaction very carefully to secure this strength. It is also necessary in the extreme cases to flatten side slopes or introduce berms at intervals to reduce the stress intensities.

Where shear strength of soil from adjacent cuts is insufficient, it is necessary to import selected better soil or improve the local soil. One case was seen where the soil from cuts was a clay of insufficient shear strength and a sandy soil was being brought a considerable distance and used with the local soil to make an embankment of adequate strength.

4. *Earthwork and Base Courses.*—Earth moving plant in the United States in general is similar to that used in New South Wales, but with larger scale work, heavier and larger plant is common. One new item seen was a pneumatic tyred bulldozer. The blade was carried by a very heavy 4-wheel tractor with all wheels driven. It is understood that this machine has not the thrust of the track-type dozer, but has a higher speed. It is not suitable for heavy rock or pioneer work, but is said to be more efficient than the track-type where

maximum tractive effort is not required, e.g., moving soil, levelling, assisting scoops in loading, etc.

The standard optimum moisture content control was used almost universally in the compaction of embankments to carry concrete or bitumen surfaced pavements. The material was usually spread in very thin layers for watering in place. With truck delivery or track-type scoop haulage, a bulldozer blade was attached to the tractor drawing the sheepsfoot roller. With pneumatic tyred scoop haulage the use of a scoop for spreading and levelling has generally been found faster and more economical and one is diverted from haulage work to this duty as necessary. Even in such cases, however, a dozer is still carried by the tractor drawing the roller, as this item can then do much of the work in conjunction with the rolling.

Compaction effort for embankments was generally provided by scoop and other construction traffic assisted by sheepsfoot roller, the minimum compaction necessary was specified, and the compaction actually attained carefully checked. The subgrade was levelled for pavement by grading, etc., and finally compacted by pneumatic-tyred roller. In airports which were designed for heavy wheel loads, the size of the pneumatic tyres and the total weight of the roller used for this work and subsequent operations were increased to make the compaction load per tyre comparable with the aeroplane wheel load.

B. NON-RIGID PAVEMENT DESIGN.

5. There is very great variety in the United States in the methods used for "design" of flexible pavements, i.e., for the determination of pavement thicknesses to be used over various subgrades and of the thicknesses of upper courses over various lower courses. There is more investigation in hand on this subject than on any other phase of road design. Methods in use can be roughly divided into three main groups:—

(*a*) *Comparison by General Soil Tests.*—In this group of methods, soils are subjected to various simple tests, and, by direct comparison, numerical comparison or classification, the pavement thickness to be used is deduced from the pavement thicknesses known to be required on other soils in similar conditions.

In this class the most widely used United States methods are that of the Public Roads Administration (see *Public Roads*, February, 1942), and the Highway Research Board's "Group Index" (see Highway Research Board's *Proceedings*, 1946). Another method of this group is that of North Carolina which uses similar tests and applies the direct comparison system, taking as the basis for comparison not, as is usual, soils with known service records, but a number of soils for which suitable pavement thicknesses have been determined by full sized field bearing tests and computation. The bearing tests were conducted on existing subgrades after years of service, so that moisture equilibrium had been attained, the pavement being removed for test.

(*b*) *Comparison by Empirical Strength Tests.*—In this group of methods, a single small scale strength test of an arbitrary nature is used as the basis of design. The scale effect is allowed for by an empirical relation between thickness and test result, usually recorded graphically, determined by experience.

The best known and most widely used method of this type is the California Bearing Ratio (C.B.R.) test used in Western States and by the United States Army. This method has been less used by the Highway Departments of Eastern and Central States, and several have developed other forms of test based on the same general principle.

A theoretical objection to tests of this class is that the full scale strength is evaluated from a single test figure obtained on a small specimen. The scale effect differs considerably with different soils, and is widely different in the extreme cases of sand, clay, and organic soil. While it is possible to compensate for this effect by adjustment of test conditions and/or by adjustment of "design" curves, these methods can only be safely applied if the soil tested is within the range that experience has shown to be safely covered. The test figure itself gives no evidence on this point.

Taking the California Bearing Ratio as the best tried example, some experienced users consider that it tends to be too conservative with sandy soils and to give too high a strength with stony, but clayey materials. There is but little experience of its application to organic soils. Also, the test is very sensitive to technique with sandy soils, and results are difficult to duplicate. Most of the principal United States users of this test have introduced various corrections, based on tests used for methods of group (*a*) preceding, and/or are investigating other methods of design free from the inherent limitations of this empirical method. It might be noted, however, that this method gives very satisfactory results for the range of soils for which it was originally developed, i.e., the plastic soils of moderate to low bearing capacity.

(*c*) *Determination of Stresses and/or Deformation.*—Much investigation in the United States is now aimed at developing methods based on the determination of the stress/strain relations for the subgrade soil and then determining by calculation the pavement thickness necessary to keep stresses and/or deflections within safe limits. The stress/strain relations are determined either by full scale field bearing tests or by laboratory tests on small samples, usually by tri-axial shear.

Much work has been done on the problem of stress and deflection computations, but the subject is too complex to discuss in this article. The major unsolved problems are the prediction of the moisture content and state of compaction of a subgrade in service and the determination of what point on the stress/strain graph, usually a smooth curve, corresponds to "failure." Large-scale investigations are in hand, but results will not be available for some years. In regard to soil compaction and moisture prediction, the California Highway Department is investigating a new and attractive idea: to determine the "swell pressure" versus "degree of compaction" relation, also the pavement thickness required for various degrees of compaction. It is then assumed that stable compaction is that for which "swell pressure" equals pavement weight. Complete saturation of compacted soil in service is assumed in this investigation.

Methods of this type have been less used in practical design than either of the first two types. In addition to their direct application, a method of this type is the basis of North Carolina design (see (*a*) above), and the California Highway Department is investigating a method approaching this type, hoping it will be free from the difficulties met with in the California Bearing Ratio test, and the work is well advanced. This method is based on compaction and moisture prediction as above, testing in a tri-axial shear machine by Hveem's method, which differs from the way in which this test is conducted by most other users, and the determination of pavement thickness by direct comparison of test results with experience rather than by computation.

Much attention has been, and is being, given to the effects of magnitude and frequency of loading and of climate. There is general agreement on the need for heavier pavements with heavier loading, but the Western States attach more important to frequency and repetitions than the Eastern States. Again, while all agree that freezing conditions involve the need for heavier pavements, the West attaches more importance than the East to variations in rainfall and evaporation. These two differences are not yet reconciled, and there is need for much more data to settle the problems.

In conclusion, it might be remarked that all modern research has demonstrated that many subgrade soils require heavy pavements to carry traffic successfully. Such soils occur almost throughout some works and on portions of most other large works. In New South Wales, local soils of fair to good quality are generally available at much lower cost than pavement materials, and can be used with advantage for the lower courses where heavy pavements are required because of poor soils. This practice is almost universal in the United States. In some cases, materials can be selected from certain cuts on the actual work, but this frequently interferes with the smooth organisation of grading operations. It is more common to select a suitable site or sites near the work and place this sub-base after completion of grading operations; this is known as "selected borrow."

C. BITUMINOUS PAVEMENTS.

6. *Pavement Materials to Carry Bituminous Surfaces.*—There is much greater uniformity in testing procedures for the selection and control of these materials than in the design of pavements. Many different classes of material are used, but principles are generally similar throughout the States for each class.

Macadam, and other metal constructions, generally follow standard principles which require no comment in this report.

Graded materials, i.e., natural and artificial gravels, sand-clays, etc., are very widely used. Practice is usually based on Grading and Plasticity specifications.

North Carolina, like New South Wales, has diversified geological conditions, and uses many different materials of this type of very varied origin. That State's specifications for gradings are expressed in a form differing from that used by the Department of Main Roads, New South Wales, but are almost identical in effect; almost always a material passing one specification would pass the other. These requirements are, in general, well policed in that State, and the standard of performance of the resulting roads is high. One or two other States had much more liberal specifications and a number of other States more restrictive specifications.

In using graded materials for pavements to be bitumen surfaced, the usual United States practice is to sample and test the deposits to be used in sufficient detail to anticipate nature of material that will be won and to plan the method of working: to run check tests during winning and delivery to ensure material being obtained from the deposits is as desired; and, finally, to inspect, sample and test the completed pavement, prior to surfacing, so that any necessary correction or replacements can be carried out and failures thus avoided.

Cement stabilisation is largely and increasingly used. Practice conforms generally with the United States Portland Cement Association's recommendations. California uses much more restrictive specifications which limit the classes of soils used for stabilisation to sandy gravels, and generally involve the selection and borrowing of the soil to be stabilised.

Bituminous stabilisation is also largely used. A number of works were seen, but all followed established practice and involved no new features.

Some experimental roads were seen in which stabilisation by Vinsol Resin and other water repellents had been tried, and some laboratory research on these materials is in hand. Results were, in some cases, satisfactory, but design and control procedures have not yet been fixed and this process is only in the developmental stage.

7. *Design of Bituminous Mixes.*—The principle of the various methods used is similar throughout:—

(*a*) The grading of the mix desired is selected.

(*b*) The proportion of the bitumen to be added is determined by trial mixes. These are subjected to some form of shear or compression test and the proportion giving adequate strength, or "stability," adopted.

Frequently, however, where aggregates of similar type and grading are regularly used, the proportion of bitumen is selected by judgment and comparison from previous work without stability tests.

There is another factor which may control and has always to be checked in dense mixes; it is necessary to have a small percentage of voids in the mix as finished and compacted on the road. The voids in the mix as compacted for the stability test are checked; if compaction is by a kneading and tamping action giving densities equal to those in road, it is sufficient for voids in compacted specimens to be not less than the 2 or 3 per cent. desired. If compaction is less efficient, a correspondingly larger proportion of voids is necessary. Should voids be insufficient, fines in mix must be reduced.

Gradings range from "open" to "dense" according to traffic and local conditions along the same lines as in New South Wales. In the United States, however, bitumen is relatively cheaper and the tendency is to use the denser gradings more frequently than here.

Proportioning of various available aggregates to give most suitable combined grading is usually done numerically. The Public Roads Administration has, however, developed a method of test by vibration compaction which can be used where dense gradings are desired to determine what proportions of given aggregates give the greatest density.

Many forms of stability test are used, of which the best known are:—

1. Hubbard-Field. This is well known and widely used.
2. The Public Roads Administration's cylinder compression test. This test is simple to conduct and lends itself readily to routine work. It is also adaptable to investigations of water preference, additives, curing, etc.
3. The Hveem test. Developed and used in California. Adopted and recommended after considerable trial in Texas.
4. The Marshall test (United States Army). A fairly recent development, not yet time tested.
5. The British Beam test (not seen in the United States).

8. *Interesting Developments in Bituminous Practice.*—In surface treatment work the United States practice in generally similar to that in New South Wales. However, with cheaper bitumen and generally heavier traffic, it is usual to use heavier treatments, frequently multi-coat, and to resurface, especially first resurfacing, before the preceding treatment has worn or deteriorated to the stage usually allowed in New South Wales. These differences are considered to be solely due to different local conditions, and do not suggest a change in current New South Wales practice. One other point noted was the widespread use of ready-fluxed materials (medium curing and rapid curing asphalts); this is again due to different local conditions, in this case the low cost of surplus flux and the good distribution organisation for such materials in the United States.

One variation seen in North Carolina is of interest. This is a compromise between surface treatment and light road-mix and is known there as "drag seal." Briefly, a first course of large gauge screenings is applied as in usual surface treatment, a light application of bitumen, a heavy application of finer screenings and a second application of bitumen is then given in succession. The surface is then immediately dragged with a special broom drag giving a mixing and levelling action, one pass sufficient, and rolled. Surface texture produced resembles a fine, open graded plant or road-mix, and is superior to an ordinary surface treatment, while minor inequalities, such as potholes, corrugations, etc., are largely corrected. As a consequence, it is usual with such work to save considerable cost in the preparation for surfacing by accepting a lower standard in regard to such inequalities. With the "drag seal" method, a satisfactory riding surface is still produced.

In Texas, bitumen is comparatively cheap and heavy multi-coat seals appeared to be used for even lighter traffic than in other States, but in its sparsely settled areas, single coat treatments on New South Wales lines are used. Texas confines this work to the summer season, and with its warm climate, uses unfluxed bitumen of 90 to 230 penetration for nearly all its surface treatment work. It also uses, in general, heavier applications of both stone and bitumen than in New South Wales.

In the North-Western States, with their lower population densities, practice differs somewhat from the more densely populated States. Surface treatments are used very extensively, generally of normal types using fluxed bitumen. A number of works were seen, however, in which cheap run-of-crusher aggregates were used in lieu of the usual more expensive one sized gradings. These surfaces were fully satisfactory, though they are naturally thinner and have a lesser life than standard treatments when wear controls. Under very light traffic they have given first-class service.

In the same States crushed round gravel is the usual source of material, and it was interesting to see that aggregate with quite a high proportion of rounder surfaces gave fully satisfactory results for premix and penetration as well as for surface treatment. Where these gravels are available for crushing in parts of New South Wales, the standard Oregon or Washington specifications could be adopted for works in those areas.

Another interesting thing noted in the North-West was the rather frequent use of penetration in place of premix or roadmix to avoid high cost of plant transport to isolated works. Using machine spreading of the dry metal quite good riding surfaces are secured, and the method is used not only for new works, but for restoring riding qualities of old bumpy roads. The success in this field was remarkable and, though cost would be higher in New South Wales, it may have an application to particular isolated works as a substitute for premix or road-mix.

9. *Durability of Bitumen.*—Bitumen is now being supplied from many different sources and in many different varieties. It has been known for a long period that there are considerable differences in the hardening with age and consequently the useful life of various bitumens, and that the routine tests were of little or no value in predicting such variations. This has become a matter of increasing concern over the past fifteen years or so, and many workers have devoted considerable attention to this question. All test methods adopted employ some form of artificial ageing, usually by heat and exposure to air, followed by some test to measure the degree of deterioration.

Many tests proposed require the making of a mixture with standard aggregates, then the artificial ageing of such mixture. The mixture is then given some test or the bitumen recovered for test. Such tests require considerable labour in testing, and there are serious difficulties in duplicating results when tests are conducted in different places by different operators.

The Public Roads Administration has developed a method of testing the bitumen only, by direct heating of a thin layer in air and testing the product. Details of method are given in "Public Roads," April, 1941, and suggested specification figures to ensure satisfactory durability in "Public Roads," April-June, 1946. This method is simple, requires only apparatus generally used in bitumen testing, and results can be duplicated much more easily than in mixture methods.

There are the usual objections to all these tests that are common to all accelerated ageing tests. It is impossible to duplicate exactly the effects that occur in long time exposure in the road. Nevertheless, they will detect those bitumens that are particularly liable to rapid deterioration by oxidation or polymerization, and thus exclude all very unsuitable materials.

10. *Water Preference and Additives.*—Failures of bituminous pavements have occurred in the United States of America by displacement of bitumen from the aggregate by water.

Several "additives" for incorporation in bitumen to improve its adhesion to aggregates are being manufactured and sold commercially in the United States. They are allowed, or even required, for certain works by a number of States.

These materials are interesting and may have much value, but the technique of their use, the testing of aggregates for water-preference, and testing to determine effect of additives are still in the developmental stage.

11. *Maintenance of Bituminous Pavements.*—New South Wales methods are generally similar to those in the United States but, with the greater concentration of work, there is more mechanisation in the United States. Patching is conducted on similar lines, but mobile mixers, small sprayers, etc., are far more commonly provided. Resurfacing is generally conducted at an earlier stage than in New South Wales. This is probably related to the lower cost of bitumen.

In the United States, with its heavier traffic and larger revenues, greater attention is paid to smoothness of riding than in New South Wales. Levelling courses are used on pavements for which a less costly simple surface retreatment would be used here.

12. *Central Bituminous Mixing Plant.*—Batch plant has now been brought to a high standard of efficiency and standardisation, and is manufactured up to very large sizes. It is considered that no other form of plant can now compete with this type for a permanent installation.

Quite large batch plants are now made in fully portable or semi-portable "knock-down" types. They do not have the capacity of similarly portable continuous mixers, but are much more versatile and flexible and will satisfactorily mix dense gradings that cannot be mixed in a continuous mixer.

13. *Road and Gravel Mixing Plant.*—There has been a large development in such plants in the last few years, and many advertisements and descriptions have appeared in the technical press. Not many of them are, however, suitable for New South Wales conditions. This applies particularly to the road mixing plants which are designed to mix and lay thick courses of cement and bitumen stabilised soil or gravel, for which there is as yet insufficient demand in New South Wales to keep a large plant usefully employed.

In addition to the above special machines, blade mixing, both by grader and by machines similar to the Department of Main Roads road-mix plant, is also practised, but nothing novel in such work was seen.

14. *Other Bituminous Plant.*—Several makes of sprayer were seen in the United States; 4-wheel, 6-wheel single unit, and semi-trailer types were all extensively used, and the size was normally larger than in New South Wales. The largest used regularly here (800 Imperial gallons) was the smallest seen in the United States, and they ranged up to four or five times that size. In all cases circulating bars and taps at each jet were provided.

Aggregate spreaders of belt or drum types were used on about 50 per cent. of works in which aggregate spreading was required, but simple spreading from tail gates was used on the other 50 per cent. There was little to choose between the two processes in uniformity of spread, though it is the majority opinion that less skill is required to secure satisfactory results with spreaders. The best spread seen was in a State using simple tail gates, and the second best in another State with belt spreader. Both were superior to current work in New South Wales.

Rollers are used in more variety than in New South Wales, and more care is exercised in selecting a roller suitable for the work in hand.

Mechanical self-propelled bituminous pavers of several makes were studied in use. There are two main types:—

(*a*) Vibrating tamping screed kept at correct level by shoe sliding on consolidated material just behind vibrating screed.

(*b*) Transversely oscilliating screeds kept at correct level either by rollers rolling on spread materials or by long skids.

D. GRAVEL PAVEMENTS.

15. *Gravel Base Courses.*—In compacting gravel, etc., used in pavements as a support for concrete or bituminous surfaces, great emphasis is placed in all States on the need for securing thorough mixing and uniformity and complete compaction. The standard practice in upper courses is to dump roughly and level the material, then work it all up into a windrow by grader, turn it over several times to get complete mix and spread in about 2-inch layers, watering as required and thoroughly consolidating each layer by pneumatic tyred roller. Lower courses are also carefully compacted, but here there is more margin and it is generally economical to allow a considerable proportion of oversize which cannot be handled in this way. If oversize permits, the procedure for upper course is followed: if not, a suitable adjustment is made. The extreme case seen was a 6-inch consolidated base laid in Oregon from a sandy gravel screened to pass a 6-inch sieve and containing a high proportion of 4-inch to 6-inch material. The way this was laid was to dump the material on the subgrade and spread forward with a dozer. The large stones were thus carried ahead to the uncovered subgrade, their tops being below finished surface course. The next loads were dumped on these stones and the process repeated. The whole thickness had then to be consolidated by rolling and traffic, but this was permissible with this sandy gravel.

16. *Maintenance of Unsurfaced Pavements.*—In three States visited, considerable lengths of unsurfaced gravel pavements were inspected. Mr. Britton was particularly impressed by the standard of maintenance of gravel roads in North Carolina, and inquiries were made as to the maintenance methods followed.

North Carolina generally reshapes its gravel roads about twice a year with a heavy power or drawn grader, more often on a few more heavily trafficked roads. Between these reshapings the surface is maintained by a light truck-hauled drag. Climate and traffic on unsurfaced roads closely resemble those of eastern New South Wales.

The drag used in North Carolina consists of a timber frame carrying two blades 3-feet centre to centre transverse to the road. The blades are 15 feet long and the drag is hinged at centre so that it can conform to the shape of the road. The width allows the road and shoulders to be covered in two passes, so long lengths can be rapidly covered when weather conditions are favourable. The speed of dragging is 2 to 5 m.p.h., depending on the nature and condition of the gravel.

E. DESIGN AND MISCELLANEOUS.

17. *Width of Roads.*—Modern United States practice is to use 11-ft. or 12-ft. lanes on all roads over two lanes in width and all heavily trafficked two-lane roads. In new construction narrower lanes are only permitted on two-lane roads where it is anticipated that the traffic offering will remain light for the whole life of the road.

Two-lane roads are greatly used in rural areas, but even here wider roads are common, and approaching cities four and six-lane roads are usual. It is now held that the next stage beyond a two-lane road should be a four-lane divided road, and the next a six-lane divided. Undivided four-lane or wider roads are not considered satisfactory except for city streets. Three-lane roads have practically been abandoned, not only on the score of safety, which is disputed by a proportion of engineers, but also because experience has shown that a road now requiring more than two lanes will probably require a four-lane divided road with growth of traffic, even if three are now sufficient. There is thus no future for the third lane, and its construction is uneconomical on the overall view.

Each carriageway of a divided road is normally limited to a miximum of three lanes. If more than three lanes are provided traffic becomes confused and hazards are introduced. The usual practice when three lanes each way become insufficient is to construct a parallel route, but in some cases two carriageways in each direction are provided. For example, United States 1 in New Jersey is being constructed with four three-lane carriageways plus service roads.

18. *Provision for Growth of Traffic.*—United States road engineers consider that one of the important lessons learnt in the past twenty years is that traffic growth is and will be much greater than has previously been realised. In the United States, 1940 traffic on all roads greatly exceeded estimates made in 1935; 1947 traffic, despite the setback from the war, already exceeds 1940 estimates for traffic in 1950, and is increasing each month. United States highway engineers consider that methods used in the past for predicting traffic growth have led to estimates of future traffic that are too low, and that any further predictions should assume a much greater rate of increase.

19. *Protection of Rights of Way.*—The growth of traffic referred to in the preceding section and the general increase in population and settlement require far-sighted provision in reservation of rights of way if expensive future resumption is to be avoided. Experience in the United States has shown that the traffic volume which justifies a road of four traffic lanes or more is sufficient to provide an inducement for small business development fronting the roads. Where unrestricted access is allowed in such roads, garages, restaurants, etc., are rapidly established, and in a few years are followed by general small shops and businesses till the whole length takes on the characteristics of a business street. Cases were seen in the United States where roads had been constructed to high standards of grade and alignment through rural country, with design speeds of 50 to 60 m.p.h. and even more, but have now become so congested with parking vehicles and pedestrians that speed limits of 35 or even 25 m.p.h. have been imposed. In certain cases the road authority, to provide for through traffic, has had to construct, or is now constructing, a new road to a similar standard parallelling the first.

20. *Expressways and Limited Access Roads.*—Traffic authorities consider that the most satisfactory solution to the city road traffic problem is the expressway. Many United States cities have constructed expressways, more are constructing or planning them. All cities that have constructed any expressways are so satisfied with the result that they are now rapidly extending the system. New York is the outstanding case.

In expressway design the following advice was obtained from New York engineers based on their long time experience in expressway construction and operation. It must constantly be borne in mind that these roads are designed for very dense fast-moving traffic, and obstructions—or interference of any kind—create most hazardous conditions. Important points are:—

(*a*) Provide ample lane widths and clearances.

(*b*) Provide space at sides of each road for parking of disabled vehicles.

(*c*) Where side entrances join without increase in number of lanes or throughway only allow single entry.

(*d*) Always provide acceleration lanes at such entries.

(*e*) Such entries and acceleration lanes should only be on correct side of through road (left in Australia). Provide under or over pass for cars from right-hand side.

(*f*) End of acceleration lanes not to be of too flat a taper. It should be clear to the driver that lane is ending.

(*g*) Provide high speed exits or adequate deceleration lanes.

(*h*) Standardise layouts at junctions and avoid movements difficult to follow.

(*i*) Avoid obstructions to sight—especially beware of closed bridge railing on or near curves.

While the complete expressway with separation of cross traffic and no side entrances from abutting properties is preferable, it is often not economically feasible in rural areas, especially so in flat country. Here a useful compromise adopted in rural areas in some States is the so-called "limited access" road with cross traffic permitted only at long intervals at carefully designed junctions at grade and access rights from adjacent properties restricted to private access to farms, etc. Junctions on such roads are provided with acceleration and deceleration lanes where traffic volumes are high enough to warrant this provision and turning traffic is guided by islands into definite traffic channels.

21. *Measurement of Riding Quality.*—Most States in the United States of America place considerable emphasis on smooth riding of pavements and adopt a very high standard of maintenance in this regard.

Throughout the United States the Public Roads Administration Road Roughness Measuring Machine has now been adopted as the standard for comparison of road inequalities. It has also been adopted by other American and some European countries.

22. *Traffic Signs.*—In this work as much emphasis is placed on efficient guidance as on control; it is considered that, in traffic, drivers hesitating because unsure of direction to take create a serious hazard. Advance signs and clearly-legible signs are regular practice at important junctions.

To simplify and cheapen work of guidance signing, the "route number" system of signing is widely used. This cheap small sign is particularly advantageous in cities, as it enables routes to be satisfactorily posted at reasonable cost, despite the number of intersections involved.

Warning sign practice in New South Wales as regards curves, narrow bridges, and other definite danger points is similar to general United States practice. In the United States many States also use a distinctly-shaped "caution" sign, which would be more properly described as an "alert" sign, on roads carrying fast traffic to inform drivers of such things as side roads and minor junctions from which other traffic might enter.

The "Halt" or "Stop" sign is used very extensively at minor road entrances and even at important junctions.

Great importance is attached to night visibility in all types of signing. Illuminated and reflector button signs are often used. A third type has recently been developed, the over-all reflectorised sign,* and is very rapidly gaining in popularity. The advantages of these signs, as compared with reflector button signs, are their high legibility and their similar appearance by day and by night.

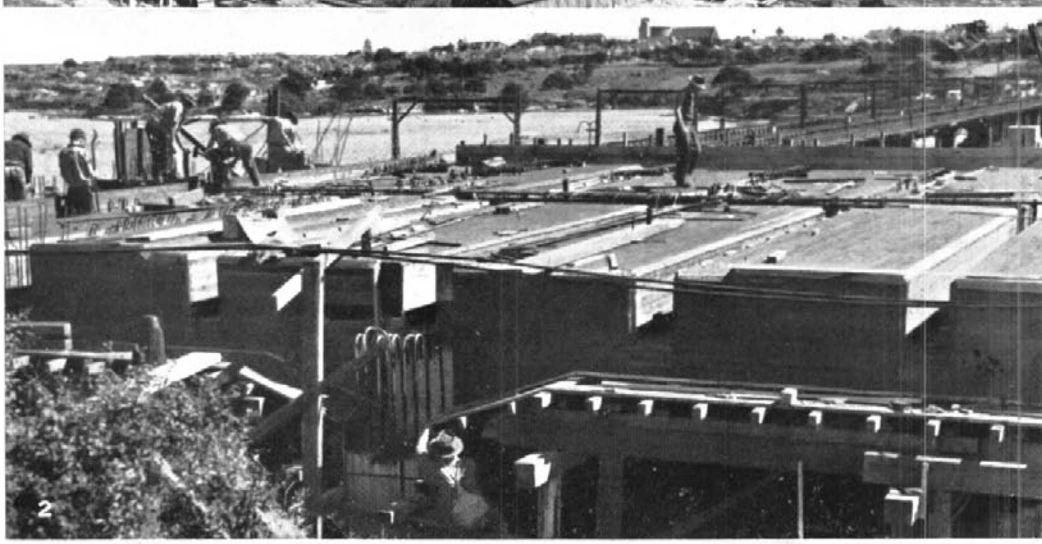
23. *Traffic Lines and Pavement Markings.*—It is almost invariable practice in the United States to centre line two-lane pavements and to mark the lane boundaries on wider roads. For this work the best mechanical plant seen was considered to be the latest model of the California Highway Department's machine. The Department's present machine is of a previous California design, but the new Californian machine has a number of improvements and additions; in particular it is equipped to add glass beads to painted lines.

Glass beads are now being added to painted lines by a number of the States in the United States to improve night visibility. The improvement so obtained is outstanding.

In many cases permanent or semi-permanent markers are built in or added to pavements. This is usually only done in cities and on bridges where traffic is heavy. In concrete pavements tile and similar markers are cast in. In bituminous work permanent concrete and similar markers are sometimes used, but the usual need for resheeting generally makes this uneconomical. A satisfactory semi-permanent marker widely used, particularly in the east of the United States, consists of small rectangles of white or yellow linoleum cemented to the road surface with asphalt.

*The material generally used in these signs is at present under trial in New South Wales.

PROGRESS OF CONSTRUCTION OF NEW BRIDGE OVER IRON COVE, SYDNEY.



1. General view of work in progress on piers and abutment. Old bridge in background.
2. Formwork—Balmain abutment.
3. Piers under construction.

Metropolitan Maintenance Depot Re-established on New Site.

•

Prior to 1942, the Department carried out its principal plant repair work in a central workshop on a site of eight acres at Granville, which also served as a centre for the Department's Metropolitan maintenance organisation. With the passage of time, the area became too crowded for efficient working.

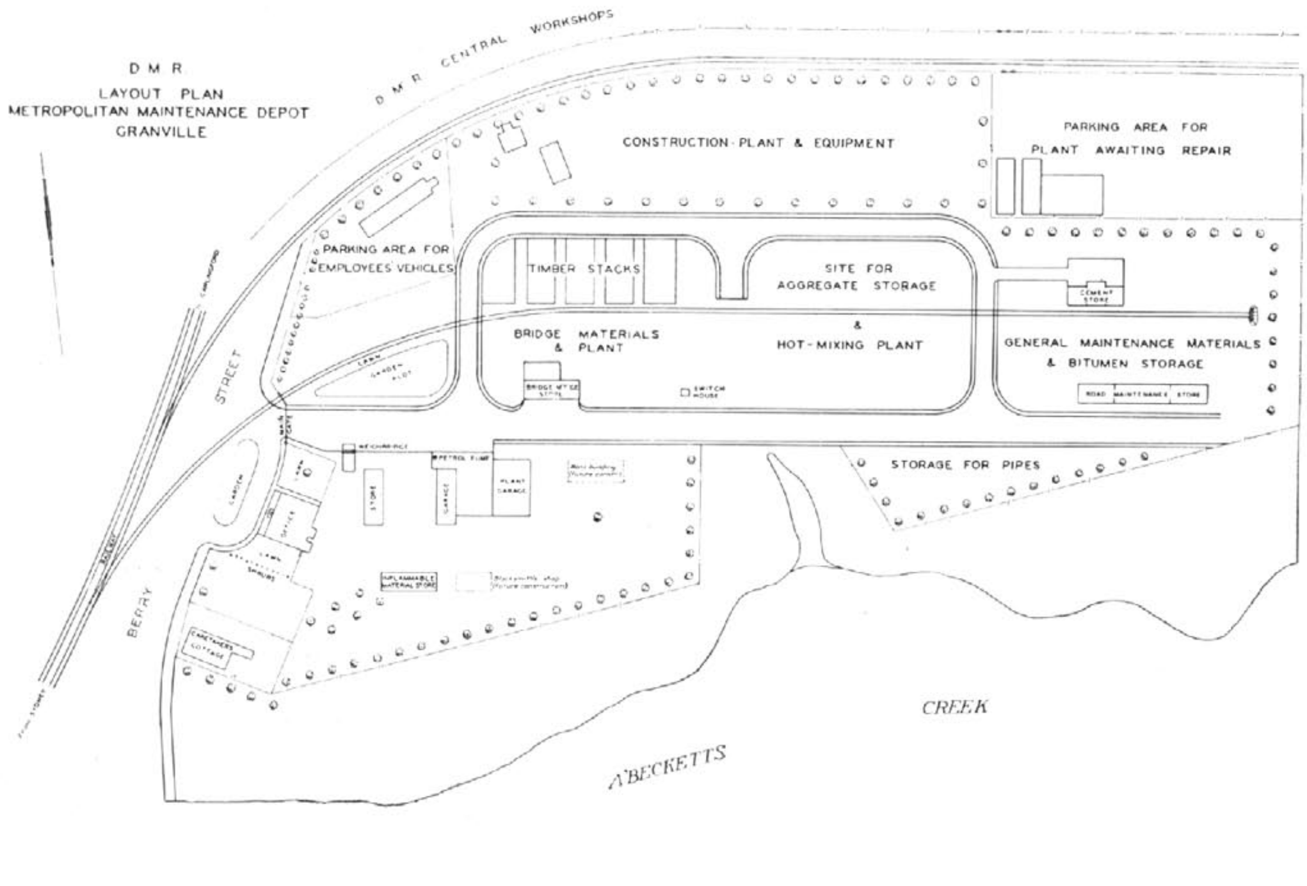
The increasing use of mechanical plant, and the activity resulting from the organisation of work on defence projects at a distance, resulted in acute congestion and extra space became urgently necessary. Arrangements were therefore made to acquire an adjacent area of seventeen acres, and to this was transferred the Metropolitan Maintenance headquarters. Parts of the area were used also for storage of plant awaiting repair and for storage of bulk materials. The original area was thus left for use for the central workshop and store, the buildings of which were subsequently enlarged to meet new requirements as described in the March, 1947 number of this journal.

In developing the new area as a Metropolitan Maintenance depot, the principal features provided for were as follows:—

- Store building, with separate buildings for paint, cement and inflammable liquids and general stores.
- Bulk materials storage.
- Hot-mixing plant.
- Plant storage.
- Vehicle garage.
- Office for clerical staff and foremen.
- Weighbridge.
- Locker rooms, etc., for employees.

The layout adopted is shown on the plan herewith. It was designed so that operations involving noise, dust, smoke or fumes should be well away from the office and from dwellings in the vicinity, and so that all movement and handling of materials might be carried out with the least difficulty and, so far as possible, by mechanical means. Ample space is provided for expansion of activities if and when necessary.

All buildings have now been erected, except the employees' locker room. It has not yet proved possible



General Office.

View of Depot.

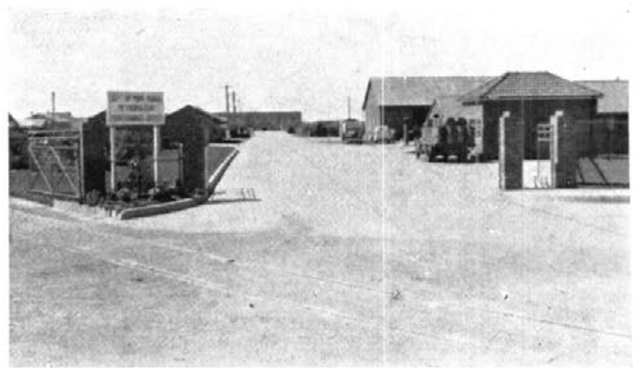
to provide for this and temporary arrangements are in use. The new hot-mixing plant has also not yet been erected, although a commencement has been made. Meanwhile the original unit on the Central Workshop site continues in use.

In establishing the new depot, every effort has been made to secure a high standard of appearance by the construction of roads, paths and lawns, and by the planting of trees, shrubs, etc. On account of the unusual soil conditions at the site, specialist advice was obtained regarding trees, and the results have been entirely satisfactory.

The depot serves the Department's road and bridge maintenance gangs in the Metropolitan area, supplemented by local subsidiary depots as and where necessary. It also serves the Department's Metropolitan road construction organisation.

It acts as the headquarters for line-marking throughout the State, and provides a central storage for bitumen. Over 70,000 drums of bitumen were received at the depot during the last financial year, and over 45,000 drums despatched. The annual output of hot-mixed bituminous materials is about 15,000 tons.

Portion of Bitumen Stockpile.



Main Entrance to Depot.

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for the period 1st July, 1947, to 31st March, 1948.

Income.	£
Road Tolls	266,556
Contributions—	
Railway Passengers	97,370
Tramway Passengers	12,384
Omnibus Passengers	6,230
Rent from Properties	7,980
	£390,520

Expenditure.	£	£
Cost of Collecting Road Tolls		15,290
Maintenance and Minor Improvements		29,771
Alterations to Archways		10,203
Administrative Expenses		1,321
Loan Charges—	£	
Interest	192,750	
Exchange	24,000	
Sinking Fund	49,500	
Management Expenses	750	
		267,000
		£323,385

Use of Elevating Graders for Road Works.

The elevating grader is a comparatively recent addition to the items of mechanical equipment used by the Department for road construction in New South Wales. Although its use is limited to some extent, by the nature of the topography in the case of formation work and by the type of material and nature of deposit in the case of gravel loading, good results have been achieved.

The Department first acquired an elevating grader early in 1940, and the machine was placed on road formation work in the Broken Hill District of the Western Division. It was later used on aerodrome construction work during the war. On completion of war-time works, in 1944, it was returned to the Western Division, and placed in the Bourke District where it is still employed. A second machine was purchased in 1946 and placed in use in the Broken Hill District early in 1947.

Earlier Use of Elevating Grader in Australia.—An early model elevating grader is known to have been used in connection with the construction of railway embankments in Victoria as early as 1907-8. This machine was drawn by horse team and the elevator belt was driven off the rear axle, not by an engine as in the modern types. Elevating graders were also used by the New South Wales Water Conservation and Irrigation Commission for channel excavation in the Murrumbidgee Irrigation Area in the early 1930's.

The earliest known use of an elevating grader for road works in New South Wales was by the Berrigan Shire Council in 1928. The area of the Shire is mainly flat with some low ranges of hills. There is a limited amount of black soil plain, but the remainder of the area is red loam of sufficiently good quality to serve as a road surface for light traffic under most conditions. The loam is generally at least six inches deep with underlying clay. Prior to 1928, road formations had been scooped into place and the resulting formation was a mixture of loam and clay. As a result, there was often an excess of clay in the upper layers, which required gravelling to produce a reasonably trafficable surface, but extensive gravelling operations were not practicable on account of cost. Formations constructed by the elevating grader, however, utilised only surface loam, and thus were more satisfactory in this respect, as well as being much cheaper.

The elevating grader first used by Berrigan Shire Council was tractor drawn and basically the same as the modern type except that the elevator was driven off one rear wheel of the grader. In spite of mechanical troubles and difficulty in obtaining imported replacement parts the machine is reported to have worked very successfully. A tractor-drawn grader was used for final shaping and for consolidating the formation. The usual formation constructed required 37 to 40 cubic yards per 100 linear feet. In good conditions and without stoppages, the machine could construct up to 20 chains of formation per day, but the average output was considerably lower. Some hundreds of miles of earth formation were constructed prior to 1939, and in some cases costs were as low as 3¼d. per cubic yard.

Inland Defence Highway, Duaringa—Charters Towers, Queensland.—The northern portion of the Queensland Inland Defence Highway, constructed over a length of 402 miles by the Department of Main Roads, New South Wales, in late 1942, gave an opportunity for demonstration of the value of elevating graders for rapid formation construction on the level or gently sloping country which predominated on the project. Originally, in the absence of elevating graders it had been intended to carry out the work with motor graders. However, six elevating graders became available shortly after the work commenced, and their use proved to be an important factor in the successful completion of the road within the short period allowed. Each of these machines was capable of excavating side ditches and placing in position, for spreading by motor graders, sufficient material to complete the formation for one mile of road each daily shift. A considerable proportion of the total length of 402 miles was formed in this way.

The elevating graders were also used on this job to load gravel in cases where gravel deposits extended over wide flat areas. At first some lorry drivers experienced difficulty in maintaining position under the elevator boom, but these difficulties were quickly overcome. Gravel production reached its peak when on one length of road one elevating grader kept 47 lorries moving continually over an average lead of four miles and, taking only 21 seconds to deliver each 5 cubic yard load, gave a total shift output of 3,000 cubic yards.

To enable a comparison to be made with "Chinaman" operation for gravel loading on this job, typical organisation and output were:—Tractors and two 2 cubic yard bottomless scoops loading over "Chinaman," and lorries limited to carry 4 cubic yard load so that one charge from both scoops constituted a full lorry load. The fastest time to load a lorry from the time the lorry became stationary under the "chinaman" till it commenced to move away with its load was 30 seconds, and the maximum output in a single shift was 1,800 cubic yards.

Stuart Highway—Northern Territory.—Following the good results of elevating grader work in Queensland, the Department employed several machines on the Stuart Highway, Northern Territory, in 1943 and 1944, but on this job they were used for the excavation and loading of gravel only.

During 1944 a total of 389,000 cubic yards of gravel was loaded from five elevating graders, the average daily output from each machine being approximately 1,100 cubic yards.

Western Division—New South Wales.—The Department's two elevating graders in the Western Division of New South Wales are being used exclusively in the construction of formations. Prior to the diversion of the first elevating grader to aerodrome construction during the war, the machine had accomplished 144 miles of completed formation. Since resuming work after the war, approximately 120 miles of formation have been completed by the same machine, notwithstanding the fact that exceptionally long periods of rain have been experienced.

On country of a gravelly nature where sand drift or soil erosion is not extensive, as in many areas in the Cobar District of the Western Division, a formation having its crown about 6 inches above, and table drains about 9 inches below, natural surface level is satisfactory, provided adequate catch drains are provided to divert surface drainage from the formation. This type of formation can be constructed readily and economically either by drawn or self-propelled graders. In other areas, however, somewhat higher formations are required in order to secure satisfactory drainage or to reduce the effects of wind erosion, and the elevating grader has proved to be the most economical unit for this class of work.

The elevating grader is not suitable for use in sandy soil as the cutting disc cannot "turn" the soil on to the elevating belt. It is unwise to use the elevating grader in ground containing large stones or other obstructions which may cause damage or over-stressing of the grader. For these soils, tractors and scoops or bulldozers can be used successfully.

Output and Costs.—The elevating grader is capable of very large output. Under good conditions the rate of excavation is in excess of 600 cubic yards per hour. For one recent period on formation work 291,700 cubic yards of earth were excavated to form 42 miles of road in 542 working hours (approximately 540 cubic yards per hour).

The elevating grader usually worked as a unit comprising elevating grader drawn by 100 h.p. tractor, tractor-drawn grader for levelling the material excavated and placed by the elevating grader, a tractor-drawn sheepsfoot roller for surface consolidation of formation, one 85 h.p. tractor being used for both levelling and consolidation. The tractor is fitted with a dozer blade if required for clearing of trees. Where clearing is extensive, the work is carried out separately in advance. Where the Unit is not attached to a construction organisation, a caravan for workmen's living purposes and part-time utility truck for use in transporting employees to and from camp, delivering fuel, stores, etc., forms part of the Unit.

The first elevating grader purchased by the Department in 1940 (48-inch wide carrier belt) carried out the following quantities of formation work between the time it was first placed in operation on the 3rd April, 1940, up to the end of December, 1947. (For a period of approximately 18 months in 1942 and 1943 the elevating grader was engaged on urgent war work most of the time being loaned to another Department for aerodrome construction.)

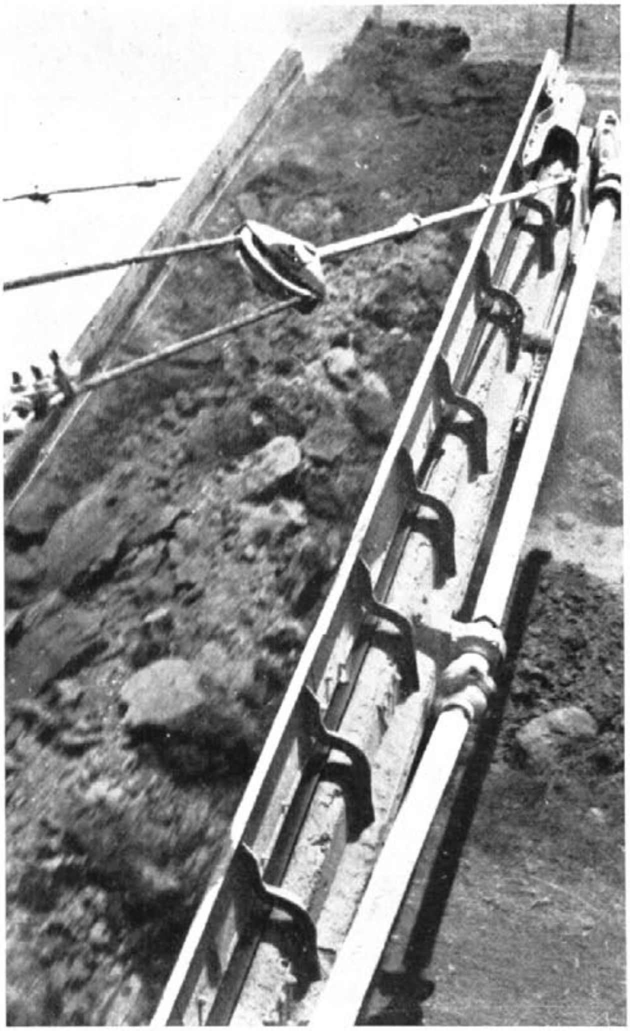
	Miles formed.	Cubic yards solid measurement.
State Highway No. 8. Broken Hill-Wilcannia Road	76	463,000
Trunk Road No. 69. Broken Hill-Wentworth Road	68	439,500
State Highway No. 7. Bourke-Barringun Road	17	110,000
Main Road No. 404. Bourke-Hungerford Road	37	333,000
Main Road No. 402. From junction of Trunk Road No. 70 southwards	22	150,000
Main Road No. 437 near Goodooga	16	109,000
State Highway No. 18. Angledool-Goodooga Road	6	43,000
	242	1,647,500

During the first nine months of the elevating grader's operations between the 3rd April, 1940, and the 20th December, 1940, the Unit, whilst engaged on State Highway No. 8, cleared, formed and consolidated 62 miles of roadway comprising approximately 397,000 cubic yards in mostly sandy and red clay soils. During this time the elevating grader's tractor was part of the time engaged on clearing, but the elevating grader for the time actually worked by it excavated and deposited this material in place at an average rate of 438 cubic yards per hour. The costs of this work are as follows:—

	Pence per cubic yard solid measurement.
Clearing (light)	.18
Excavation and spilling in place by elevating grader	1.29
Spreading by grader and consolidation by Sheepsfoot roller	.89
Miscellaneous:	
Foreman's supervision, utility truck running costs, provision of caravan, statutory holidays, Workers' Compensation Insurance and Pay Roll Tax	.64
Total cost of completed formation per cu. yd.	3.00

Subsequent to the 20th December, 1940, it was necessary to release for urgent war work the tractor engaged on spreading and consolidating, leaving the elevating grader's large tractor to carry out all operations of clearing, pulling the elevating grader, the grader for levelling the material excavated, and sheepsfoot roller for consolidation. In consequence, the time that could be worked by the elevating grader itself was considerably reduced with a drop in the total

1. Soil spilling off end of Elevating Grader.
2. Construction of formation in progress.
3. Elevating Grader loading gravel into lorry.
4. Sheepsfoot Roller consolidating surface of earth formation.
5. Typical Elevating Grader formation prior to use by traffic.
6. Typical Elevating Grader formation in use by traffic.



Excavated soil moving by elevator for discharge on to road.

quantity of work that could be carried out and an increase in unit costs. For the period 20th December, 1940, up to the 12th June, 1942, the elevating grader unit completed, while working under the handicap of tractor shortage, 82 miles of raised formation comprising 505,500 cubic yards at an average cost of 3.90 pence per cubic yard consolidated, the cost of excavating and placing by the elevating grader amounting to 1.50 pence of the total unit cost of 3.90 pence. From commencement of operations up to the 12th June, 1942, peak outputs of the elevating grader per hour actually worked by this machine were 693, 609, 608, 576, 574 and 567 with an average of 505 cubic yards for the 505,500 cubic yards completed between the 20th December, 1940, and 12th June, 1942.

Since return in December, 1943, from aerodrome construction, this elevating grader has completed a further 635,000 cubic yards of formation, the cost today averaging approximately 4.75 pence per cubic yard for the completed operations of clearing, excavating, spreading and consolidation, including cost of foreman's supervision, caravan provision, utility truck, holidays, workers' compensation insurance and pay roll tax.

Many difficulties created by the war were met with during the major part of the time this particular machine has been in operation. Shortage of separate tractor for levelling and consolidation of the excavated material and shortage of spare machine parts considerably reduced the time that could normally have been worked by the elevating grader. While these disabilities did not appreciably affect the output of the elevating grader per hour actually worked, they nevertheless caused a substantial drop in the volume of work possible in the same period under normal conditions.

Time losses due to wet weather, wet ground, plant breakdowns and repairs, and moving between jobs can considerably reduce the productive working time. For example, during the year 1946/47 time losses experienced in the use of one elevating grader were as follows:—

	Percentage of total working time
Wet weather and wet ground	24
Dismantling and moving between jobs	14
Plant breakdowns and repairs	18½
Miscellaneous	7½
Total time lost	64%

The lost time in this case was greater than normal due to unusually long periods of wet weather, high incidence of plant breakdowns and the need for frequent movement of plant between jobs.

Manner of Formation Construction.—The desired width of formation is 26 feet, and this is secured by making eleven complete circuits with the elevating grader and then spreading slightly for the edges of the formation with drawn grader.

When commencing a section of new work a line of pegs is placed at 23 feet from the centre line of the proposed formation and the centre of the towing tractor is driven to these pegs. The first cut is thus made at 28 ft. 6 ins. from the centre line of the formation and the first two lines of spill are deposited on the far side of the centre line while the machine is opening the borrow pit. Taking into account the clearance between the cutting disc and elevator, the length of the elevator, and the normal low cast of the material after leaving the elevator, the machine has a reach

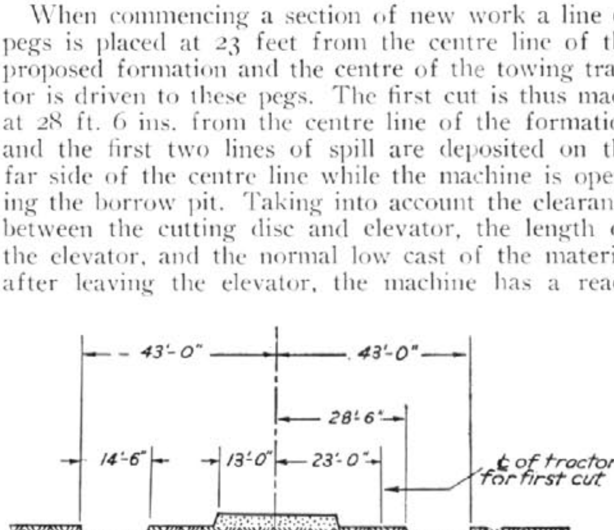


Figure 1. Elevating grader formation as constructed.

from "cut" to "drop" of about 30 feet. Full depth of cut is not attained until the third circuit. The elevating grader can be adjusted to make varying widths of cut but, as employed in the Western Division, usually makes a cut of from 16 inches to 18 inches wide. Eleven cuts 16 inches wide make a borrow pit 14 ft. 6 ins. wide. The shape of the resulting cross-section is shown in Figure 1.

The width of clearing in timbered country is usually about 100 feet, to clear roots from the path of the disc of the machine.

Under routine maintenance and the action of wind and rain, the formation becomes within a year after

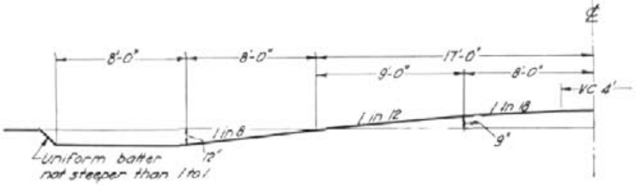


Figure 2. Ultimate shape of elevating grader formation.

construction similar in form to the Department Type "A" Flat Country Cross-section, see Figure 2. However, side drains or "borrow pits" often are completely filled by drifting soil in a short period.

The depth of cut may vary from 9 inches up to 24 inches, depending on the nature of the ground. Assuming a cut of 18 inches wide and 15 inches deep, a fair average figure for the quantity of material deposited in the formation is 4½ cubic yards per chain (solid pit measurement). Where possible extra depth of cut gives better results than extra width of cut.

It is necessary to build into the embankment a height up to twice that ultimately required. The material as excavated is largely in the form of clods and there is a high percentage of voids. Placing is followed by shaping with drawn grader and surface consolidating with sheepsfoot roller. Complete consolidation occurs within a period of twelve months under the effects of traffic and weather. The object of consolidating the surface of the bank is to enable it to carry traffic immediately after construction, and no attempt is made to secure complete consolidation of the bank with the roller.

Another example of new formation constructed by Elevating Grader.

Historical Roads of New South Wales.

DEVELOPMENT OF THE ROUTE OF THE HUME HIGHWAY.

The Hume Highway is the main road leading from Sydney to Albury, and thence to Melbourne, via Liverpool, Cross Roads, Narellan, Camden, Picton and Berrima to Goulburn, and onwards through Gunning, Yass, Coolac, Gundagai, Tarcutta and Holbrook to Albury.

Prior to 1928 the Hume Highway was known as the Great Southern road (Main Road No. 17). In 1928, the Main Roads Board adopted the principle of giving each important State Highway the same name throughout its length and, after consultation with the local governing bodies concerned, arranged with the Country Roads Board of Victoria for the re-naming of the road from Sydney to Melbourne, via Albury, as the Hume Highway. This name was adopted as a tribute to Hamilton Hume, one of the two pioneers who led the first exploration party overland to Port Phillip in Victoria, much of the route of the Highway being along that followed by Hume on his overland journey.

Hamilton Hume.

Hamilton Hume was born in New South Wales in the year 1797, his parents having been amongst the earliest settlers in the Colony. In his early days he was hardy and athletic, as well as intelligent and spirited. He acquired from the natives an unusual facility for finding his way without the aid of a compass. In addition to his exploration of the route from Sydney to Port Phillip, his name is associated also with other noteworthy explorations, particularly in the western portion of New South Wales. Hume died on the 19th April, 1873.

EARLY EXPLORATIONS.

In the first years of the Colony, the main southern route from Sydney Cove and Parramatta went by way of Prospect (about 17 miles west of Sydney) and then turned generally south via Carne's Hill and Narellan to Camden, as those localities came to be called. Later a route was developed from Sydney via Liverpool and Cross Roads to Carne's Hill, and this became the principal avenue for traffic southwards. Shortly before the passing of the Main Roads Act the road between Cross Roads, Campbelltown and Narellan was improved, and for some years carried the main traffic to the south without passing near Carne's Hill.

Hume was one of the earliest explorers of that part of New South Wales situated between Liverpool and Goulburn. During the year 1814, in company with his brothers, he discovered a tract of country, which was named "Argyle," subsequently forming the County of Argyle, and situated immediately north of Goulburn. On the 3rd March, 1818, he accompanied Surveyor James Meehan on a journey which commenced at Liverpool, under instructions to see if overland communication could be effected between Sydney and Jervis Bay. Meehan's party proceeded by a then existing track as far as the site of Moss Vale, thence on a line to the north of the present route of the Hume Highway, which the party reached at Marulan, and from there in a southerly direction to the east of Bungonia and to the west of Lake Bathurst, making the return journey to the south of where the City of Goulburn now stands.

With the extension of settlement from Sydney Cove towards the west and south, in 1824, the Governor, Sir Thomas Brisbane, supported an expedition to obtain information regarding the unexplored territory between Sydney and the southern coast of what is now the State of Victoria. The leaders of the expedition were Hamilton Hume and William Hilton Hovell. The latter resided at Naralling, where he obtained a grant of land in 1821, and from which the present village of Narellan takes its name. The party set out from Appin, near Sydney, on the 3rd October, 1824, and travelled first via Picton, Bong Bong, Kenmore and Breadalbane to Hume's property near Lake George, which was reached ten days later.

Cooma Cottage, Yass. Residence of Hamilton Hume.

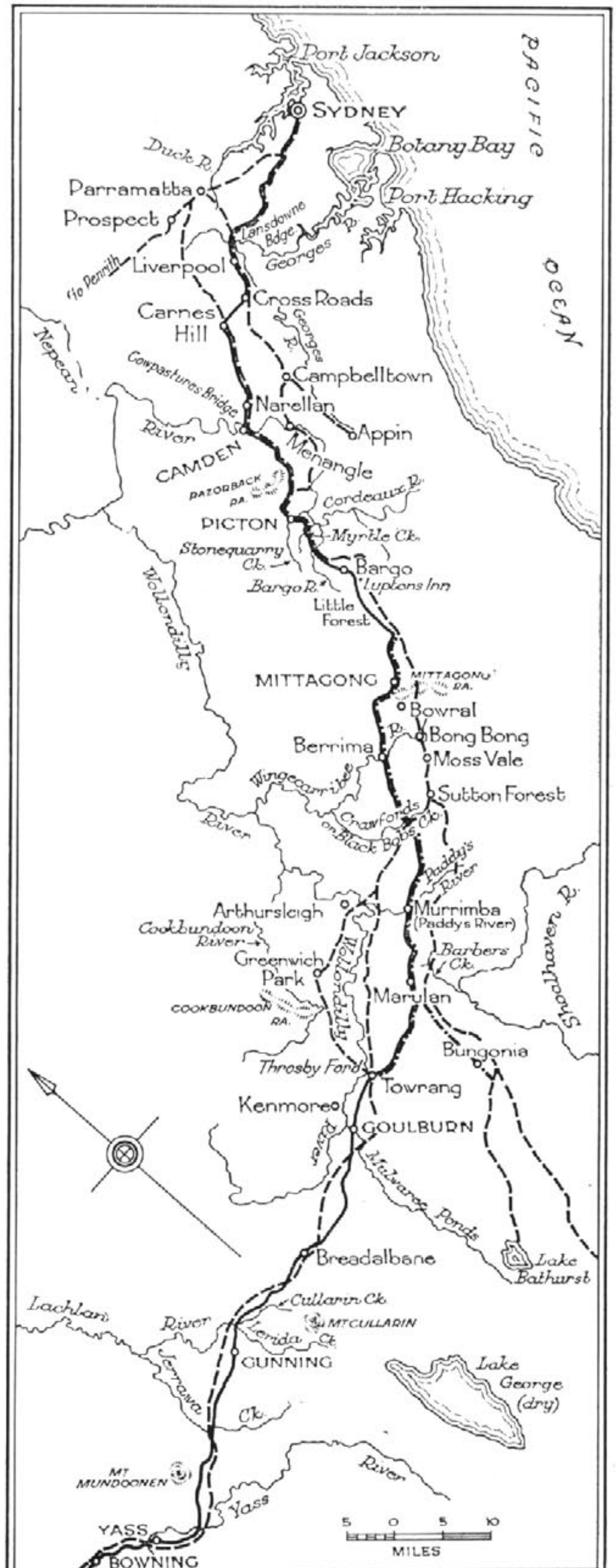
They then proceeded to Yass Plains, crossing the Goodradigbee River, where they were delayed by a flood, and entered unexplored and mountainous country. They passed close to the site of the present town of Tumut, and on the 16th November, 1824, reached the Murray River near the site of what is now the City of Albury. The journey ended on the western side of Port Phillip near the site of the present City of Geelong. The route of Hume and Hovell's party thus followed to a considerable degree the general route of the present inland road connection between Sydney and Melbourne, now known as the Hume Highway.

EARLY SURVEYS.

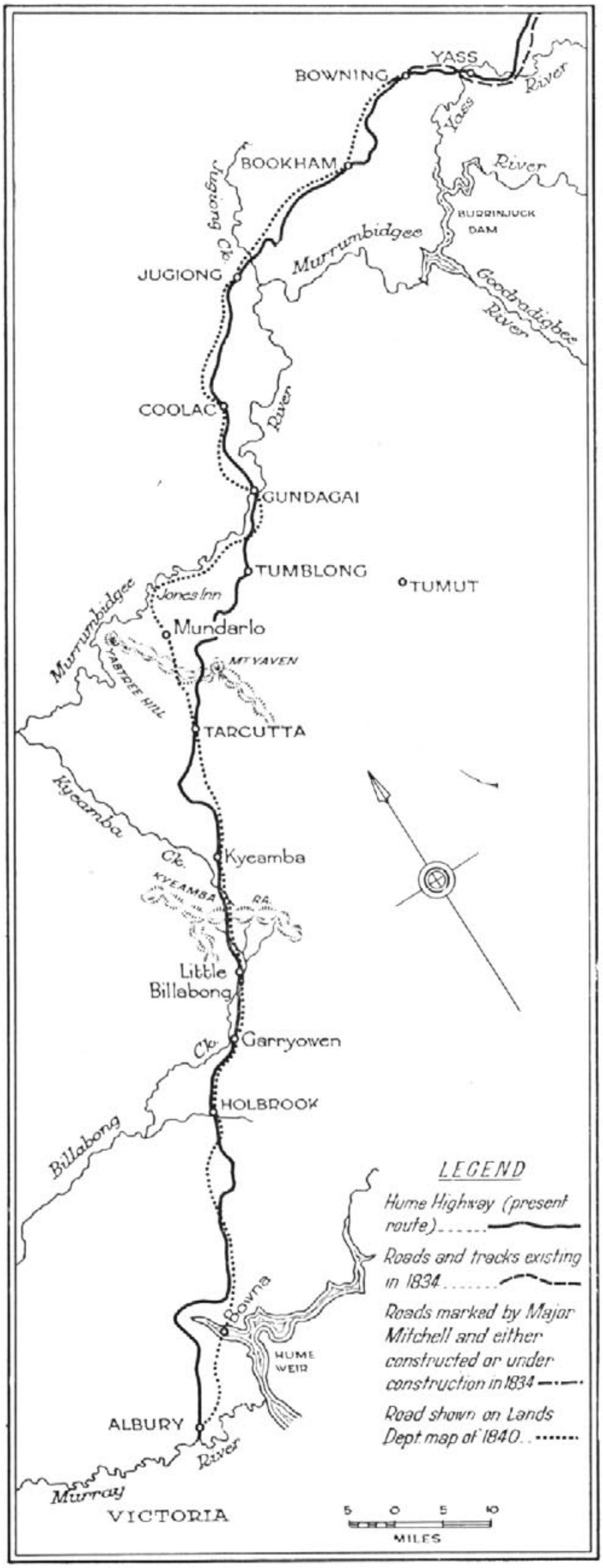
The earliest survey of the route of the future Hume Highway appears to have been carried out by William Harper in 1821, his field books containing particulars of a traverse from the Nepean River, near Camden, over the Razorback Range and onwards to the Wollondilly River near Paddy's River. Following this a survey was carried out by Surveyor Ralfe over Cookbundoon Range, continuing until it intersected the Wollondilly River near Breadalbane. This was completed on the 8th July, 1826.

In a statement accompanying a letter dated 21st July, 1829, from the Colonial Secretary to the Surveyor-General, Major T. Mitchell, it is set out that the line of the road in use through the Argyle district was from Campbelltown to Menangle Ford, then from Stonequarry Creek to Myrtle Creek, and on to Bargo and Lupton's Inn, about 10 miles south of Picton, thus not passing over the Razorback Range. The route then passed over the Mittagong Range to the township of Bong Bong, near Moss Vale, and from there to Paddy's River, where a good bridge had been constructed. It then proceeded to Barber's Creek, a distance of 67 miles from Menangle Ford. The route previously projected over the Razorback Range was not abandoned, however, because on the 11th November, 1829, Surveyor H. F. White was instructed to proceed to Stonequarry Creek and make a detailed survey of the Razorback Hills, and to show a line of road on his plan.

On the 26th March, 1830, Mitchell reported that, in accordance with the Governor's instructions, he had marked a line of road. Apparently this line followed the existing route via Campbelltown, as far as Lupton's Inn. Between the latter point and Little Forest, a



Locality Map Showing Mitchell's Line.



Locality Map.

distance of about 6 miles, the previous line was straightened, with a slight saving in distance. From Little Forest a considerable alteration in the existing route was made. The new line left the old track at Little Forest Hill, and "although it was somewhat tortuous, the ascent to favourable ground was easy, and this ground could not be reached by any other manner." The new line continued to the northward of the old track and passed through Bowral to Berrima, where Mitchell reported there were two natural piers of rock upon which a small but permanent bridge could be built. The line then went southwards along almost flat country to Black Bob's Creek, where there was a slight detour to the east in order to avoid a deep gully, which Mitchell recommended should be bridged. The then existing track to Goulburn was intersected almost immediately after crossing Black Bob's Creek, and the new line reached Paddy's River at Murimba. Mitchell recommended the erection of an iron bridge at Paddy's River, although he said that both at this point and at other places where he had recommended bridges, even if they were not built at once there would be no great impediment to travelling when the line had been cleared. The new line then proceeded by way of Marulan to Towrang, where it rejoined the old line at a distance of 10 miles from the "Marked Tree" west of Barber's Creek. The saving in road length by adopting the new line proposed by Mitchell was 22 miles 9 chains, and it dispensed with the need for two crossings over the Wollondilly River, which were necessary on the line proposed previously.

As stated previously, Mitchell's new line did not cross the Razorback Range. However, a line for a road across the range was determined following on the detailed survey of Surveyor H. F. White previously referred to, and an inspection by the Commissioners for partitioning the Territory. Many objections to this route were raised in the Press, and it was opposed by Mitchell, but without result. Mitchell stated that the suggested route was not in the proper line for the great road through the Argyle district, and that he "would never have thought of applying all the means allowed for the construction of great roads through the most important part of the Colony to the Razorback, where the road must, in time, become a cross road, being out of the best direction for a great road to Argyle."

EARLY CONSTRUCTION.

The first definite record of a road being constructed from Sydney to the south is the construction of a section between Sydney and Liverpool by William Roberts, and its opening on the 22nd March, 1814.

The discoveries of Hume and Meehan to the south in 1818 had disclosed the existence of promising lands, and Governor Macquarie decided to encourage settlement in the new country. In order to give access to it a road was necessary, and this was constructed by convict labour. The earliest reference to this road is in a letter from the Governor to Commissary-General Drennan, dated 9th September, 1819, where instructions were given for "the construction of a cart road through the country as far as the settlement about to be established there." The work was commenced on the 9th

October, 1819, and was completed in February, 1821. The length of the road was 75 miles, and its average width 33 feet. The cost of operations was £280 3s. 8d., which included the erection of six bridges. The road crossed the Bargo River at the point where the present highway passes over the stream by a bridge, thence it passed over the Mittagong Range. Proceeding south, the new road crossed the Wingecarribee River below the present bridge at Bong Bong, and passed through what are now Moss Vale and Sutton Forest, beyond which it went west across Paddy's River by means of a low level bridge, and a short distance further on the road crossed the Wollondilly River. It then ran through Arthursleigh, an early land grant, thence to Greenwich Park and across the Cookbundoon Range. The old road appears to have reached the Wollondilly River again at what is now Throsby's Ford.

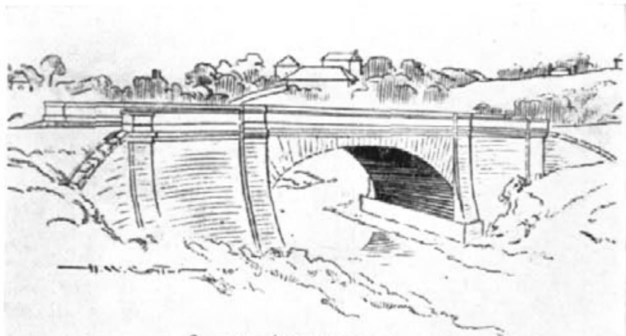
Early in 1822 a new line from Merrimbo to Goulburn Plains was discovered, and this route, although not actually surveyed, was used.

In 1832, with the greater part of his surveys completed, Mitchell's active mind was exercised in planning the construction of new great roads, and in devising some means of preventing the stoppage of the King's Highways as a result of destruction by flood or fire of the rude wooden bridges which had hitherto served as crossings of the various watercourses. In that year, when passing along Macquarie-street, Sydney, he saw a mechanic engaged in cutting the coping stope of the dwarf wall in front of the Legislative Assembly. This man was David Lennox, who afterwards became Superintendent of Bridges. Lennox, who was born in Ayr, Scotland, was 45 years of age when he took service under Mitchell, having arrived in Sydney on the 11th August, 1832. The early bridge erected over Prospect Creek during the construction of the original road from Ashfield, Sydney, to Liverpool, had been destroyed by flood, and others, subsequently erected, had suffered in the same way. At this time a bridge carried on stone piers existed, but was in a ruinous condition. Lennox designed a stone bridge of a single span to replace the latter, and the design and erection was approved by the Governor. It was erected by convict labour, the stone

Lansdowne Bridge over Prospect Creek.

for the bridge being obtained from 7 miles downstream on the banks of George's River, and conveyed to the site of the bridge by means of punts. The foundation stone was laid by the Governor on 1st January, 1834, and the bridge was opened to the public on the 26th January, 1836. The span of the arch is 120 feet, the height of the crown above high-water mark 30 feet, the length 190 feet, and the breadth 27 feet. This bridge is still in use.

Approval was given in 1832 to the construction of the road on the new line surveyed by Mitchell in 1830. In the course of an address to the Legislative Assembly in 1833, the Governor stated the road might be opened in six months. However, it was not completed until some years later. There are no definite records as to the order in which the work was carried out, but there are records of the bridges built by Lennox in conjunction with the road construction. In 1833 he received instructions to construct a bridge over the Wingecarribee River at Berrima, and although there was some delay in the commencement of the work it was completed in June, 1836. It was designed on the lines of the Lansdowne Bridge, and had an arch span of 50 feet and a width of 27 feet, including parapets. This bridge was destroyed by flood in 1860.

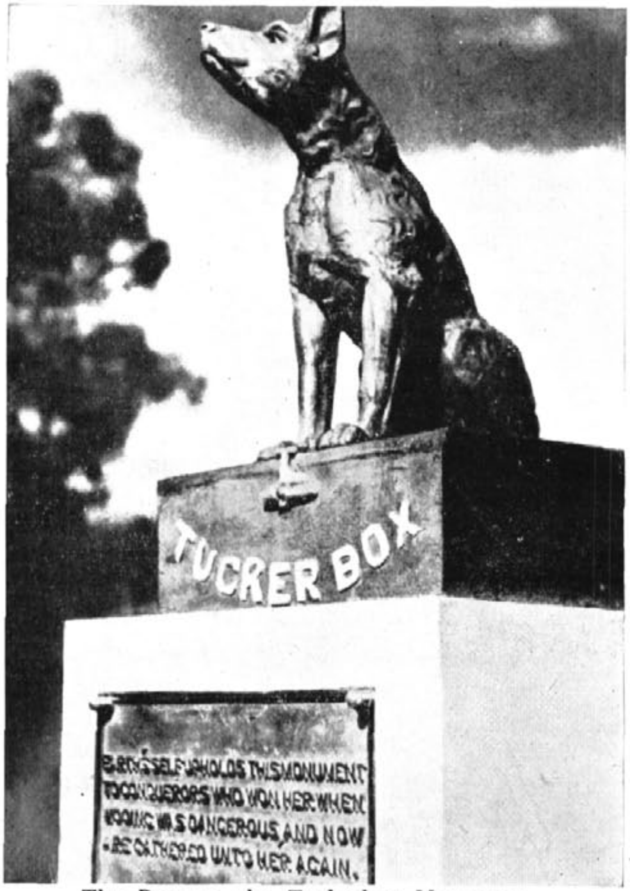


BERRIMA (original) BRIDGE
from Sketch in Sir Thomas Mitchell's Field Book C. 53 Mitchell Library
Designed and built by David Lennox Opened 1836
Destroyed by Flood 1860

On the 23rd January, 1834, Lennox reported having laid out the site of a bridge on the main southern road at the crossing of Midway Rivulet, 3 miles south of Berrima. For this crossing a wooden bridge was designed supported by three masonry piers 20 feet apart. In 1835 the Surveyor-General reported that the bridge had been completed.

Again in 1834 Lennox laid out the site of a bridge at Crawford's or Black Bob's Creek, 7½ miles beyond Berrima. The span of the bridge was 30 feet. Although the bridge was passable for traffic in April, 1836, it was not completed for some considerable time afterwards. The Surveyor-General reported that the piers and walls were of excellent stone resting on a solid mass of rock, and that the bridge was constructed of strong beams, supported by a brace. This bridge has since been replaced.

A map dated 1847 shows that by then the main southern road passed through Goulburn and Yass. The Yass River was bridged by a structure completed by



**The Dog on the Tuckerbox Monument.
Erected on Site of Drover's Camp 5 miles from Gundagai.**

Lennox in 1854. A track then continued through Bookham, Jugiong and Coolac to Gundagai, where the Murrumbidgee River was crossed by a ford. Prior to a great flood in the Murrumbidge River in 1852, the township of Gundagai was located on the half-mile wide flat on the northern bank. The flood destroyed the original town, inundating the flat to a depth of about 15 feet, with the loss of eighty-nine lives. As a consequence settlement was transferred to higher ground overlooking each bank.

The track then followed the southern bank of the river to Jones' Inn, a distance of 20 miles from Gundagai, where it turned sharply southwards to Tarcutta (passing through Mundarloo, crossing a range between Yabtree and Yaven Hills), running generally in a south-westerly direction through Kyeamba Station and over Kyeamba Range to Garryowen and Germantown, now Holbrook, thence via Bowna to Albury. At this time the route was merely a track serving the various holdings which had been taken up, although the route of the track is substantially the same as that of the Highway to-day.

The control of the main southern road was assumed by the Department of Public Works in the year 1861. At that time a fair amount of metalling had been carried out between Sydney and Goulburn, although the surface was not good, excepting in a few small sections. From Goulburn to Albury very little construction work had been undertaken.

By the Shires Act of 1905 the care and control of public roads was transferred to the Councils of Shires and Municipalities.

With the passing of the Main Roads Act in 1925 the Great Southern road became eligible for assistance from Main Roads Funds. In 1928 it was proclaimed a State Highway and named in honour of Hamilton Hume. Since 1925 the highway has been improved throughout, including the construction of many deviations. By 1940 it had been provided with a bituminous or other dustless surface over its full length in New South Wales, 375 miles, and similarly on through Victoria to Melbourne.

Step by step, over a period of 150 years, the Highway has been developed and improved. After the construction of railways, and prior to the introduction of motor vehicles, the Great Southern road, like other main rural highways, lost much of its earlier significance, and improvement lagged. This lost ground has been more than regained since the introduction of motor vehicles. To-day the Hume Highway carries a heavy and concentrated traffic. It performed a vital function during the war years. The Highway, as it now exists, forms a permanent and fitting memorial to the Australian born and intrepid explorer—Hamilton Hume.

Tenders Accepted.

The following Tenders (exceeding £500) were accepted by the Department during the months of January, February and March, 1948.

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Bankstown M. ...	508	Construction of 4-span reinforced concrete bridge over gully near Keys Parade.	McConnell Building Co. Ltd.	6,768 15 10
Eurobodalla S. ...	1	Bridge over Clyde River at Bateman's Bay—Supply and delivery of metal-work and machinery.	The Clyde Engineering Co. Ltd.	62,540 0 0
„ ...	1	Bridge over Tuross River at Bodalla—Supply of steelwork	„ ...	29,670 0 0

Why do we Drive on the Left Hand Side of the Road?

Uruguay, last American country to cling to the practice of driving on the left, recently started conforming to the right-hand rule of the road. Now the Pan-American motorist can laugh at international borders—unlike his European counterpart who must swing from one side of the road to the other as he drives across some of the borders of the countries of the Old World.

Uruguay's action in making the rule of the road unanimous in the Americas, raises the question why mankind did not agree on such a simple thing in the first place. Why did some nations adopt one practice and others do exactly the opposite?

The answer lies deep in the mists of time when men stopped carrying loads on their backs and on horseback and began using carts and wagons. It probably traces, says the National Geographic Society, to that universal badge of the wagoner—the horsewhip.

In old England the predominant type of transport was the simple four-wheeled box wagon with a board across the front end for the driver's seat. The driver sat on the right end of this board so as to keep his whip hand free. He could wield the whip with more ease from the right side because his arm and whip would swing clear of the vehicle. When two of these wagons met, the drivers pulled to the left. They did this so they could see if their vehicles were clearing each other.

England's American Colonies aped the mother country in the rule of the road until about 1750. Conditions peculiar to the colonies—greater distances, more long hauling, bigger freight loads—resulted in the development of the Conestoga wagon about that time. Two or, more likely, three pairs of horses pulled these heavy wagons. The driver, or postilion, sat on the left rear horse. He did not choose to sit on the right rear horse because then his own body would be in the way when whipping the horse to his left.

From the left rear horse, however, he was in a position to strike with his whip hand at all the horses. Naturally he kept to the right when meeting other vehicles, for only on that side could he watch the space between the passing wagons to see that they cleared each other. In time the ponderous freight wagons forced all other types of vehicles to conform to their rules of the road.

Published in "Highway Research Abstracts," February, 1948, and from "Traffic Safety," Volume 9, Nos. 11-12.

PAYMENTS FROM THE ROADS FUNDS FOR PERIOD 1st JULY, 1947, to 31st MARCH, 1948.

	Amount Paid.
County of Cumberland Main Roads Fund—	£
Construction of Roads and Bridges	281,897
Cost of Acquisition of Land for Road Widening	17,952
Maintenance of Roads and Bridges	300,212
Interest, Exchange and Repayment of Loans	6,516*
Other Expenditure	156,201
Total	£762,778
Country Main Roads Fund—	
Construction of Roads and Bridges	539,449
Cost of Acquisition of Land for Road Widening	3,741
Maintenance of Roads and Bridges	1,443,326
Interest, Exchange and Repayment of Loans	142,272
Purchase and Repair of Plant and Motor Vehicles	144,234
Other Expenditure	146,880
Total	£2,419,902
Developmental Roads Fund—	
Construction of Roads and Bridges	67,017
Other Expenditure	1,890
Total	£68,907
Summary All Funds—	
Construction of Roads and Bridges	888,363
Cost of Acquisition of Land for Road Widening	21,693
Maintenance of Roads and Bridges	1,743,538
Interest, Exchange and Repayment of Loans	148,788*
Purchase and Repair of Plant and Motor Vehicles	144,234
Other Expenditure	304,971
Total	£3,251,587

* Excludes a special payment of £696,096 in the liquidation, prior to the ordinary due date, of outstanding loan liabilities.

Tenders Accepted.

The following Tenders (exceeding £500) were accepted by the respective Councils during the months of January, February and March, 1948.

Council.	Road No.	Work.	Tenderer.	Amount. £ s. d.
Albury C. ...	2	Supply and delivery of aggregate	Hurricane Hill Quarries	718 4 0
Apsley S. ...	11	Supply, delivery and spreading 2,609 c. yds. gravel between 17.4 m. and 21.55 m. west of Walcha.	W. H. Marshall ...	897 13 3
Ashfield M. ...	167 2018	Supply and application of 6,500 gallons bitumen... ...	B.H.P. By-Products Pty. Ltd.	734 10 0
Bibbenluke S. ...	288	Construction of bridge and approaches over Hopping Joe Creek.	F. L. Hall	2,339 18 3
Bland S.	2	Gravel resheeting between 14 m. and 18.1 m.	Miller and Lewington...	642 6 8
Bogan S. ...	7	Construction culverts, approach ramps, etc.	B. J. Boland	752 1 4
,, ...	1178	Clearing and grubbing 55 ft. wide between Giralambone and Murrawombie.	W. H. Johnston ...	665 0 0
Boree S.	61 237	Supply, delivery and spreading 4,144 c. yds. gravel on T.R. 61 and 3,205 c. yds. gravel on M.R. 237.	R. R. Barnes	2,376 13 9
Burrangong S. ...	78	Surfacing	B.H.P. By-Products Pty. Ltd.	1,776 19 8
Coolamon S. ...	...	Supply, delivery and spreading 3,706 c. yds. gravel ...	Staines and Grundy ...	833 17 0
Gilgandra S. ...	18	Supply and delivery 4,786 c. yds. gravel 38 m.—58.31 m.	S. J. Bailey	1,676 15 4
,, ...	18	Supply and delivery 3,200 c. yds. loam 33 m.—38 m. ...	,, ...	533 6 8
Guyra S.	73 135	Supply and delivery 16,108 c. yds. gravel	Frost and Spriggs ...	2,541 9 0
Hastings S. ...	112	Resealing at Comboyne	B.H.P. By-Products Pty. Ltd.	960 2 2
Holbrook S. ...	331	Supply and delivery 5,300 c. yds. gravel	F. A. Carstans	971 13 4
Hume S.	...	Surfacing and resurfacing	B.H.P. By-Products Pty. Ltd.	1,484 11 0
Jemalong S. ...	1104	Supply, delivery and spreading 4,288 c. yds. gravel ...	J. P. Dean	946 4 0
Lockhart S. ...	57	Sealing and resealing	B.H.P. By-Products Pty. Ltd.	1,051 6 5
,, ...	57	Surfacing	,, ...	3,713 10 4
Manning S. ...	10 111 192	Supply and delivery of crushed and screened gravel and grit.	L. C. Wilson	1,114 13 9
Murrumbidgee S.	14	Supply, delivery and spreading 13,416 c. yds. loam ...	Hardie and Co. ...	2,805 8 0
Nepean S. ...	155	Construction of gravel pavement, including clearing, fencing, etc., from 3 m. 3,600 ft. to 5 m. 1,750 ft.	N. H. Bowers & Leard Pty. Ltd.	17,722 14 0
Patrick Plains S.	181	Surfacing with bitumen between 8.6 m. and 9.6 m. from M.R. 503.	B.H.P. By-Products Pty. Ltd.	1,393 7 11
,, ...	503	Surfacing with bitumen between 6.10 m. and 7.82 m. from Singleton.		
Severn S. ...	9	Supply, delivery and spreading 3,750 c. yds. gravel, Ben Lomond Range.	Frost and Spriggs ...	843 15 0
Tenterfield S. ...	16	Construction of reinforced concrete culvert 2.5 m. east of Tenterfield.	P. Dwyer	1,291 17 6
Tumut S.... ...	4	Supply and delivery 2,100 c. yds. gravel	A. Sheather	787 10 0
Wade S.	80 321	Surfacing	B.H.P. By-Products Pty. Ltd.	1,829 3 8
,, ...	80	Resealing	,, ...	1,484 11 0
Waradgery S. ...	14	Resurfacing with limestone gravel between 38 m. and 49.2 m.	D. A. Newman & Sons	2,355 0 0
Weddin S. ...	6	Supply, delivery and spreading 5,120 c. yds. gravel between 216 m. and 232 m.	S. J. Bailey	974 6 8
,, ...	6	Supply, delivery and spreading 12,992 c. yds. gravel between 234.5 m. and 275.1 m.	,, ...	3,729 15 4
,, ...	3028	Clearing, forming and gravelling 4 m. 1,550 ft.—4 m. 3,691 ft. from S.H. 6 towards Goolagong.	A. J. Gam	1,476 15 11
Wollondilly S. ...	177 179	Supply and application of 23,320 galls. Duratenax ...	Australian Gaslight Co.	1,870 9 2
,, ...	177 179	Supply and delivery of 1,400 tons crushed river gravel to stockpiles.	Blue Metal and Gravel Pty. Ltd.	1,696 7 6

Sydney: Thomas Henry Tennant, Government Printer—1948.

MAIN ROADS STANDARDS.

NOTE: Numbers prefixed by "A" are drawings, the remainder are specifications unless otherwise noted.

Form No.

EARTHWORKS AND FORMATION.

70* Formation. (Revised, July, 1946.)
A 1532* Standard Typical Cross-sections.
A 1149* Flat Country Cross-section, Type A. (Revised, 1930.)
A 1150* Flat Country Cross-section, Type B. (Revised, 1936.)
A 1151* Flat Country Cross-section, Type D1. (Revised, 1936.)
A 1152* Flat Country Cross-section Type D2. (Revised, 1930.)
A 1476 Flat Country Cross-section, Type E1. (Revised, 1937.)
A 1101 Typical Cross-section One-way Feeder Road. (1936.)
A 1102 Typical Cross-section Two-way Feeder Road. (1931.)
A 114 Rubble Retaining Wall. (1941.)

PAVEMENTS.

71* Gravel Pavement. (Revised, January, 1939.)
228* Reconstruction with Gravel of Existing Pavements. (Revised, January, 1939.)
254 Supply and Delivery of Gravel. (Revised, August, 1939.)
72* Broken Stone Base Course. (Reprinted with amendments, August, 1947.)
68* Reconstruction with Broken Stone of Existing Pavement to form a Base Course. (Revised, October, 1933.)
296 Tar. (Revised, March, 1939.)
337 Bitumen. (Revised, February, 1939.)
305 Bitumen Emulsion. (Revised, September, 1942.)
351 Supply and Delivery of Aggregate. (Revised July, 1941.)
65* Waterbound Macadam Surface Course. (July, 1939.)
301* Supply and Application of Tar and/or Bitumen. (Revised, August, 1946.)
122* Surfacing with Tar. (Revised, May, 1940.)
145* Surfacing with Bitumen. (Reprinted with amendments, August, 1947.)
93* Re-surfacing with Tar. (Revised, May, 1940.)
94* Re-surfacing with Bitumen. (Revised, July, 1940.)
230* Tar or Bitumen Penetration Macadam, Surface Course, 2 inches thick. (Revised, December, 1936.)
66* Tar or Bitumen Penetration Macadam, Surface Course, 3 inches thick. (Revised, September, 1936.)
125* Cement Concrete Pavement (April, 1939) and Plan and Cross-section A 1147 (March, 1932).
466 Bituminous Flush Seals and Reseals—Fluxing of Binders. (March, 1947.)

GENERAL.

342* Cover Sheet for Specifications, Council Contract. (Revised, April, 1939.)
24B*General Conditions of Contract, Council Contract. (Revised, February, 1947.)
64* Schedule of Quantities.
39* Bulk Sum Tender Form, Council Contract. (Revised, August, 1946.)
38* Bulk Sum Contract Form, Council Contract.
121* Provision for Traffic (Revised, June, 1947) with general arrangement, A 1323* and details A 1325* of temporary signs. (Revised, January, 1947.)
A 1342* Warning Signs, Details of Construction.
A 1346 Iron Trestles for Road Barriers.
A 1341 Timber Trestle and Barrier.
A 1824 Light Broom Drag. (1941.)
A 1924 Pipe Frame Drag.
A 178 Mould for Concrete Test Cylinder.
A 1381–3 / A 1452–5 } Tree Guards, Types A, B, C, D, E, F, and G.
197* Hire of Council's Plant. (Revised, April, 1937.)
A 478* Specimen Drawings, Rural Road Design, with drawings A478A* and A 478B*.
A 478C*Specimen Drawing, Flat Country Road Design.
A 1113* Rural Road Plan and Longitudinal Section Form (tracing cloth).
A 1114* Rural Road Cross-section Form (tracing cloth).
A 1115* Urban Road Plan Forms (tracing cloth).
193 Duties of Superintending Officer (instructions). (Revised, July, 1938.)
314 Standard Regulations for Running of Ferries. (Revised, January, 1947.)
A 1645 Stadia Reduction Diagram. (1939.)
355* Instructions for Design of Two-lane Rural Highways (1937).
A 1487* Horizontal Curve Transitions (diagrams).
A 1488*, A 1488A*, A 1488B*, and A 1488C*.—Horizontal Curve Transitions (tables for speeds of 30, 40, 50, and 60 miles per hour).
A 1614 Widening of Shoulders on Crests.
369* Instructions for Design of Urban Roads (1939).
288 Instructions for Design of Intersections (1939).
402 Instructions for Design of Rural Intersections (acceleration and deceleration lanes). (1941.)

Form No.

KERBS, GUTTERS, AND GULLY PITS.

243 Integral Concrete Kerb and Gutter and Vehicle and Dish Crossings (Revised, July, 1939) and Drawing. (A134A.)
245 Gully Pit (Revised, May, 1939) and Drawings (*a*) with grating (A 1042); (*b*) Kerb inlet only (A 1043); (*c*) with grating and extended kerb inlet (A 1352); (*d*) extended kerb inlet (A 1353).
A 190 Gully Grating. (1933.)
A 1418 Concrete Converter. (1936.)

FENCING.

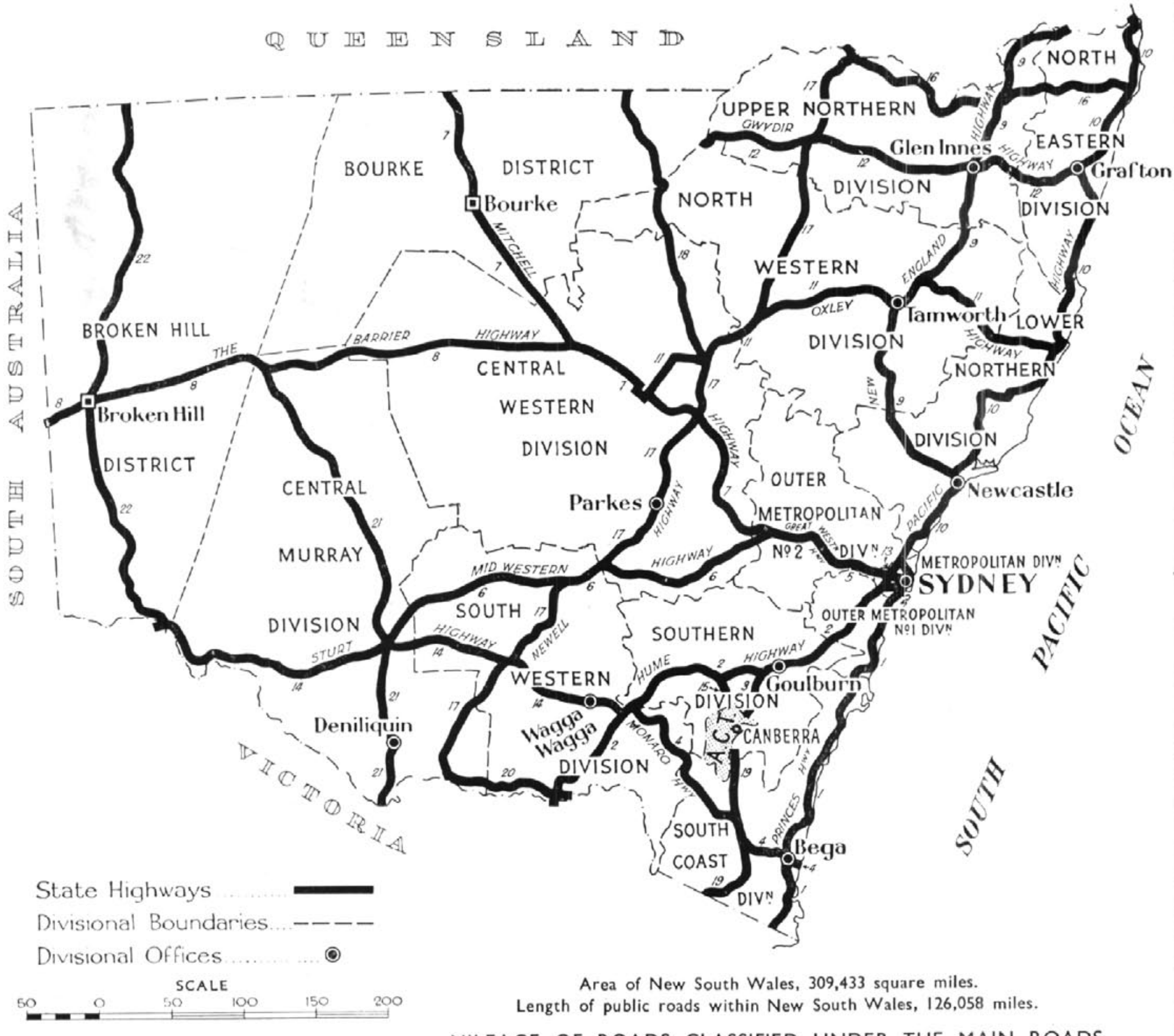
142 Split Post and Rail Fencing and Drawing (A 43).
141* Post and Wire Fencing (Revised, December, 1947) and Drawings (*a*) Plain (A 494); (*b*) Rabbit-proof (A 498); (*c*) Flood gate (A 316).
143 Ordnance Fencing (Revised, February 1934) and Drawing A 7. (Revised November, 1939.)
144 Chain Wire Protection Fencing and Drawing (A 149).
246 Location of Protection Fencing (instruction). (Revised, May, 1940.)
A 1301 Motor Traffic By-pass 9 feet wide. (1936.)
A 1875 Motor Traffic By-pass 20 feet wide. (1942.)

BRIDGES AND CULVERTS.

A 4 Standard Bridge Loading (general instruction). (1938.)
A 4A Standard Bridge Loading (instruction for dead-end Developmental Roads.) (Revised, 1938.)
18* Data for Bridge Design. (Revised, August, 1944.)
84* Data accompanying Bridge or Culvert Designs.
A 26 Waterway Diagram. (Revised, 1943.)
371 Waterway Calculations. (1939.)
A 421 Boring Gear, 2 inches. (1930.)
A 44 Boring Gear, 3½ inches. (1926.)
A 2847 Rod Sounding Apparatus. (1945.)
A 2995 Rod Sounding Apparatus, with tripod (1947).
25* Pipe Culverts and Headwalls (Revised, December, 1939) and drawings, Single Rows of Pipes, 15 in. to 21 in. dia. (A 143*), 2–3 ft. dia. (A 130*), 3 ft. 6 in. dia. (A 172*), 4 ft. dia. (A 173*), 4 ft. 6 in. dia. (A 174), 5 ft. dia. (A 175), 6 ft. dia. (A 177); Double Rows of Pipes, 15 in. to 21 in. dia. (A 211*) 2–3 ft. dia. (A 203*), 3 ft. 6 in. dia. (A 215), 4 ft. dia. (A 208), 4 ft. 6 in. dia. (A 207), 5 ft. dia. (A 206), 6 ft. dia. (A 213); Treble Rows of Pipes, 15 in. to 21 in. dia. (A 210), 2–3 ft. dia. (A 216), and Straight Headwalls for Pipe Culverts, 15–24 in. dia. (A 1153*).
A 1* Joint for Concrete Pipes. (Revised, August, 1933.)
A 142* Inlet Sump for Pipe Culverts 3 ft. dia. or less (Revised, December, 1947.)
138* Pre-Cast Concrete Box Culvert (Revised, November, 1947) and drawings, 9 in. high (A 485*), 12 in. (A 446*), 1 ft. 6 in. (A 447*), 2 ft. (A 448*), 2 ft. 6 in. (A 449).
A 311 Concrete Arch Culvert, 5 ft. high. (1931.)
A 314 Concrete Arch Culvert, 10 ft. high. (1931.)
206* Reinforced Concrete Culvert (Revised, February, 1948) and instruction sheets (A 305, A 359, A 306, A 304).
A 1832 Cast-in-Place Concrete Pipe Culverts. (1942.)
A 309* Concrete Culvert Posts. (Revised, June, 1937.)
300 Pile Drivers, specification for 25 ft., and drawings for 50 ft. (A 209), 40 ft. (A 253), and 25 ft. portable (A 1148).
A 1886 Arrangement of Bolting Planks for various widths of deck. (1943.)
A 45 Timber Bridge, Standard Details. (Revised, October, 1947.)
A 1791 Timber Beam Skew Bridge Details. (1941.)
164 Timber Beam Bridge (Revised, April, 1947) and instruction sheets, 16 ft. (A71), 18 ft. (A 68), 20 ft. (A 70) and 22 ft. (A 1761). (Amended August, 1946.)
A 1226 and A 1165 Low Level Timber Bridges, instruction sheets for 16 feet, and 18ft. between kerbs. (1932.)
A 1222, A 1166, and A 1223 Single Span Timber Culverts, instruction sheets for 16 ft., 18 ft. and 20 ft. between kerbs. (1931.)
139* Timber Culvert and drawings, 1 ft. 6 in. high (A 427), 2 ft. (A 428), 3 ft. (A 429), 4 ft. (A 430), 5 ft. to 8 ft. high, (A 431). (1928.)
326 Extermination of Termites in Timber Bridges. (Revised, October, 1940).
A 222* Pipe Handrailing Details. (Revised, July, 1947.)
350 Reinforced Concrete Bridge. (Revised, January, 1946.)
495 Design of Forms and Falsework for Concrete Bridge Construction. (September, 1947.)

Standards marked * may be purchased from the Government Printer, Sydney.
Others may be purchased from the Head Office of the Department of Main Roads, 309 Castlereagh Street, Sydney, single copies being free to Councils.

State Highway System
of the
State of New South Wales



Area of New South Wales, 309,433 square miles.
Length of public roads within New South Wales, 126,058 miles.

MILEAGE OF ROADS CLASSIFIED UNDER THE MAIN ROADS ACT, AS AT 1st JULY, 1947.

State Highways	6,501
Trunk Roads	3,731
Main Roads	12,653
Secondary Roads (County of Cumberland only)	81
Developmental Roads	2,805
	25,771
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	2,309
TOTAL ...	28,080