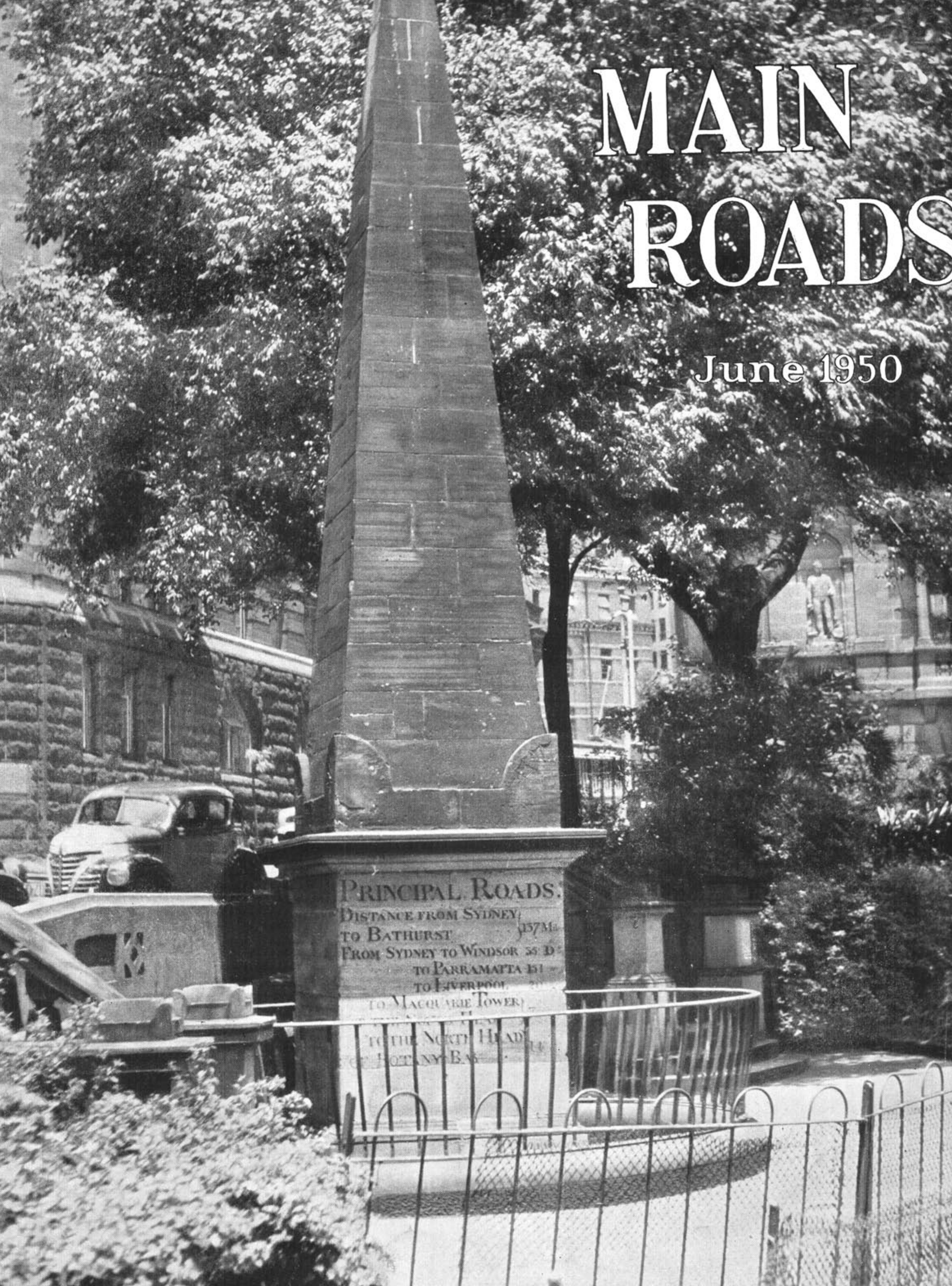
MAIN ROADS

June 1950



MAIN ROADS.

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Cover Page.

Obelisk in Macquarie Place, Sydney. Erected 1818. See article, page 127.

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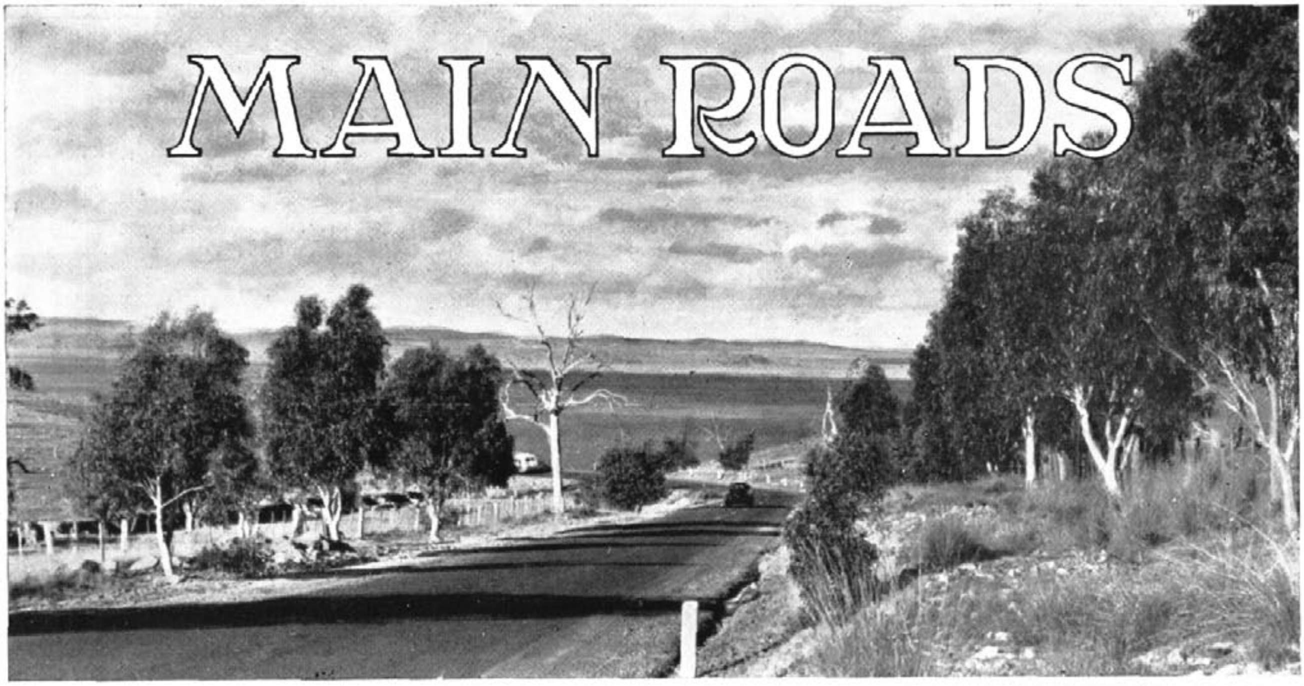

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The Battle of Maintenance

Maintenance means "care and upkeep," and, applied to roads, covers the inescapable assignment that (*a*) traffic may operate both safely and economically, and (*b*) the investment in the roads will be protected and conserved.

Maintenance costs have progressively increased since the beginning of the recent war, but principally during the last few years, and to-day costs are substantially above the immediate pre-war period. This is mainly due to the higher costs of carrying out an equivalent volume of work compared with previous periods, but is also the result of higher speeds and heavier loads of motor vehicles, the lag (due to war causes and shortage of funds) that has occurred in modernising pavements to keep pace with the advance in motor transport. The increase in income of road authorities has, however, not kept pace with increased costs, and consequently an ever-increasing proportion of total revenue is required for maintenance purposes. The effect of this is that less and less construction, reconstruction and improvement works can be carried out; yet to reduce maintenance costs there must be a rapid advance in present rates of strengthening and reconstructing existing pavements to better types. Even with adequate facilities available, this can only be achieved by a long-range programme. In the meantime the problem is to find ways and means of providing an adequate standard of maintenance appropriate to transport needs, to preserve the enormous asset in roads and to obtain maximum efficiency in maintenance operations in order to offset as far as possible the effect of increased costs. It is a battle and must be recognised as such. It can only be won by careful study and investigation, and it provides scope for ingenuity, organisation, and inventiveness. Success will give great satisfaction.

The operation of maintenance organisation may be viewed under three headings—

(*a*) Costs.
(*b*) Revenues.
(*c*) Benefits.

Costs: Rates of wages and prices of materials cannot be controlled by the road engineer, but he can eliminate wasteful expenditure by employment of labour to best advantage, by the economic selection and use of materials, and by the organisation of the work necessary on most economical lines. Probably the most important responsibility of those concerned is the creation and maintenance of interest and pride of the individual performing the work. This is the first principle to be established in the development of efficiency. It is axiomatic that quality and expedition based on most suitable methods will produce economy, and if responsibility for these is properly placed and appreciated, then interest and pride in the organisation and in work performed is automatically established. It is not sufficient, however, to place responsibility arbitrarily. It must be established by mutual agreement where all parties accept their share of both success and failure. Without this sharing of results there cannot be the degree of co-operation that is necessary for the creation of interest and pride, and for the establishment of the first principle of efficiency. This thought, therefore, introduces a field where all concerned, from the highest to the lowest, should get to know each other, to appreciate each other's problem and to exchange ideas so that all will be seized with the reason why, when, and how work should be carried out.

Improvement of methods contains a wide field for study, ingenuity, and improvisation. Take, for example, the work ordinarily called "patrol grading." This might be brushing or light smoothing out; it might be heavy scraping or it might be scarifying and grading. In any case, the definite object is to produce and leave a surface that will protect the pavement from adverse weather, wear, and provide a smooth, hard surface for traffic. The efficiency of the work will lie in its serviceability and it is in that field that technical investigation and direction are essential. It is customary to prepare a road for re-surfacing or surfacing with tar or bitumen by correcting faults beforehand with the object of ensuring that the black top will last for its full economical life. Why then would it not be correct to apply the same principle to grading of gravel pavements with a view to making the effects of grading more lasting?

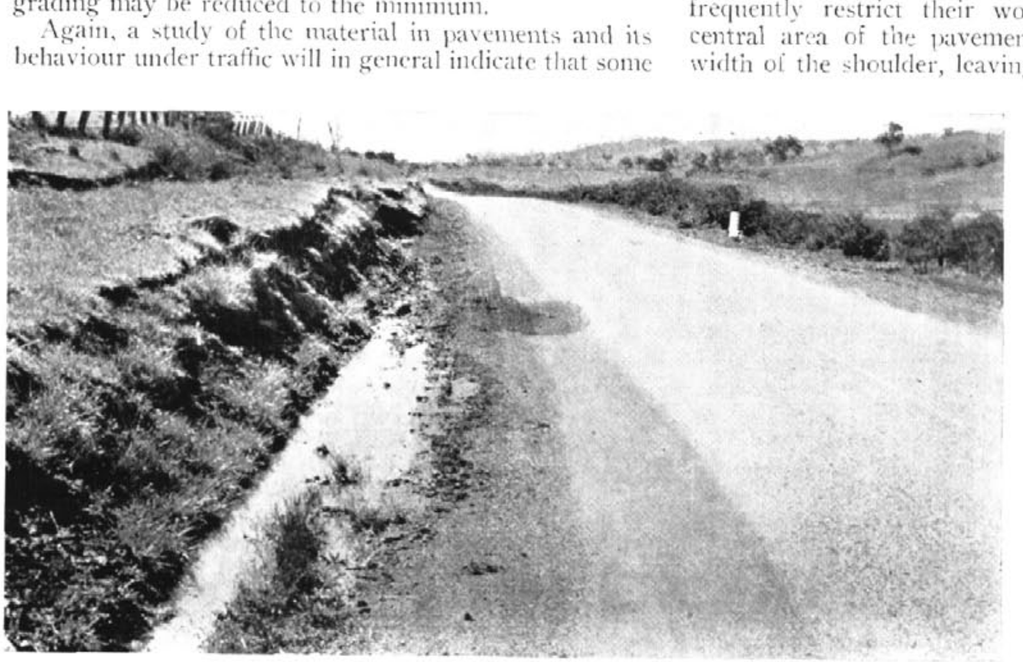
The filling of a pothole is a relatively simple matter, but unless its operation is properly regulated, its serviceability, particularly in its relation to routine grading, is lost. In the first place, it should be filled when the road is in a condition to ensure that a proper bond is made between the new material and the old. If it is not in such a condition, and the condition would deteriorate by delay, then means should be provided to make it so. Then the new material to be added should be selected to ensure that not only does it bond well with the old but will wear subsequently in approximately the same manner. Potholes should not be allowed to develop and, in particular, should be repaired immediately before grading so that, because of the better stability of the material in the pavement, the frequency grading may be reduced to the minimum.

Again, a study of the material in pavements and its behaviour under traffic will in general indicate that some sections of the road need special treatment. Curves in particular, or isolated lengths of road frequently corrugate or are susceptible to cross water scours or become raw much more frequently than other sections. They must either remain in such condition until general grading is carried out or the grader has to be brought specially to such sections at the expense of work elsewhere. In such cases the material in the pavement should be improved and the drainage system corrected in order that the whole length will wear uniformly in between grading operations, and so that the pavement will not need grading as frequently in the future as has been done in the past. During the actual work of grading, the severity of the cut to be taken can be studied to advantage before work starts, for indiscriminate grading can readily cause losses in pavement material far greater than that caused by wear and tear of traffic.

These principles apply also in the maintenance of a bituminous or bituminous-sealed road. There is no use reinstating the bitumen seal unless all failed areas are repaired and the cause of the failure is determined and eradicated.

Again, the edges of a bitumen seal are often frittered away by the action of traffic. The available width to traffic gradually dwindles, which accelerates the edge wear on the remaining width. Before resurfacing, edges should be corrected and realigned to the original width.

Another field in which costs can be regulated to advantage lies in the work carried out by plant operators. A single type of road machine is frequently designed for a range of uses, and full advantage should be taken of this range of adaptability. This is particularly the case with patrol graders which are capable of undertaking many separate operations such as the restoration of roadside drainage, clearing of refuse from shoulders, etc. Yet, at times, operators of graders frequently restrict their work to the more or less central area of the pavement and perhaps a narrow width of the shoulder, leaving roadside work not done



Failure of a patch owing to the cause of original failure having been neglected

Typical case of reduction in width of a "black top" pavement caused through neglect to maintain edges.

Damage caused by scouring because table drain and entrance to side drains were blocked when pavement was graded.

or to be carried out by other men with hand tools. This practice is both expensive and wasteful.

The surface drainage system is as important as the foundation of a pavement. An inefficient system can do more harm than traffic to a road formation, and for that reason can, if neglected, become a material contribution to the cost of maintenance. It should be in a condition to function before the need for its service occurs, and its maintenance, therefore, should be a regular performance rather than one carried out after damage has been done. Narrow drains cut by hand or "VEE" drains cut by a steeply tilted grader blade are frequently to be seen, yet it is obvious that water concentrated in this form must do damage. Such concentration is quite unnecessary, and smooth and even distribution can be achieved within and from drains by setting the grader blade close to the horizontal position when drains are being constructed or cleaned out. This field is one offering great scope for improvement of methods and reduction of costs, and it contains much interest because of the many varieties of circumstances and the employment of ingenuity and inventiveness in the solution of the problems presented.

The underground drainage system is a field of operation that has not received the attention its importance deserves. The need for such a system is usually recognised and more often than not it is established during construction, but sub-grade drains do not last forever and they must be maintained. Maintenance patrols are usually unaware that such drains exist, or, if their presence is known, the gangs have no specific record of actual location. It is a simple matter to mark location by pegs painted a distinctive colour and with this identification the maintaince of such drains can be properly regulated and the responsibility for the work kept before the notice of those concerned.

The use of materials provides an almost unlimited field for selection and use. In the first place, the best materials will, in the long run, pay dividends and it is really worth while to make extensive search for materials of good quality. If these are not available within the permissible current expenditure, then it becomes a matter for discretion whether inferior materials should be introduced or another process adopted, but never should the use of inferior material be accepted simply because a first search has failed to find anything better. In this connection sampling and testing must play an important part, for observation alone cannot and must not be allowed to become the sole responsibility for selection or the basis for use. Sampling in particular must be exact and informative, for too often the lack of information hinders the proper analysis of samples and introduces risks in the application of results.

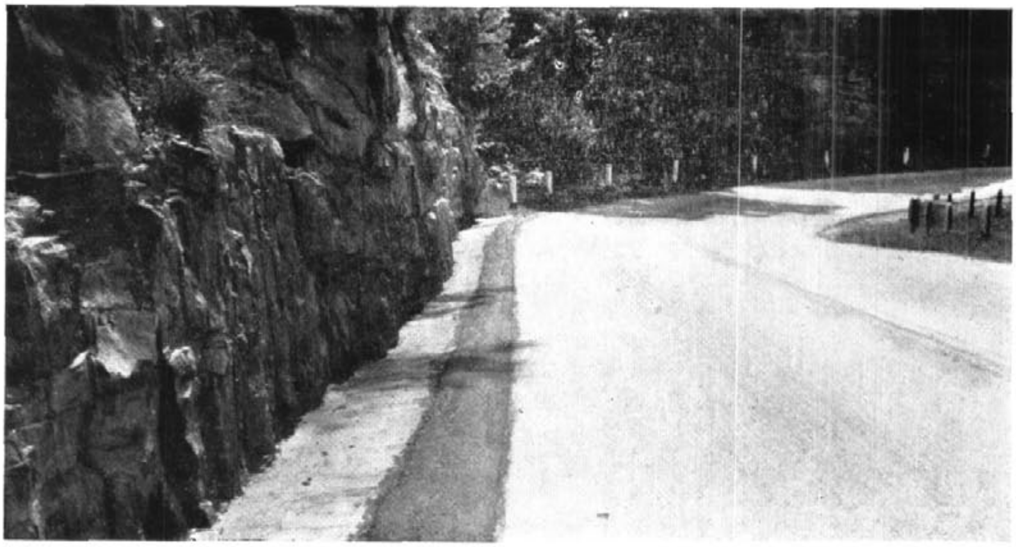
Revenues: Under the heading Revenue the ideal is reached when revenue is sufficient to meet all programmed expenditure for construction, the obligations of maintenance operations, and the remedial or replacement works which would have the effect of reducing subsequent maintenance. It is doubtful if that ideal will ever be reached and some compromise must be made in balancing the funds to be distributed between construction and maintenance. Maintenance naturally has the first call on revenues but that call should never be less than the amount required to provide the minimum standard to establish reasonable safety and economy for traffic and to preserve the investment in the road. This may introduce a new field of maintenance—one in which work may need to be carried out to delay the time when something more permanent must be done. Nevertheless, it is a field which will probably remain always, though the degree of its importance will depend upon

Illustrating a case where water is wrongly being discharged from the catch drain to the table drain, overloading the table drain, and creating liability to scour. The catch drain should have been continued behind the trees on left to discharge to a nearby watercourse.

the extent to which "Revenue" is able to balance "Costs." Naturally, it contains many dangers and pitfalls and must be handled with great care because the degree to which conservation of investment in the original pavement must be maintained becomes involved. It may be that an old black top pavement, known to require strengthening is in the state that failure in the near future is evident. If funds are not available for the work which is obviously the best technical solution, then it has to be decided whether a cheaper process would be warranted, knowing that it will not serve its normal life. The final decision in such a case must be based on whether the actual service expected to be given by the alternative process would warrant the expenditure of the finance involved and not merely on the efficiency with which it would delay the obvious work.

Benefits: In respect of the third heading "Benefits," the securing of maximum benefits from expenditure presents probably the greatest scope for the application of ingenuity and improvisation. The proper direction of work and the release of the potential energy contained in an organisation is an interesting and absorbing study in itself but it can be made more interesting by attempting something better than has been achieved previously. The avenues available cover all the known methods of work and improvement of them to give better results and it is in this field in particular that discussion or ideas can play so great a part.

Briefly the function of a maintenance organisation might well be described as the production of work of the greatest public benefit and of the greatest serviceability. It requires constant vigilance, the adoption of the right remedial measures and their execution at the right time. It requires each individual to create in himself a high interest in the work to be performed and to impart that interest to others concerned. Problems must be solved while we work and the solutions passed on to others faced with similar circumstances. In that way there will be built up strong and formidable resources, that must win the day in this "Battle of Maintenance."



Cement-grouted stone pitched Table Drains on mountain road to prevent scour.

Progress in Improvement of Coastal Highways

Post-war Works on Pacific Highway and Prince's Highway

The two great coastal highways of the State are the Pacific Highway, extending from Sydney along the North Coast to the Queensland border, a length of 592 miles, and the Prince's Highway, extending from Sydney along the South Coast to the Victorian border, a length of 342 miles.

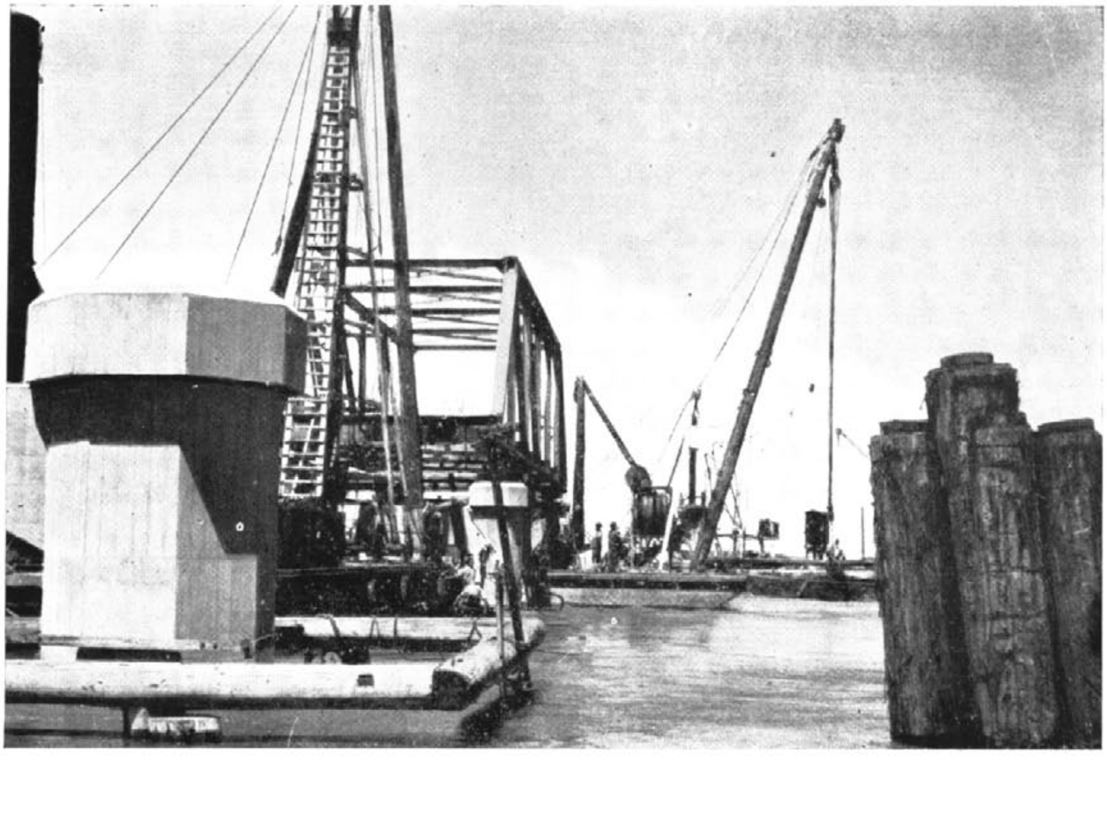
Descriptions of these highways and of the Department of Main Roads' proposals for their further improvement, were given in the March and June, 1947, issues of *Main Roads*. This article records the subsequent progress that has been made.

Road works in the post-war years involved special problems because of shortages of plant, materials, technical and other staff, and skilled labour. As the effect of these shortages has gradually eased, another and more serious difficulty has arisen due to rising costs without a corresponding equivalent increase in revenue for main roads. Expenditure on main road works, including those on the Pacific and Prince's Highways, must necessarily be limited to the revenue available. In spite of the limitations imposed by the factors mentioned, substantial progress has been made.

THE PACIFIC HIGHWAY.

Describing first the Pacific Highway, the road has previously been reconstructed with a bituminous or concrete pavement from Sydney, via Newcastle and Hexham, to Deep Creek, a distance of 138 miles.

There is one major work at present in progress on this length, namely, the construction of a bridge over the Hunter River at Hexham, to replace an existing ferry service. The work is being carired out by contract. The bridge is to comprise three approach spans at the Newcastle end and ten approach spans at the Raymond Terrace end. The main bridge consists of five 121 feet truss spans and one 124½ feet long lift span. The total length of the bridge is 1,254 feet. It will have a 22 feet wide carriageway and a 7 feet wide footway on the downstream side. Progress made includes all steelwork for the truss and lift spans together with three of the approach spans. One truss span is in position. Machinery for the lift span is being manufactured. Four piers have been completed and work on several others is proceeding.



Bridge under construction over Hunter River at Hexham. First steel truss span floated into position and being lowered on to piers.

[Photo, by courtesy of "Newcastle Morning Herald."]

Dealing with the balance of the length from Deep Creek to the Queensland border, section by section, the following describes the work in progress or completed, the mileages shown in brackets being distances from Sydney:—

Deep Creek near Booral via Stroud to Gloucester (181 miles).—This section is to be improved and surfaced with bitumen by the Councils of the Shires of Stroud and Gloucester and both Councils are now engaged on the work. A length of 9 miles between Stratford and Gloucester has been surfaced with bitumen and other completed lengths will be surfaced early next summer.

A large new reinforced concrete bridge has been constructed over the Karuah River at Booral and opened to traffic. It comprises four spans of 360 feet total length. Designs are in hand for new structures to be erected at Deep Creek, Cameron's Creek and Cromarty Creek. The three bridges will be of timber, that at Deep Creek comprising three spans of 30 feet each, that at Cameron's Creek two spans of 30 feet each, and that at Cromarty Creek three spans of 30 feet each.

Gloucester to Hillview Turn-off (223 miles).—No work is being carried out on this section at present.

Hillview Turn-off to Taree (227 miles).—The length between Hillview turn-off and Purfleet (7 miles) has recently been reconstructed and surfaced with bitumen. The short length from Purfleet to Taree was previously sealed.

Taree to Coopernook (240 miles).—Of this length, 7½ miles have been reconstructed and bitumen surfaced previously. The Council of the Shire of Manning is undertaking the reconstruction and bitumen surfacing of the remaining 6 miles, and work is in progress. One and three-quarter miles have been surfaced with bitumen recently.

Coopernook to John's River (249 miles).—Between Coopernook and Moorland, 5½ miles have previously been surfaced with bitumen. On the balance of the length, reconstruction is in progress by the Department of Main Roads, the work to be completed wtih a bituminous surface.

John's River to Heron's Creek (263 miles).—This length was previously reconstructed and surfaced with bitumen.

Heron's Creek to the Oxley Highway near Port Macquarie (273 miles).—Reconstruction of this section by the Department of Main Roads is almost complete. It is proposed to surface the pavement with bitumen during next summer.

Oxley Highway to Telegraph Point (291 miles).—This section has previously been reconstructed and bitumen surfaced.

Telegraph Point to Kempsey (312 miles).—This length is being reconstructed on a much improved alignment, by the Department of Main Roads. Work has commenced at the northern end.

Designs have been completed for two new bridges on this length, situated at Stumpy Creek and Scrubby Creek respectively. Both bridges will be of timber and each will comprise three spans with a total length of 85 feet.

Kempsey to Frederickton (317 miles).—This length was previously reconstructed and surfaced with bitumen.

Frederickton to Allgomera Creek near Eungai (338 miles).—Reconstruction of this length by the Department of Main Roads is approaching completion. Approximately half the total length has been surfaced with bitumen following on the reconstruction, and it is expected that the remainder will be surface treated by the end of June, 1950.

Allgomera Creek to Warrell Creek (345 miles).—Immediate reconstruction of this length is not proposed. Preparations are being made, however, for the work to be carried out later.

Warrell Creek via Macksville and Nambucca Heads to Nambucca (357 miles).—This length is provided with a bituminous surface.

Nambucca to the Bellingen Shire Boundary (363 miles).—Immediate reconstruction is not proposed. Preparations will be made for the work to be carried out later.

Pacific Highway. Light earthworks in progress near Eungai, between Kempsey and Macksville.

Narrow winding section of Pacific Highway 3 m. north of Telegraph Point to be reconstructed.

Bellingen Shire Boundary via Urunga and Raleigh to Repton (*374 miles*).—This length has previously been reconstructed and surfaced with bitumen.

Repton to Coff's Harbour (*368 miles*).—Reconstruction of this length passing through hilly country is approaching completion by the Department of Main Roads, and is to be followed by surfacing with bitumen. The details of the work are described in a separate article in this number of *Main Roads*. The work includes the construction of five bridges, details of which are given in the article referred to.

Coff's Harbour to Korora (*393 miles*).—This length has previously been reconstructed and surfaced with bitumen.

A new reinforced concrete bridge comprising three spans of 29 feet each has been constructed since the war over Coff's Harbour Creek on the outskirts of Coff's Harbour township.

Korora via Woolgoolga to Dirty Creek (*415 miles*).—It is proposed to put in hand the reconstruction of this length, immediately work is completed between Repton and Coff's Harbour and preparations to this end are in hand.

Dirty Creek, via South Grafton and Maclean to Mororo (*477 miles*).—This length has been reconstructed previously. The pavement has a bituminous surface except for about 10 miles east of Grafton which is cement concrete.

Designs have been prepared for a new bridge over Bom Bom Creek about 6 miles south of Grafton to replace a worn-out timber bridge. The work will be undertaken shortly by the Department of Main Roads by day labour. The bridge will be of reinforced concrete and will comprise four spans of 35 feet each.

Mororo to 9 Miles South of Woodburn (*493 miles*).—It is proposed to commence the reconstruction of this length as soon as resources are available. Preliminary action is in hand.

Woodburn to the Queensland Border (*592 miles*).—From 9 miles south of Woodburn to the Queensland border the entire length of the Highway has a bituminous or equivalent surface. There are several short lengths of temporarily unsealed road where reconstruction is in progress.

The Woodburn Shire Council has completed recently a deviation 3 miles north of Woodburn to eliminate two right angled bends and the Tintenbar Shire Council has commenced the preparation for surfacing with bitumen a deviation of some 2¼ miles at Tintenbar, constructed in the early years of the war to improve alignment and avoid areas subject to flood.

Since the war a new reinforced concrete bridge over Byron Creek at Bangalow has been built by contract. Deviation in approach to the bridge is now being constructed by Byron Shire Council.

At Fern Vale, just south of Murwillumbah, there is a deviation over a length of 4.3 miles, partly constructed before the war, which remains to be completed and surfaced with bitumen. This work has not yet been put in hand, pending the completion of new bridges at either end of the deviation, which are necessary to make it fully effective. Of these bridges, one, that over Dunbible Creek, has been completed and the other over the North Coast Railway is under construction.

Other post-war bridge works in progress include a reinforced concrete bridge over Burringbar Creek at Burringbar (563 miles north of Sydney), comprising five spans of 40 feet each, and a subway under the North Coast Railway near Crabbe's Creek built to eliminate a level crossing.

THE PRINCE'S HIGHWAY.

Before the war, the Prince's Highway had been reconstructed and provided with a bituminous surface continuously from Sydney to Bateman's Bay, a distance of 174 miles. The only work of significance completed on this length since the war is the construction of a reinforced concrete bridge over Millards Creek at Ulladulla, 142 miles south of Sydney. The bridge comprises two spans of 35½ feet each. There is at present under construction a reinforced concrete bridge at Toubouree Lake, 150 miles from Sydney. This comprises six spans of 32½ feet each.

The Prince's Highway, from Bateman's Bay to the Victorian border, is 168 miles in length. The following describes, section by section, the work in progress or completed, the mileages shown in brackets being distances from Sydney.

Bateman's Bay to Moruya (191 *miles*).—A commencement with the reconstruction of this length to the end of the existing bituminous surface about 2 miles north of Moruya was made prior to the war, but work did not progress very far. Since the war, the reconstruction of the entire length has been completed. The work passes through rough country, and was described in the issue of *Main Roads* of March, 1948. Approximately half the length has now been provided with a bitumen surface, and the balance will be surfaced as practicable.

A large steel truss bridge, with opening span, is being constructed across the Clyde River at Bateman's Bay. It will consist of two approach spans at each end of 62 feet each, five truss spans of 121 feet each, and one lift span with 75 feet vertical and horizontal clearance—a total length of 948 feet. The work is being carried out by contract, and full details were given in issue of *Main Roads* of March, 1948.

A new reinforced concrete bridge comprising three spans of 38 feet each is under construction by the Department of Main Roads over Jerramandra Creek, about 7 miles south of Bateman's Bay.

Moruya to Bodalla (206 *miles*).—The reconstruction of this length is at present in hand by the Department of Main Roads. When the work is completed, the length will be surfaced with bitumen.

Just north of Bodalla the Highway crosses the Tuross River. A contract has been let for a new bridge at this site, the bridge comprising two approach spans at each end of 35 feet each and four truss spans of 121 feet each. Further details of this bridge were given in the issue of *Main Roads* of March, 1948.

A temporary rolled steel joist bridge with timber deck consisting of 23 spans with a total length of 805 feet was built by the Department of Main Roads over the Moruya River, following on the loss of the old bridge by flood.

Bodalla via Narooma to Corunna Lake (225 *miles*).—The ultimate location of the Highway throughout

Heavy reconstruction on Prince's Highway south of Bateman's Bay.

A section of Prince's Highway between *Brogo River* and Allsop's Creek near Bega after construction and bituminous surfacing.

this length is under consideration following aerial surveys, and detailed surveys and plans are in hand so that construction work may be commenced immediately after the completion of work north of Bodalla.

Corunna Lake to Tilba (230 *miles*).—This length was constructed before the war, and will be surfaced with bitumen following strengthening of the pavement.

Tilba-Cobargo (243 *miles*).—With the exception of a short length between Central Tilba and Tilba Tilba, this length was reconstructed before the war, and has recently been surfaced with bitumen.

Cobargo to Brogo River (257 *miles*).—The reconstruction of this length has recently been begun by the Department of Main Roads.

Brogo River to Allsop's Creek (260 *miles*).—This length along the gorge of the Brogo River was reconstructed before the war by the Department of Main Roads. It has recently been surfaced with bitumen.

Allsop's Creek to Bega (269 *miles*).—Survey investigation is proceeding on this length, with a view to determining the route finally to be adopted.

Bega to Wolumla (282 *miles*).—This length was constructed some years ago, and has recently been surfaced with bitumen to Frog's Hollow Bridge, approximately 7 miles south of Bega.

Wolumla to Merimbula (290 *miles*).—Three miles of this length immediately north of Merimbula are at present being strengthened, together with a short piece of regrading and realignment, with a view to surfacing with bitumen.

Merimbula via Eden to Victorian Border (342 *miles*).—No recent work has been undertaken on this length.

GENERAL.

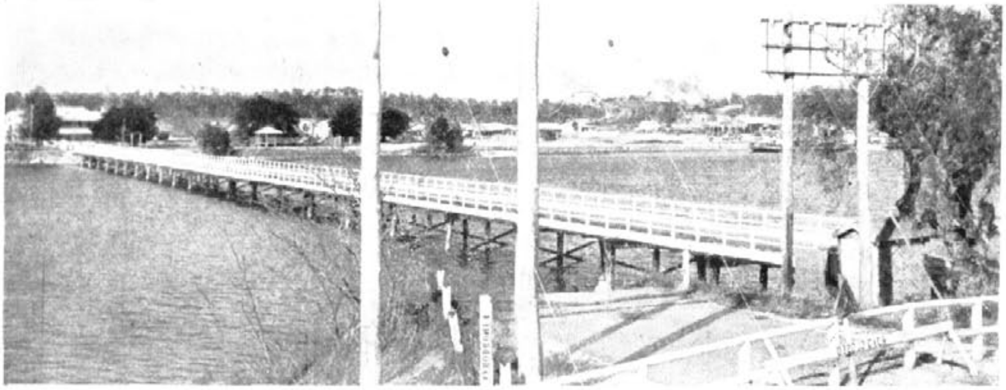
The hilly nature of much of the country along the New South Wales coast renders road-making especially costly on both the Pacific and Prince's Highways.

While these roads link Sydney with Brisbane and Melbourne respectively, the inland highways, *i.e.*, the Hume Highway and the New England Highway, are regarded as the principal interstate links because they are shorter, and on this account and because of the nature of the country they pass through, permit of faster travel.

Both the North and South Coasts are becoming increasingly popular for holidays and for tourist travel. It is largely past improvements on the Pacific and Prince's Highways that have made this possible. For example, a considerable number of people from Queensland spend their holidays on the New South Wales far North Coast, which is not served by direct rail connection with Brisbane.

While holiday resorts have been actively developing on both North and South Coasts since the war, there are still many attractive coastal areas almost untouched by development. The further improvement of the coastal highways now being undertaken is going to increase the number of persons choosing these routes for long distance travel, or selecting coastal resorts for holidays.

Apart from the tourist industry, however, both North and South Coasts have a solid economic foundation based mainly on the dairying, timber and fishing industries, with bananas and sugar cane also on the North Coast. The improved roadways will thus be of considerable benefit to the local residents and business people.



Temporary Rolled Steel Joist Bridge with Timber Deck over Moruya River, built to replace old bridge destroyed by flood.

The Department of Main Roads is putting its principal constructional efforts at present into the reconstruction and bituminous surfacing of those lengths of the Pacific and Prince's Highways not already up to the required standard. The rate at which the work can be carried out is necessarily dependent on the funds available, and the needs of other parts of the main roads system. Each extension of bituminous surfacing tends to create a greater contrast between the older lengths and the newer, and public attention tends to be concentrated on the less favourable travelling conditions on the older lengths. The maintenance of the older lengths is difficult due to climatic conditions, the generally poor nature of the local road-making materials, and the increasing weight and volume of traffic, but the councils concerned and the Department of Main Roads are making every effort to maintain these lengths to the best advantage pending their reconstruction.

PAYMENTS FROM THE ROAD FUNDS FOR PERIOD 1st JULY, 1949 to 31st MARCH 1950.

	Amount Paid. £
County of Cumberland Main Roads Fund—	
Construction of Roads and Bridges	530,448
Acquisition of Land and Buildings for Road Widening	22,715
Maintenance of Roads and Bridges	424,017
Interest, Exchange and Repayment of Loans	67,879
Other Expenditure	76,140
Total	£1,121,199
Country Main Roads Fund—	
Construction of Roads and Bridges	944,301
Acquisition of Land and Buildings for Road Widening	12,500
Maintenance of Roads and Bridges	1,758,395
Interest, Exchange and Repayment of Loans	121,394
Purchase and repair of Plant and Motor Vehicles	255,304
Other Expenditure	142,579
Total	£3,234,473
Developmental Roads Fund—	
Construction of Roads and Bridges	123,970
Other Expenditure	1,424
Total	£125,394
Summary All Funds—	
Construction of Roads and Bridges	1,598,719
Acquisition of Land and Buildings for Road Widening	35,215
Maintenance of Roads and Bridges	2,182,412
Interest, Exchange and Repayment of Loans	189,273
Purchase and Repair of Plant and Motor Vehicles	255,304
Other Expenditure	220,143
Total	£4,481,066

United States Highway Practice

Extracts from a report by C. A. Hawkins, B.E., M.I.E., Aust., Deputy Chief Engineer, following a visit to the United States in 1949. Mr. Hawkins attended a course in American Highway practice, conducted by the U.S. Bureau of Public Roads, as a result of an invitation extended to Australia to send representatives. The course covered all aspects of highway engineering and administration. The lectures were given by leaders in various phases of highway work. Following the lectures, visits were paid to a number of States to inspect recent developments in engineering practice.

HIGHWAY PLANNING RESEARCH.

Highway Planning Research in its present form commenced in the United States of America about 1935. Earlier highway activity had been directed towards completing the initial stage of construction of all highways. When this initial stage construction had been substantially completed and reconstruction of the highway system commenced, it was considered necessary first to establish the facts regarding the following:—

(*a*) What existed on all roads, *i.e.*, a physical inventory of road conditions and traffic.

(*b*) Traffic behaviour.

(*c*) Financial aspects of what was being undertaken.

The 1934 amendment of the Federal Aid Roads Act provided for the expenditure of 1½ per cent. of State apportionments on Highway Planning Surveys, and by 1940, surveys had been undertaken in all States.

The physical inventory of what existed on the road comprised:—

(i) Collection of information in regard to type, length and location of all existing rural roads.

(ii) Counting, classification, and weighing of all traffic.

The recording and mapping of this information is now a continuous operation by all State Highway Departments.

Research was also initiated into the functional and organic aspects of highway traffic movement. This research covered highway capacity studies, motor vehicle performance studies, and design required for groups of vehicles as opposed to design for individual vehicles.

In connection with the financial aspects of what was being undertaken, information was available in 1935 as to expenditure on the various phases of Highway activity, such as construction, maintenance, engineering and administration, etc., but, as average age of pavement was low, information as to road life was meagre, although it was known that some roads were wearing out physically and functionally.

Since 1938, information has been recorded by the Bureau of Public Roads and by certain of the States as to the average service life of the different types of road surfaces and other elements of the highway.

Federal Aid Road projects are all numbered for each State, and the project number allocated to a certain length of highway is maintained indefinitely no matter how often that section is subsequently reconstructed, so information as to the life history of individual types of road surface or other highway element on any particular project can be readily determined.

All the foregoing studies relate essentially to rural roads. Studies undertaken more recently have been urban traffic studies in the form of Origin and Destination Surveys to determine the desire lines of travel in connection with the design of urban freeways.

Preparation of Highway Maps.—In many States, there are no maps available similar to the maps produced by the Lands Department in New South Wales and the general highway maps produced in connection with the Highway Planning Surveys were necessary as a first stage in the Inventory. The maps, as produced, had the advantage that they were essentially for highway purposes and showed all types of development, which would be traffic generators, *e.g.*, town halls, racecourses, baseball parks, residences, etc.

In some States the detailed maps show individual residences in relation to improved roads, to aid in the selection of roads to be included in the Federal Aid Secondary system. Other maps may be prepared to show traffic densities. Diagrams have also been prepared on lines suggested by the Bureau of Public Roads, giving the horizontal and vertical alignment of all rural highways.

Traffic Counts.—Traffic volume counts are carried out with machines on a sample basis which is expanded to give annual figures.

For example, the State of South Carolina, with a population of approximately 2,000,000, has:—

(*a*) Ten fixed installations at which continuous records are kept throughout the year giving hourly, daily, weekly, monthly and seasonal variations. Eight of these units are cathode ray tube electric recorders and the other two magnetic field type recorders.

(*b*) One hundred and twenty control stations operated by portable pneumatic electric hourly

Four-lane divided highway with depressed median and flattened slopes in cutting. Median and sides of cuttings are grassed.

recording traffic counters, giving hourly variation for one week in each season of the year, *i.e.*, spring, summer, autumn, winter.

(*c*) Coverage stations using hourly recording and cumulative recording instruments, as necessary for all other traffic count stations in the State, with measurement for forty-eight hours

A small team, ten employees, is engaged full time on this work:—

One man in the field looks after the ten permanent stations and the 120 coverage stations.

Four men in the field are employed on the coverage count stations, each man being responsible for sixty-five to seventy instruments.

Five officers are employed in the office dealing with the traffic survey data when received.

The information is scheduled manually and then recorded on punch cards, from which the information available can be scheduled in whatever form may be required.

Such a count may not be required in such detail again for about ten years.

In North Carolina (with a population of 3,000,000 and a bigger organisation) a trained team is used continuously on classification and weight and measurement counts.

Origin and Destination Surveys.—The most generally adopted method is the "area sampling" type of survey. The procedure is as follows:—

(i) Determine travel into the city from rural areas by a cordon of stations around the city.

(ii) Collect results for traffic generated within the city by interview on 1/10th or 1/20th basis.

The record sought is always that of trips made on the previous day (always a week-day). Interviews, both internal and external, extend over several months and, therefore, are a composite of the traffic over a period of months.

Another method is by "post-card" interview, as used for Columbus, Ohio, and the surrounding Franklin County, where a questionnaire was sent out by mail to each motor owner for details of trips made the preceding day. The information obtainable was more limited and could not be checked as well as information obtained on an "interview" basis, and depended also on the availabiltiy of a split-up of motor vehicle registration into reasonably small zones, as was available in Columbus, Ohio.

A compromise between the "mail questionnaire" and the "interview" method is to select residences in zones on a 1/10th basis and post questionnaires to the householders. Interviews are made only where the reply to the questionnaire is unsatisfactory.

A further reduction in the work involved in Origin and Destination Surveys has been tested by the Californian Division of Highways. Two different 2 per cent. samples from a 10 per cent. interview were selected to determine desire lines of travel in Sacramento, and it was found that there was so little to choose between the two that it was considered that, subject to check from time to time, very small samples could be used to give indication of traffic movement.

Construction Costs.—Records have been maintained by the Bureau of Public Roads for many years for twenty-five major items of construction, comprising:—

Excavation	4 items.
Sub-base	2 items.
Steel	3 items.
Base Course	3 items.
Surfacing	6 items.
Structural	3 items.
Pipe culverts	4 items.

These items represent 71 per cent. of all money expended on Federal Aid construction. The information is submitted from the field immediately tenders are opened. Contractors are required to report cost of fifteen major material items, representing 90 per cent. of expenditure on materials and man-hours of labour and total wages.

Information prepared from these figures and published regularly is as follows:—

(*a*) Schedules for the whole of the United States for the current quarter, giving price trends.

(*b*) Construction cost index based on typical (composite) mile of road construction (30 per cent. excavation, 50 per cent. surfacing (concrete), 20 per cent. structural).

Maintenance Costs.—Maintenance cost trends are obtained on approximately 19,000 miles of representative Highway sections. Each State selects about twenty sections for study, so selected that each section is uniform throughout its length in age, type, thickness and width of surface, and in each case, reconstruction is not anticipated for a number of years. Detailed costs are kept in accordance with a standard form supplied by the Bureau of Public Roads. These costs are then used to determine the annual cost of maintenance and operation of a composite 10,000 miles of State Highway, from which the maintenance cost Index is determined.

Sufficiency Ratings.—Highway sufficiency rating, as a method of determining projects to be included in annual programmes, was first developed in some of the western States in collaboration with the Bureau of Public Roads, and while further refinement of the present method of rating may be necessary, it offers a reasonable means of arriving at the relative urgency of various projects.

Three aspects are considered in a general survey for sufficiency rating. These, together with weighting of the various elements, are as follows:—

(*a*) Condition Rating:—Surface 16, Drainage 10, Shoulders 4, Major Structures 4, Minor Structures 2, Roadside 2, Traffic Service 2. Total, 40 per cent.

(*b*) Service Rating:—Horizontal alignment 12, Passing sight distance 8, Surface Width 5, Rideability 5. Total, 30 per cent.

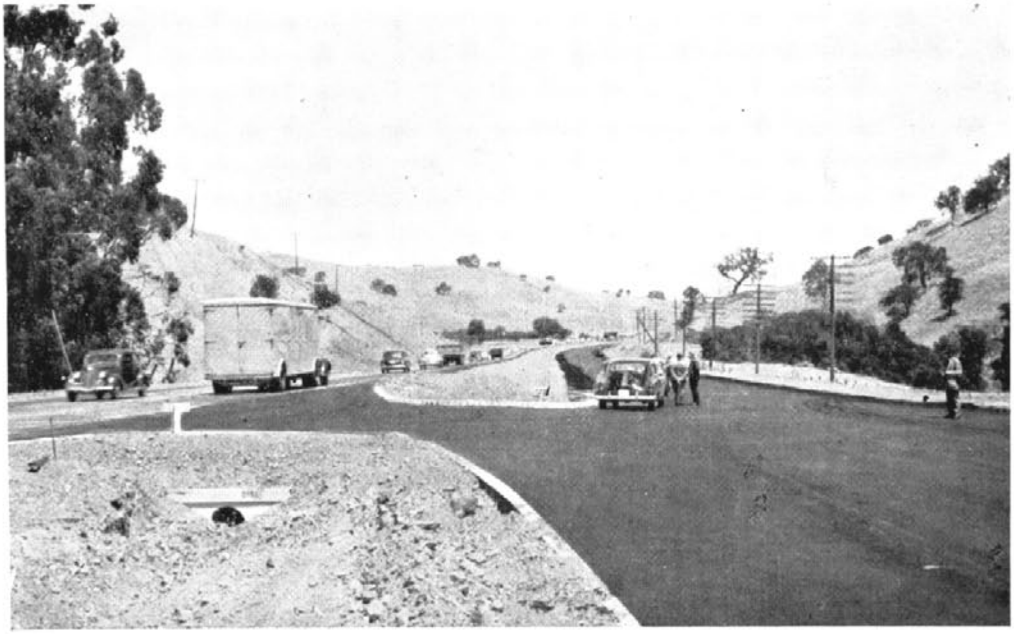
(*c*) Safety Rating:—Shoulder width 8, Consistency of alignment 5, Surface width 7, Stopping sight distance 10. Total, 30 per cent.

To arrive at the sufficiency rating, the A.A.S.H.O. standard for each section of highway is taken as a yardstick. Rating is based on personal judgment, but it is found that rating is remarkably consistent.

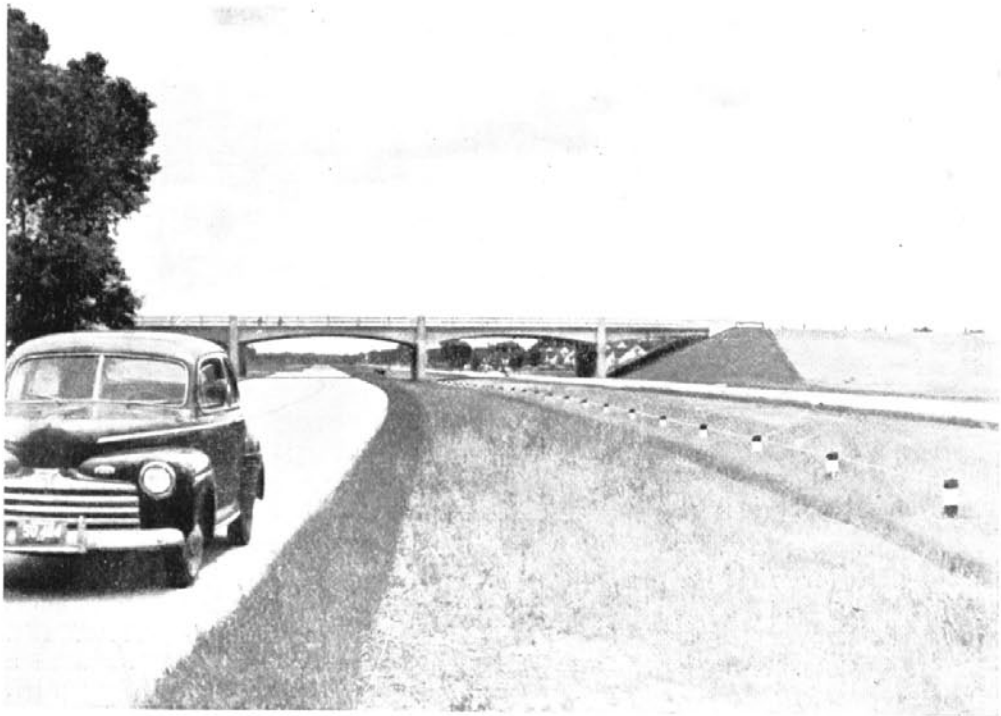
GEOMETRIC DESIGN.

Rural Design (Two-lane Highways).—Rural Highways in U.S.A. are divided by the Bureau of Public Roads into Federal Aid Primary, Federal Secondary, and non-classified or tertiary highways.

The volume of the traffic carried by many of the Federal Aid Primary Highways is much in excess of that on rural roads in New South Wales, except in the immediate vicinity of the larger cities.



Four-lane divided highway with depressed median. Kerbing at ends of median provide for turning movement.



Four-lane divided highway with grade separation. Shoulders and bottom of depressed median are turfed and intermediate area seeded and mulched.

For example, the State of Indiana is at present engaged in the construction of a four-lane divided Highway from La Fayette to Indianapolis, a distance of 61 miles. This is required to cope with a traffic volume of between 3,500 and 5,000 vehicles per day, which is not uncommon on major rural highways in the more populous States. On these highways, ruling grades of 3 per cent. and very large radius curves are being used.

In the case of American roads carrying traffic comparable with that in New South Wales, *i.e.*, the less heavily trafficked Federal Secondary roads and the tertiary roads, the standards of alignment and grading do not vary materially from those in use here. However, there are three practices in rural highway design in the United States of America which are applied to design of highways at relatively low traffic volume, and have not so far generally been adopted in Australia:

Grade separation on four-lane divided highway under construction.

Arterial street with frontage roads and bus stopping place clear of through traffic.
[Photo, by courtesy of Bureau of Public Roads, U.S.A.

Arterial street with wide median. Storage bay for left turning traffic.
[Photo, by courtesy of Bureau of Public Roads, U.S.A.

(*a*) *Extra lanes for truck traffic on steep grades, particularly at crests.* These lanes are used as an alternative to reducing grade and increasing sight distance at crests.

(*b*) *Wider pavements* (up to 24 feet) for the more important two-lane rural highways. This width has been determined as a result of detailed studies carried out by the Bureau of Public Roads to determine the width necessary for comfortable passing of trucks. It not only provides comfortable passing for trucks but results in saving in maintenance of shoulders.

(*c*) *Flattened slopes* (maximum 3 to 1) on batters in cuttings and side slopes of fills. Flatter slopes have been advocated and justified on the basis of aesthetics, but American highway engineers are satisfied that, in many circumstances, they can be justified on the basis of economics.

In States with good natural pasture growth, every effort is made to encourage the growth of grass on the slopes, and the flatter slopes not only assists in the growth but, if kept at 3 to 1 or flatter, permit of the mowing of the slopes with power machines. Expenditure on mowing is considered much cheaper in the long run than expenditure on anti-surface erosion measures and constant building up of shoulders. In consequence, most eastern States spend relatively large sums on mowing. One State spends as much on mowing as on all other routine maintenance work. In States where conditions are not suitable for good pasture growth, the slopes are kept flat in order to establish low shrub growth. In the State of Washington the slopes of a series of deep cuttings in earth were covered with "Broom" which had been planted in rows on the contours in order to mitigate erosion of the slopes.

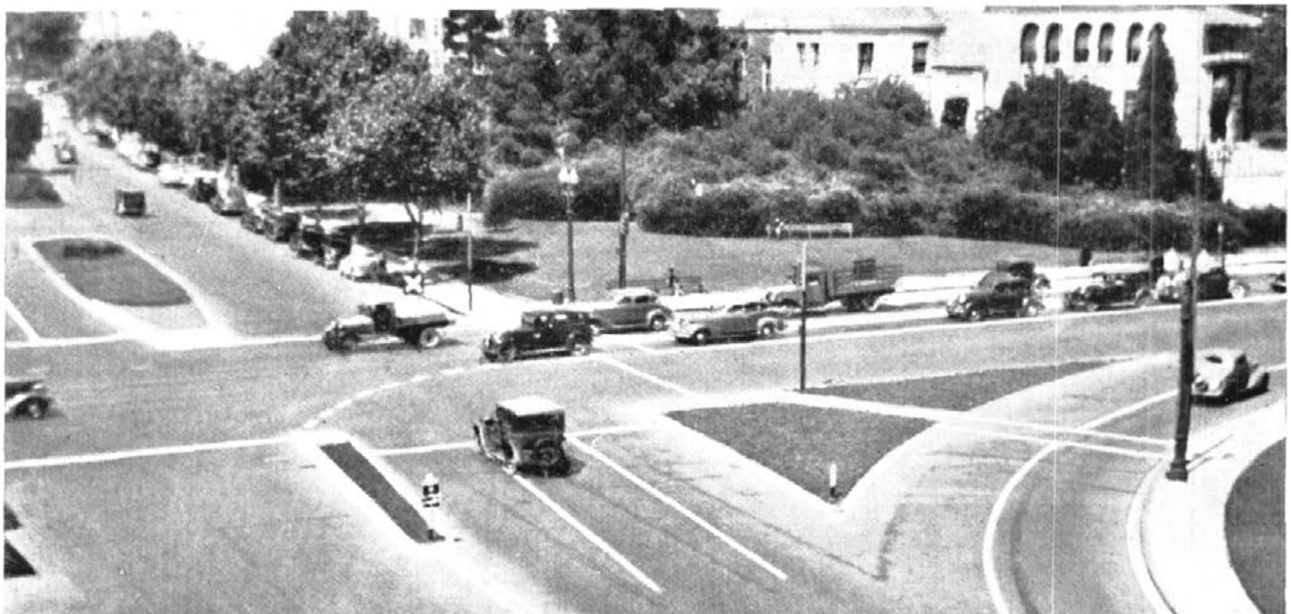
Rating of Rural Designs.—In addition to the normal rating of designs by the Bureau of Public Roads on the basis of traffic and design speed, a useful rating adopted for two-lane highways is the percentage of the highway which has a passing sight distance for 50 m.p.h. As the result of observations made during research into actual traffic movement, it has been determined that on the highest speed roads, only 5 per cent. of vehicles overtaken are travelling at over 50 m.p.h. (actual speed measurement, not speedometer readings). Therefore, the availability of sight distance for passing at 50 m.p.h. is a criterion of the capacity of the highway. This criterion exists irrespective of the nominal speed design standard, as most vehicles being passed will be accelerated to 50 m.p.h. whenever there is sufficient sight for passing at that speed.

Availability of passing sight distance is not only directly related to practicable capacity, but it is also, in consequence, related to safety, particularly with two-lane roads carrying heavy holiday and week-end traffic.

One interesting approach to the problem of providing adequate passing distance seen in California on more heavily trafficked two-lane highways was the provision of a section of approximately one mile of four-lane divided highway at five to ten mile intervals.

Rural and Suburban Design (Four-lane Highways).—Four-lane highways recently constructed and at present under construction are, with few exceptions, divided highways. Except in heavily built-up areas where the right-of-way is restricted, the present tendency is towards depressed median strips, 30 feet to 50 feet wide, with the preference to as wide a median as can be reasonably obtained.

Much four-lane construction is being undertaken, with the existing two-lane highway forming one of the pair of two-lane sections for the time being, and construction being confined to the median zone and the second of the pair of two lanes.



Arterial street—channelised intersection.

(Photo. by courtesy of Bureau of Public Roads, U.S.A.

The majority of four-lane divided highways are being built with the cross sectional levels symmetrical about the mid-point of the median strip, but in some States, the levels of each half of the divided carriageway are determined in relation to the natural surface without reference to the levels of the other half width, and there is no doubt that aesthetically the result is a great improvement.

One disadvantage of the depressed median strip is its lack of definition at intersections, and this is being met in California by construction of a rolled over kerb section to the median strip for 100-300 feet either side of the intersection. This kerb is also designed to facilitate traffic movement (see Fig. I).

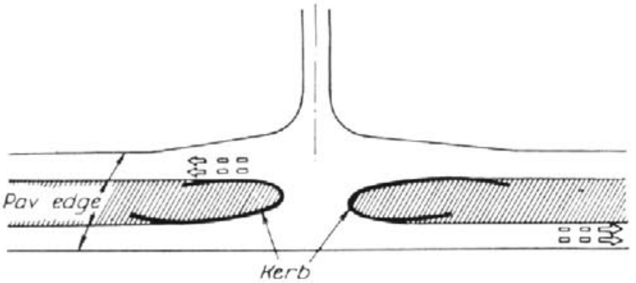
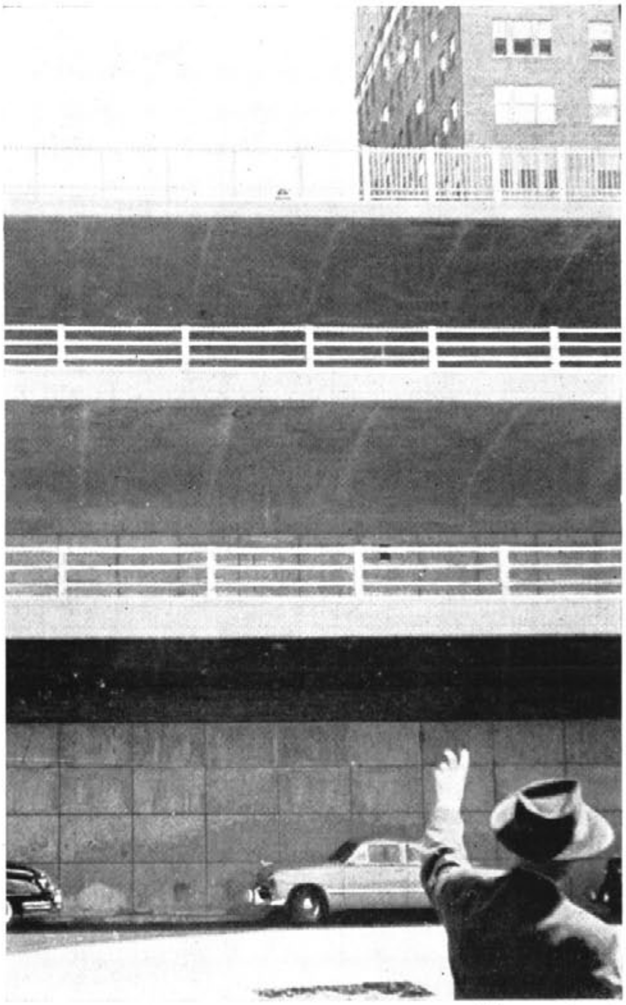


Fig. 1. Plan showing low kerb provided in depressed median at side road, California.

Urban Design.—It is in the sphere of urban design that the greatest development has occurred in American practice in recent years. While rural highways are not yet regarded as adequate, they conform much more closely to a tolerable standard than do urban highways. Also, with the appreciation of the highway transport problem as one of the flow of motor traffic en masse rather than a series of individual movements, and the much greater impediment to the free flow of motor traffic in city areas by comparison with rural areas, there has come a greater concentration of effort on the part of highway engineers in America on the urban aspects of highway design.

Much has been heard of the more spectacular "freeway" designs, but considerable advance has also been made in the design of arterial streets and expressways at grade, particularly in regard to intersections. These may comprise anything from a relatively minor improvement of an intersection, to major improvements such as that at present in progress in Washington, D.C., at the Dupont Circle, where the main traffic movement in Connecticut Avenue is being taken underground through the Circle, including a separation underground of the tram and motor traffic, at a total cost of about 2,000,000 dollars.

Arterial Streets.—As this description covers the lowest form of urban highway (continuous route), there is usually no control of access, all intersections are at grade, and the only practical alteration to the geometrical layout is by extending and enlarging intersections and channelization treatment. Other improvements to traffic flow are provided by marking all traffic lanes where there is sufficient width for four or more traffic lanes and by light signals at principal intersections.



Urban expressway with opposing traffic at different levels. Designed to reduce width required for right of way.

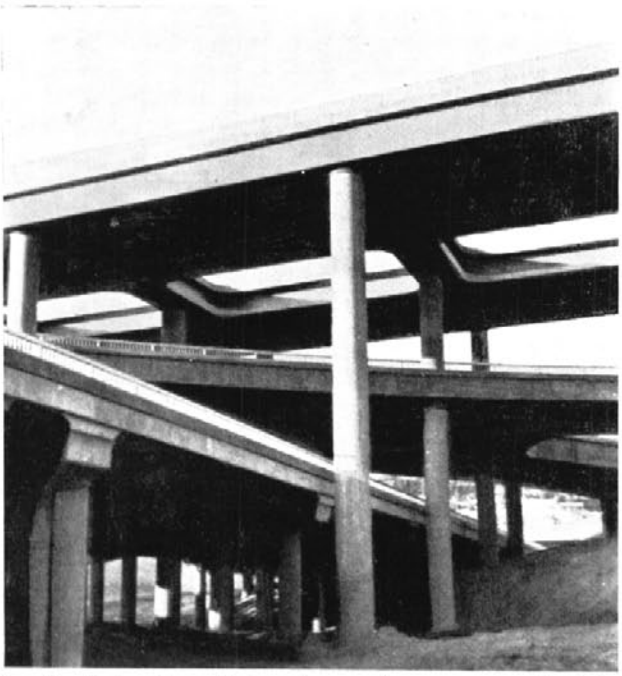
Expressways at Grade.—These highways are regarded as an intermediate type of facility, and while freeways are usually necessary in the larger cities, in the small cities an expressway at grade will often be the most important type of road.

Special provision made for improvement of traffic flow in connection with expressways at grade are:—

(*a*) Partial control of access.
(*b*) Median strips.
(*c*) Exclusion of parking lanes.
(*d*) Shoulder space for disabled vehicles.
(*e*) Provision of channelization and speed change lanes.

Freeways.—With completion of proposals for freeways in the majority of the larger cities in U.S.A., freeway location in relation to the down town area of large cities has been seen to conform to a fairly uniform overall pattern. The high priority arterials are radial routes which join to form a distributor road around the central hard core of the city.

By examination of origin and destination surveys, it is found that, while a very small proportion of the



Four-level structure designed to reduce area required for grade separation intersection of two urban expressways.

traffic passing through a city under average conditions can be provided for by a by-pass, a large proportion of the traffic moving within a city can be dealt with by an expressway passing through the city but being diverted around the central core of the down town area.

Much of the freeway construction to date has not been truly urban in character, having been built in suburban rather than urban areas, and as construction extends further into the cities, it is being found that the capacity of the freeways is being controlled by the ramps and the capacity of the adjoining streets to take the traffic entering and leaving the expressway.

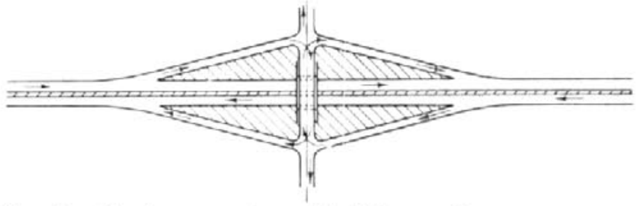


Fig. 2. Grade separation with "Diamond" pattern ramp.

Fewer full clover-leaf intersections are being built owing to the space required for this type of development, and more use is being made of modified cloverleafs, the "diamond" ramp pattern (see Fig. 2) and structures with two and three deck levels.

In the detailed design of ramps, it has been found that separate deceleration lanes are not as useful as anticipated, and that it is necessary to provide a sufficient length of deceleration on the turn-out after the vehicle has left the expressway.

From observation, separate acceleration lanes are not used to any great extent by traffic entering freeways, but it is considered that they constitute a safety measure, and at period of peak capacity allow vehicles to merge safely into the line of expressway traffic.

In preparing layouts of ramped intersections, it is found that the most satisfactory way to lay in the ramps both in plan and for grading (drainage) is to work in smooth curves with plastic splines and calculate the curvature corresponding to the alignment thus determined.

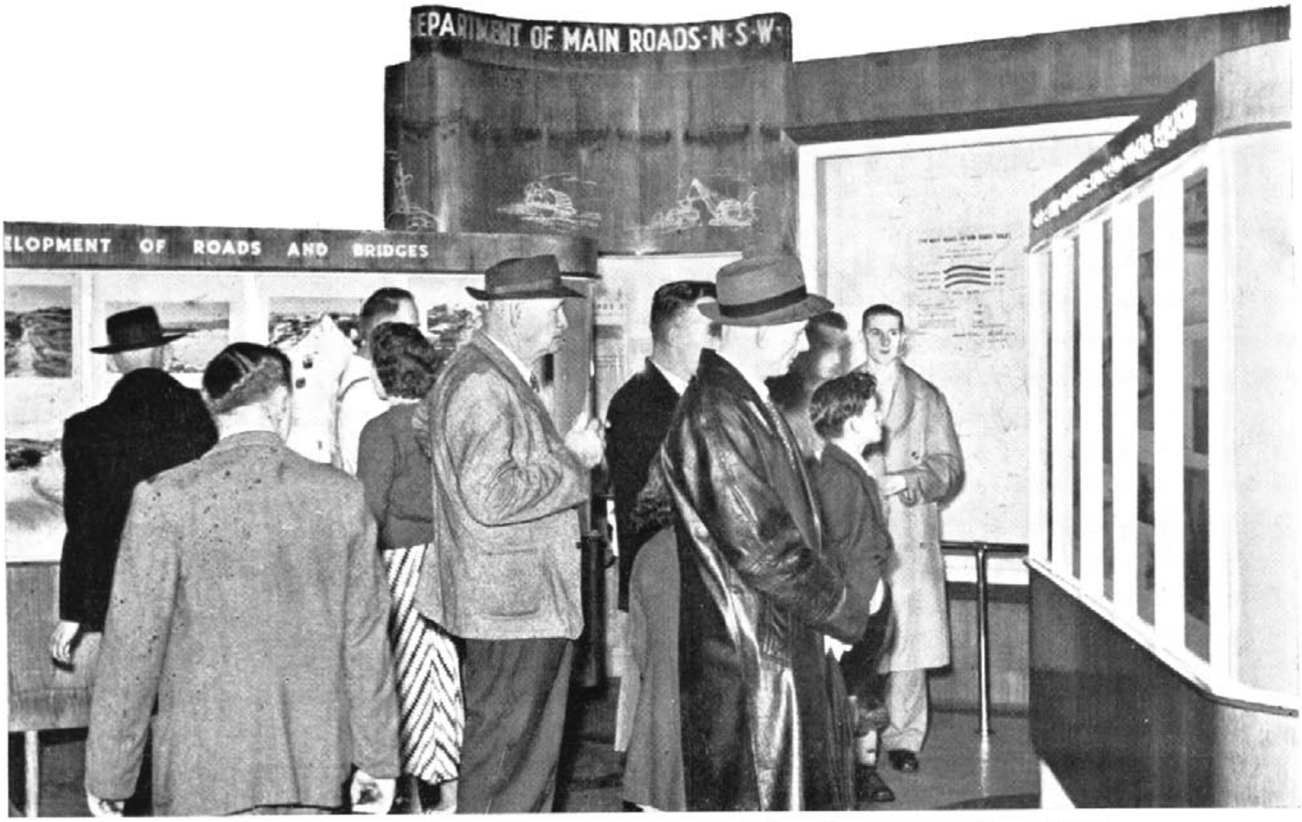
(To be continued.)

Main Roads Exhibit

SYDNEY ROYAL EASTER SHOW, 1950

An exhibit was displayed by the Department of Main Roads at the Royal Agricultural Society's Easter Show, 1950. It had for its theme the completion of twenty-five years' work under the Main Roads Act. A modelled relief map of the State of New South Wales showing the main roads system in colours formed the central feature. This was flanked by display cases in which were shown typical cross sections of various classes of road pavement, statistical data in pictorial form, and the Department's journal "Main Roads." This was supplemented by two island structures on which were diplayed coloured illuminated photographs illustrating the development of roads and bridges during the past twenty-five years, the changes that have occurred in vehicles and road building equipment, developmental roads serving country areas, and safety furnishings and works on main roads.

The exhibit was seen by many thousands of visitors to the Show, and evoked considerable interest. It was apparent, from the numerous inquiries which were made, that the display made a material contribution towards informing the public of the Main Road activities of Municipal and Shire Councils and the Department.



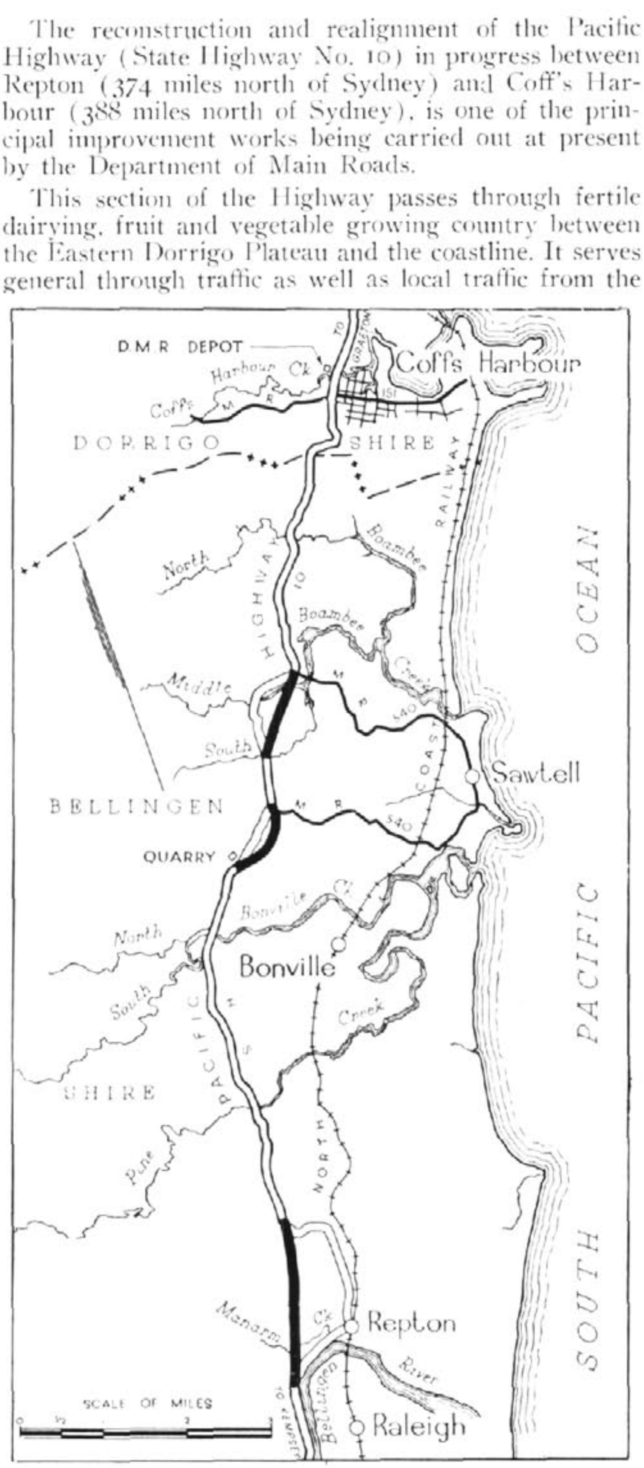
Views of Department of Main Roads Exhibit at Sydney Royal Easter Show, 1950.

Reconstruction of Pacific Highway

Repton to Coff's Harbour Section

The reconstruction and realignment of the Pacific Highway (State Highway No. 10) in progress between Repton (374 miles north of Sydney) and Coff's Harbour (388 miles north of Sydney), is one of the principal improvement works being carried out at present by the Department of Main Roads.

This section of the Highway passes through fertile dairying, fruit and vegetable growing country between the Eastern Dorrigo Plateau and the coastline. It serves general through traffic as well as local traffic from the Dorrigo Plateau and the rich Bellingen River flats to the port of Coff's Harbour. The traffic density varies seasonally from 150 to 300 vehicles per day.



Before reconstruction commenced in November, 1946, this portion of the Highway consisted of a narrow gravel pavement with numerous sharp horizontal and vertical curves, with poor visibility.

Design.—The new work has been designed with alignment and grades suitable for 50 m.p.h. speed. The horizontal curves have a minimum radius of 700 feet and the maximum grade is 8 per cent. Formation width is 28 feet. The pavement will be 20 feet wide and bituminous surfaced.

The sharp curves of the old Highway will be eliminated, and the length decreased by approximately 1¾ miles, mainly by three major deviations, of which the longest, near Repton, is 2¼ miles long.

The Repton-Coff's Harbour area has an average annual rainfall of 65 inches, mostly in the summer months. As numerous large and small creeks cross the Highway, many drainage structures are required. One timber bridge and four reinforced concrete bridges are being constructed over the larger creeks, and box culverts and concrete pipe culverts at smaller watercourses. The heavy rainfall and the nature of the subgrade have necessitated the provision of extensive subsoil drainage.

Depot and Camp.—Prior to beginning the construction works, a site for the main depot was selected about half a mile north of Coff's Harbour, on the Pacific Highway, and a site for a construction camp about 5 miles south of Coff's Harbour.

An office, store, single staff quarters, four married staff quarters, fuel store and a workshop have been erected at the depot, which will be used also in respect of other work to be undertaken later north of Coff's Harbour.

Earthworks.—Earthworks will total 241,000 cubic yards or approximately 19,000 cubic yards per mile. The materials excavated have varied from clay to hard shales, 12 per cent. being rock necessitating drilling and blasting, and 19 per cent. requiring ripping before moving.

The major items of plant being used on earthworks are:—

- One 110 h.p. tractor with trailbuilder attachment.
- One 130 h.p. tractor, with either 8-10 cubic yard scoop or trailbuilder attachment.
- Two 70 h.p. tractors, with either 6-8 cubic yard scoop or trailbuilder attachments.

Reconstructed section of Pacific Highway, 3 m. from Coff's Harbour, showing heavy earthworks.

Motor lorries of 5 cubic yards capacity, used for long hauls and loaded in loading docks by bulldozer.

It is anticipated that all earthworks will be finished by the spring of 1950.

Pavement.—The pavement of the reconstructed Highway will consist of:—

(*a*) A shale sub-base of 6 inches consolidated thickness.

(*b*) A bitumen surfaced crushed stone base course of 4 inches consolidated thickness.

(*c*) A surface course, to be constructed later, of premixed bituminous macadam, 1 inch consolidated thickness.

Shale, from pits adjacent to the Highway with an average haul of 3 miles, has been won by tractor with bulldozer attachment loading over a dock into tipping trucks of 5 cubic yard capacity.

After tip-spreading on the formation, the shale has been trimmed by power grader, rolled with drawn cleated roller to break up large pieces, and consolidated by grading, watering and traffic.

The shale sub-base has been used as a temporary pavement to carry traffic pending construction of the base and surface courses. To prevent dust, a light tar flush seal coat has been applied on the shale, consisting of H.6.3 grade coke-oven tar applied at the rate of 0.2 gallon per square yard, covered with sand at the rate of 1 cubic yard per 150 square yards.

The base course is being constructed as follows:—

(i) Four inches consolidated thickness of 2½ inches-1½ inches gauge crushed stone, filled with ½-inch-3/16-inch screenings and crusher dust, waterbound, on the three major deviations, from which traffic can be diverted during construction.

(ii) Four inches consolidated thickness of 2½-inch-1½-inch gauge crushed stone, filled with ½-inch-3/16-inch screenings without dust, lightly penetrated with 0.5-0.75 gallon per square yard of H.100 tar, on the remaining lengths where traffic has to be carried on the road during construction. Penetration with tar is to prevent ravelling of the base course by traffic pending the application of a bitumen seal coat.

Quarrying.—The stone being used is obtained from a quarry near Bonville, centrally situated as regards the work, and about a quarter of a mile from the Highway. It is a hard silicified blue shale, fine grained, difficult to drill, and very abrasive on the jaws of crushers.

The quarry face has a width of 120 feet and a depth of 40 feet. Clearing of heavy scrub timber and removal of clay overburden of an average depth of 4 feet were necessary. Drilling is by pneumatic drills controlled either by tripod mount, waggon mount, or hand. The use of waggon-drills is mainly confined to horizontal drilling for "lifter" shots in the toe, as rugged conditions at the top of the face preclude the use of waggon-drills there.

Tungsten carbide tipped rock bits are being used in all drilling. Experiments are being carried out with respect to life of bits, drilling speed, durability of stem steels, and effect of stem-taper. Though final results may not be given at this stage, an average life of 100 feet per bit has been obtained at this quarry, and an average cutting speed of 2½ inches per minute.

Clearing on Repton Hill Deviation.

Explosive used has been gelignite AN-60 at the average rate of ½ lb. per cubic yard solid of rock excavated.

Spalls are loaded from the quarry floor into lorries by a bulldozer operating over a loading ramp and dock. The lorries haul the spalls to the crusher, which is set up in a sheltered position about 600 feet from the quarry face.

Crushing.—A portable plant consisting of primary jaw crusher and secondary roll crusher with vibratory screen is used, with a trommel screen independently powered, interposed between the primary and secondary crushers. The output of the primary crusher, which is set to 2½-inch opening, is passed through the trommel screen, which passes material smaller than 1½-inch to the secondary crusher, and 2½-inch to 1½-inch material direct to bins, the oversize being returned for re-crushing.

The stone pasing 1½-inch trommel screen is chuted to a ¾-inch or ½-inch opening vibrating screen. Rejects from the screen are passed through the roll crusher and returned by rotary elevator and belt conveyor to the vibrating screen, this being repeated until all material passes ¾-inch. Material passing the latter is separated on a 3/16-inch opening vibrating screen into "passing 3/16-inch" and "retained 3/16-inch" sizes, and discharged by belt conveyor to bins or lorry as required.

The crushing unit has a rated output of 25 cubic yards per hour, with a maximum of 40 cubic yards per hour. The maximum produced in this quarry in an eight-hour day has been 220 cubic yards—all sizes.

The estimated requirements of crushed stone are as follows:—

2½"-1½" gauge—21,500 cubic yards.
½"-3/16" gauge—7,500 cubic yards.
¾"-3/16" gauge—5,000 cubic yards.
Total—34,000 cubic yards.

Structures.—Details of the four new reinforced concrete bridges built or in course of construction are:—

(i) *Middle Boambee Creek.*—This bridge, which is on a deviation, was completed in October, 1948, and has four 30-feet simply supported spans. The piers consist of concrete piles and headstocks, and the abutments are of the anchor beam type founded on piles.

(ii) *Pine Creek.*—The new bridge over Pine Creek, completed in February, 1950, is 12 feet higher than the old timber bridge. Traffic was often blocked at the old Pine Creek Bridge after heavy rain, as the water level frequently rose to the handrails of the bridge, and sometimes higher.

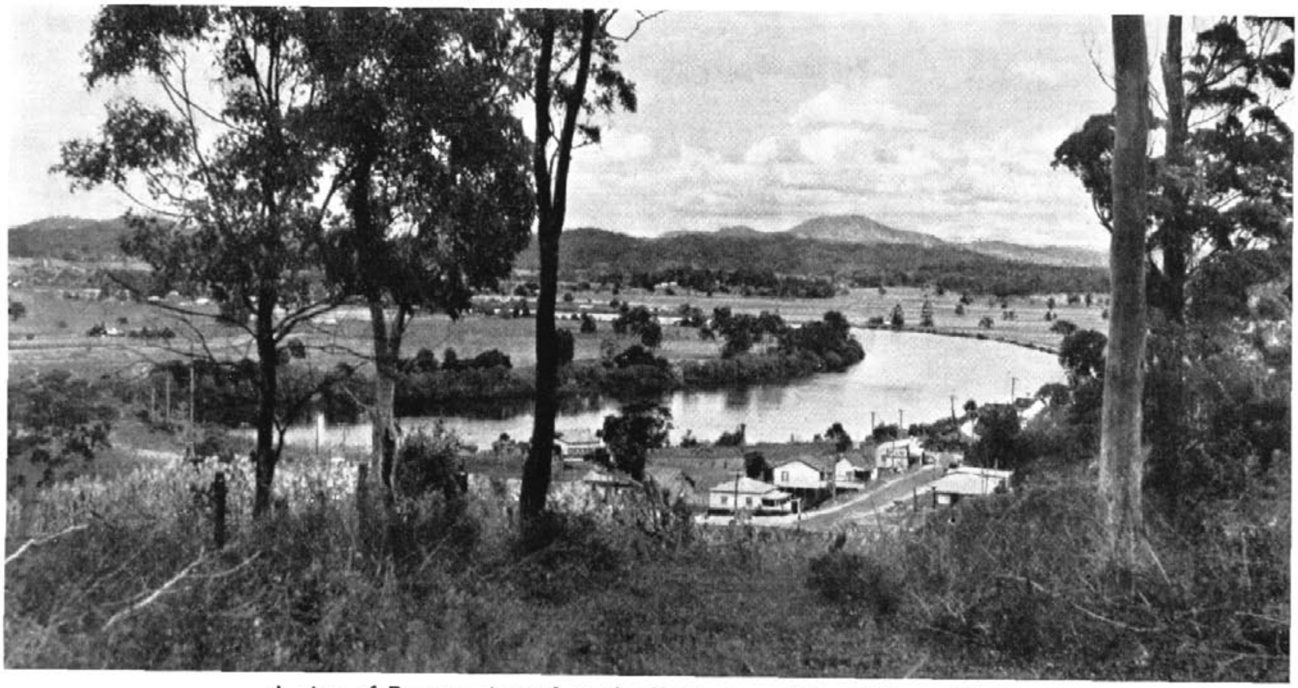
The new bridge has three 40 feet 8 inches simply-supported concrete spans on piers consisting of frames resting on piles. Abutments are of anchor beam type, also founded on piles.

(iii) *Man Arm Creek and Man Arm Creek Overflow Channel.*—These bridges near Repton are on the longest of the three deviations. The bridge over Man Arm Creek has seven 36-feet spans, whilst the bridge over the flood channel to the south has four 36-feet spans. The spans on both bridges are simply supported on piers of concrete piles and headstocks, with spill-through abutments.

One timber bridge has been built over the flood channel of South Boambee Creek, and a timber overbridge at Bonville is to be commenced shortly.

Seven reinforced concrete box culverts, each of 7 feet x 3 feet, have been built, the largest having eight cells. Sixty-seven precast reinforced concrete pipe culverts, ranging in size from 15-inches diameter to 60-inches diameter, are being used for minor streams and general drainage. In several cases large multiple concrete pipe culverts have been used in lieu of box culverts, because of shortage of the steel reinforcement for box culverts.

Clearing and Grubbing.—Heavy clearing and grubbing have been necessary in traversing a State Forest near Repton. The Forestry Commission recovered marketable timber before clearing operations commenced. Clearing was done by bulldozer or by tractor and wire rope. Trees with 9 feet to 15 feet girth and up to 200 feet high were frequent, and digging and root-cutting were necessary in many cases before felling.



A view of Repton, situated on the North Arm of the Bellinger River.

Provision for Traffic.—This has been difficult and expensive, due to the frequent interference between the old alignment and the new. During excavation operations it had been necessary in many places to provide a temporary pavement. The clay subgrade and heavy rainfall would otherwise make side tracks impassable to wheeled traffic.

Quantities of Work (Estimated).

Earthworks—Clay and medium and soft shales, 211,000 cubic yards; hard shales requiring drilling and blasting 30,000 cubic yards (solid measurement)—241,000 cubic yards.

Pavement—

Shale base course, 6 inches—185,490 square yards.

Waterbound macadam, 4 inches (laid on deviations only)—40,260 square yards.

Crushed stone with light surface penetration with tar, 4 inches thick (laid on other than deviations)—110,800 square yards.

Premixed bituminous macadam levelling course, 1 inch, with bituminous seal coat—151,060 square yards.

Concrete pipe culverts—Sizes 15 inches to 60 inches diameter—3,090 lineal feet.

Concrete in box culverts—570 cubic yards.

Subsoil drains—20,000 lineal feet.

Fencing—boundary post and wire (new)—58,300 lineal feet.

Fencing—remove and re-erect post and wire—25,650 lineal feet.

Unit Costs for Main Items of Work in Hand or Completed.—(Direct costs only, exclusive of Workers' Compensation Insurance, Pay Roll Tax, Holidays, Camp,

A section of the highway between Repton and Coff's Harbour prior to reconstruction, showing winding nature of the old road.

New reinforced concrete bridge on concrete piles over Middle Boambee Creek.

Depot, Engineering Supervision and Clerical Costs. Unit costs shown are for completed items and items substantially complete.)

Earthworks, including trimming and consolidation (solid measurement)—3s. 3d. per cubic yard.

Pavement—Shale base course 6 inches consolidated thickness—2s. 1d. per square yard.

Concrete pipe culverts, including concrete headwalls—Average for all sizes—£1 16s. per lineal foot.

Concrete in box culverts (excluding reinforcement and excavation)—£8 11s. 6d. per cubic yard.

Fencing—Boundary post and wire (new)—£5 2s. per 100 lineal feet.

Fencing—Remove and re-erect post and wire—£5 per 100 lineal feet.

Supervision.—This work is being carried out under the supervision of the Department's Divisional Office at Grafton and Local Office at Coff's Harbour.

The general supervision of the reconstruction was carried out by Mr. S. W. Down until May, 1947, and thereafter by Mr. A. G. Scott-Findlay, successive Divisional Engineers at Grafton.

The engineers directly in charge of the work at the Coff's Harbour Local Office have been, in succession, Messrs. T. S. Hope and G. B. Welch.

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for period 1st July, 1949, to 31st March, 1950.

Income.	£
Road Tolls	323,586
Contributions—	
Railway Passengers	93,805
Tramway Passengers	9,235
Omnibus Passengers	8,628
Rent from Properties	9,265
Miscellaneous	168
	£444,687

Expenditure.	£	£
Cost of collecting road tolls		20,436
Maintenance and minor improvements		55,749
Alterations to archways		4,696
Administrative Expenses		1,523
Loan Charges—		
Interest	180,750	
Exchange	20,250	
Sinking Fund	51,750	
Management Expenses	975	
		253,725
Miscellaneous		859
		£336,988

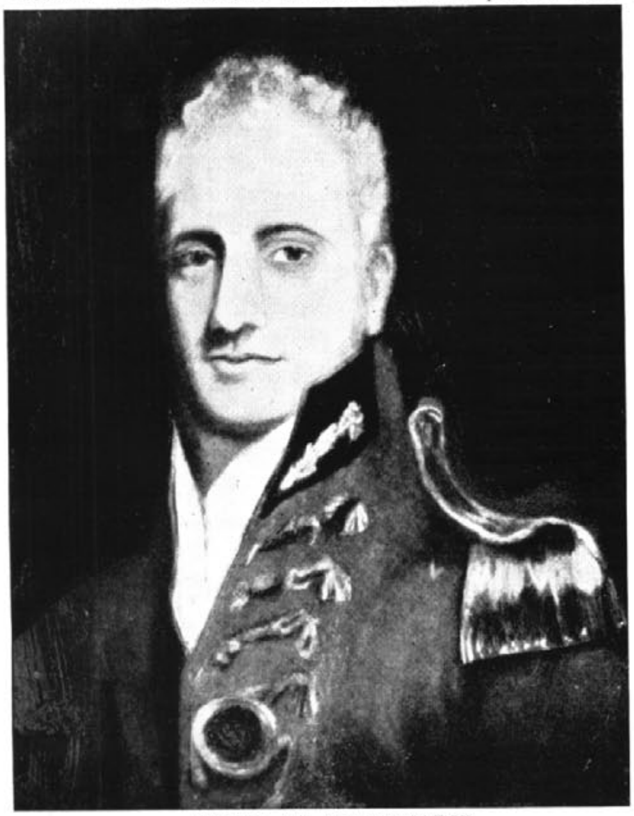
Miles and Milestones

Lachlan Macquarie's systematic erection of numerous permanent public works during his term as Governor of New South Wales (1810-1821) was the public avowal of his private belief that the colony was the beginning of a new corner of Empire. To him is usually attributed the credit for the erection of the first milestones in New South Wales.

The word "milestone," with its essential association with roads and travel, seems to exude an aura of old-world romanticism. In early times, when foot, horseback and horse-drawn carriage were the modes of travel, the milestone was an eagerly awaited record and friendly guide to the traveller. To-day, route maps, adequate signposts, and the speedometer have rendered the traveller by motor vehicle more or less independent of milestones in their original role. However, the need for maintaining and improving the roads has given milestones a new and important part to play. Though they still serve the traveller, they also provide clearly defined reference points along the roads, and are used to indicate readily the precise position and extent of any work that is to be done on the roads.

THE MILE.

"Mile," a terrestrial measure of length, is derived from the Latin "mille," meaning a thousand, and the Roman mile consisted of one thousand paces, each of five Roman feet. The pace was the distance covered in marching from the point where one foot was lifted from the ground till the same foot came down again. 11.65 to 11.62 inches constituted the Roman foot, so that the Roman mile was less than the English mile by from 142-144 yards.



LACHLAN MACQUARIE.
Governor of New South Wales, 1810-1821.

The English mile was borrowed with some latitude from the Romans. Before the time of Elizabeth, scientific writers made use of a mile of 5,000 English feet, *i.e.*, 12 inches to the foot, from the notion that this was the Roman mile, forgetting the difference in value between the English and Roman foot. However, there was no regularity and it was quite common for an individual district to have its own local mile.

During the reign of Elizabeth, the growth of London proceeded with such rapidity that an Act was passed to prohibit building within three miles of the city; this law necessitated the definition of a legal mile. The perch, the oldest English linear measure, had been defined by statute as 5½ yards. In defining the mile it was enacted that 40 perches constituted a "furrow-long" or furlong, and 8 furlong were a mile. The Act to prohibit building within three miles of the city was not generally applied, but the Post Office adopted the 8-furlong mile in the reign of James I (1603-1625).

The introduction of the measured mile was due to John Ogilby, Cosmographer to Charles II. The instrument, "wheel-meter," he used for measuring was a tape ten miles long mounted on a wheel, which was pushed forward by one man while another read the distances.

The eight-furlong mile was not legalised until the general Act for the Establishing of Uniform Weights and Measures in 1824.

ROMAN MILESTONE.

The custom of placing milestones on the roads in Europe was begun by Caius Gracchus (154-120 B.C.). Plutarch tells us "he divided all the road into miles of near eight furlongs each, and set up pillars of stone to mark the divisions. He likewise erected other stones, at proper distances on each side of the way, to assist travellers who rode without servants, to mount their horses."

A typical Roman milestone was of cylindrical form, standing above the ground 6 or 7 feet, and having a diameter of nearly two feet. It was generally inscribed with the name of the Emperor in whose reign it was erected, and the mileage. The Romans called milestones "milliarii lapides." The initials "M.P." (mille passus) placed on the posts stood for "mile."

On page 128 is a reproduction of a Roman milestone now standing on the Capitol in Rome, but which originally stood on one of the highways radiating from the city to mark the first mile. The rest of the inscription refers to the Emperors Vespasian and Nerva by whom it was successively restored.

Roads in general received little attention after Caius Gracchus until Augustus Caesar (63 B.C.—14 A.D.) undertook a thorough repair of the road system. He paid from his own purse the cost of reconstructing the Via Flaminia, the great North Road from Rome to Arminium (modern Rimini) on the Adriatic Sea. Great roads—"viae Augustae"—were laid everywhere.

Roman milestone which marked the first mile from Rome.

To ensure more timely repairs in future, Augustus in 20 B.C. created a permanent board of "curatores viarum," who were made responsible for the maintenance of the main highways. He commemorated his formal appointment as head commissioner of all roads by placing a pillar covered with gilded bronze in the Forum near the temple of Saturn, with the distances of all the chief places along the great roads measured from the thirty-seven city gates from which these roads branch out.

Milestones were erected in nearly every province of the Roman Empire. There are not many extant in England, as in later times they were often broken up to fill pot holes in the road. Central pillars, in imitation of the "milliarium aureum" in the Forum at Rome, were often set up in the large provincial cities.

The oldest Roman milestone known in England was found on the Foss Way two miles from Leicester in 1771. It was of cylindrical form resting on a quadrangular base. Still decipherable on the stone was the fact that it was erected in A.D. 120 in the reign of Hadrian.

A milestone found near Aber, in North Wales, was 6 feet 7 inches high and 19 inches in diameter. On it was inscribed: "The Emperor Caesar Trajanus Hadrianus Augustus, high priest, possessed of the tribunition power, father of his country, consul for the third time. From Kanovium eight thousand paces."

The practice of placing milestones died out in Britain after the Romans. Although signposts were erected in the Middle Ages, for they were recorded in 1598, and as being especially good in Lancashire in 1695, milestones were only re-introduced about 1720. They were later made compulsory by various turnpike Acts, including those of 1744, 1766 and 1773. Milestones and the penalties imposed upon persons injuring them are mentioned in the reign of George III (1760-1820).

MILESTONES IN NEW SOUTH WALES.

The exact date of the erection of the first milestones in New South Wales is not available in the early records of the colony, but the indications point to a date between 1814 and 1816.

The first milestone at the south-east corner of George and Liverpool Streets is inscribed on the northern side "Parramatta XIV miles" and on the southern side "1 Mile from Macquarie Place." At one time the stone was much larger, but time and misadventure reduced its size and destroyed its original shape. In 1903 the stone was removed and recut, in the process of which it was made much smaller. This stone stands as a reminder of the days when the town of Sydney clustered chiefly near the water's edge; when Liverpool Street was the cross road leading to and from Surry Hills.

The credit for the making of the first milestones in the colony belongs to Edward Cureton. In the Police Fund Quarterly Account, ending 30th September, 1814, stands the entry, "Edward Cureton for Fifty-four milestones. £40 10s. 0d."

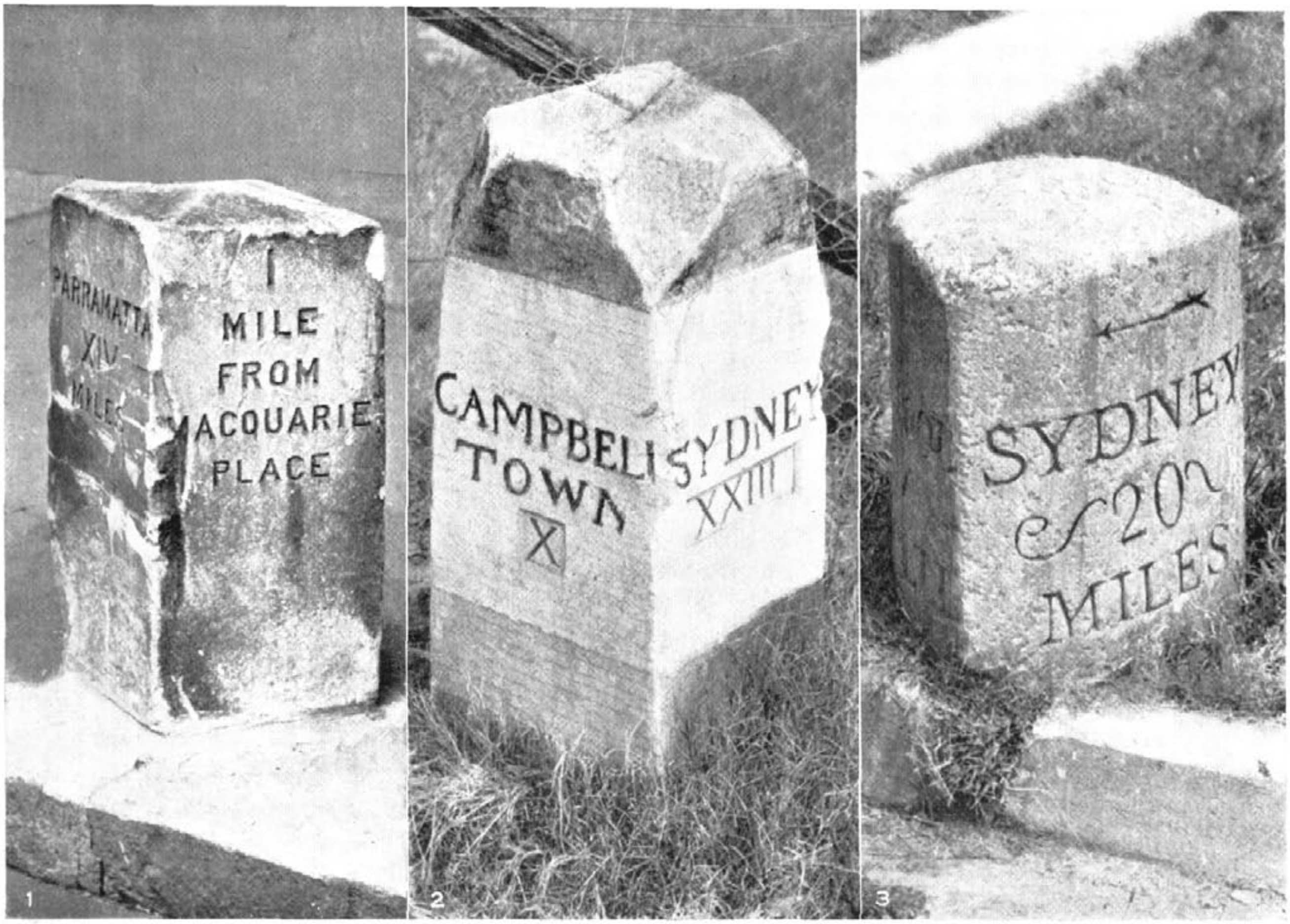
By 1816 milestones had been laid along the Parramatta, Liverpool and South Head Roads. These dignified monuments, however, were not proof against local vandals whose mischievous behaviour in altering the Roman numerals became so serious as to occasion a public notice that "several of the milestones which were some time since erected by the Government for the public use and accommodation along the New Roads leading from Sydney to the Interior . . . having been of late wantonly and mischievously defaced and injured, it is hereby publicly notified that any Person who shall hereafter break, deface or injure any of the Milestones on the said Roads will be prosecuted according to the Law and on Conviction severely and exemplarily punished." (*Sydney Gazette*, 26th October, 1816.)

On the Great Western Road beyond Penrith mile marking was simultaneous with construction. Cox's journal, written at the time of building the road, reveals the system of mile-marking he used. His entry for 27th July, 1814, reads, "measured the ground from the ford in the river to the creek leading from Emu Plains to the mountain, three miles, marked the trees at the end of each mile at the left side of the road." Wooden mileposts were later erected on this road west of Penrith.

In 1818, to acknowledge that New South Wales had ceased to be a settlement and was beginning to be a country, Governor Macquarie set aside "an allotment of ground in the centre of the town, named Macquarie Place, enclosed with a dwarf wall and wooden railing; planted with shrubbery and having a stone obelisk erected in the centre of it, to measure the distances in miles to all the different settlements in the interior of the country." ("Report on the Colony of New South Wales in July, 1822"—L. Macquarie.) This obelisk, which is illustrated on the front cover, still stands in Macquarie Place.

On 20th October Edward Cureton was paid an advance sum to erect the obelisk which was to cost "eighty-five pounds sterling" and "to be completed within six months from this date, according to the plan and elevation delivered to the Contractor" (Macquarie's Journal, 19th September, 1816.)

Francis Howard Greenway, architect of many of the first public buildings in the colony, designed this, the first decorative column in the country.



TYPICAL OLD MILESTONES.

1. On south-eastern corner of George and Liverpool streets, Sydney.
2. On Hume Highway between Liverpool and Crossroads.
3. At intersection of Elizabeth and George streets, Liverpool.

FRANCIS HOWARD GREENWAY.
Designer of obelisk in Macquarie-place, Sydney.

On one side of this "very handsome stone obelisk" (Macquarie's Journal) is inscribed:—

This Obelisk
was erected in
Macquarie Place
A.D. 1818.
To Record that all the
Public Roads
Leading to the Interior
of the Colony
are Measured from it
L. Macquarie Esq.
Governor

On the other side:—

Principal Roads.
Distance from Sydney to Bathurst 137 Miles.
From Sydney—
To Windsor 35 ½ Miles.
To Parramatta 15½ Miles
To Liverpool 20 Miles.
To Macquarie Tower at the South Head 7 Miles.
To the North Head of Botany Bay 14 Miles.

Ultimately milestones, many of which are still extant, were erected on the Great Western Road as far as Penrith, on the Windsor Road from Parramatta to Windsor, on the South Head Road, on the Southern Road (now the Hume Highway) to Liverpool and on the Liverpool-Campbelltown Road.

Historic monument outside Liverpool Railway Station serves as memorial to Captain Cook and as a milestone.

By 1846 the milestones on Parramatta and Liverpool Roads had apparently fallen into complete disrepair for in the *Sydney Gazette* of September, of that year, tenders were called "for such number of milestones as may be required for erection on the Parramatta and Liverpool Roads." The contract was to include the "lettering and placing in such positions on the Parramatta and Liverpool Roads as may be pointed out by

Typical milestone on the roadside 8 miles from Campbelltown towards Crossroads.

the Surveyor in charge of roads." The tender of Michael McCormack was accepted and the work executed.

The proposed erection of new milestones in 1846 reawakened a question which had first been raised in 1839 by James Raymond, Postmaster-General at the General Post Office, who had suggested to the Surveyor-General that the Penrith and Windsor Roads should be shortened by having them measured from the General Post Office as a commencing point instead of the Obelisk, which was not a central point. There is no record of definite action from this proposal, but in 1846 the Deputy Surveyor-General, S. A. Perry, again raised the matter as a result of which the change from the Obelisk to the General Post Office was approved by the Governor. That the change was effected is evident from the fact that the second and succeeding old milestones on the Parramatta Road are 2,000 feet west of their correct positions in relation to the Obelisk.

The erection of milestones on the Liverpool-Campbelltown Road in 1854 had a special significance which is noted in the *Sydney Morning Herald*, 4th November, 1854: "The Commissioners of the Road Trust are using every means in their power to speedily repair the roads under their charge, and as they proceed are placing milestones between Liverpool and Campbelltown . . . making the starting place an obelisk of about 12 feet high and similar to the one in Macquarie Place in the city of Sydney." The Commissioners consented and the work was carried out. On the square part of the obelisk is engraved the distance between Campbelltown and Liverpool and on the top:—

"To the Memory of Captain James Cook, R.N., the discoverer of New South Wales, born at Marton, Yorkshire, 27th October, 1728, and killed at the Sandwich Island, 14th February, A.D. 1779."

The obelisk, which originally stood at the corner of George and Moore Streets, now stands outside the Liverpool Railway Station.

The disposition of the old milestone was reviewed by the Department of Main Roads, when instituting its own system in 1934. It was at first proposed that these historic stones, monuments of mason's work in the early days of the colony, be incorporated in the new system of mileposting. Upon investigation it was found that the existing milestones were incomplete and inconsistent. In most cases the information on the stones, due to alterations and deviations of the roads, was found to be inaccurate and the stones seemed too old to stand up to alterations of position and lettering. In addition some of the old milestones were being used by the Department of Lands as survey marks and could not be removed to new locations. Consequently none of the old milestones except the first one at the corner of George and Liverpool Streets was incorporated in the new system.

In the case of Sydney it was intended that the starting point should be the historic Obelisk in Macquarie Place. It was subsequently decided that it would be preferable to have the point of origin on the direct route used by traffic proceeding in a north-south direction through the city, and, consequently, a distance of one mile was measured back from the old 1-mile stone situated at the corner of Liverpool Street and George Street along George Street and Grosvenor Street to a point opposite St. Patrick's Roman Catholic Church in Grosvenor Street. Thus, while the figures on the new mileposts along the Hume and Great Western Highways leading out of the city represent the distance from the point in Grosvenor Street and also from the Obelisk, those across the Sydney Harbour Bridge refer to the point in Grosvenor Street only.

ACKNOWLEDGMENTS.

Material for this article has been obtained from:—

Mr. B. T. Dowd, Department of Lands.

The Public Library, New South Wales.

The Mitchell Library, New South Wales.

The Royal Australian Historical Society.

—J.M.E.

Main Road Improvements in the Holbrook Shire since 1936

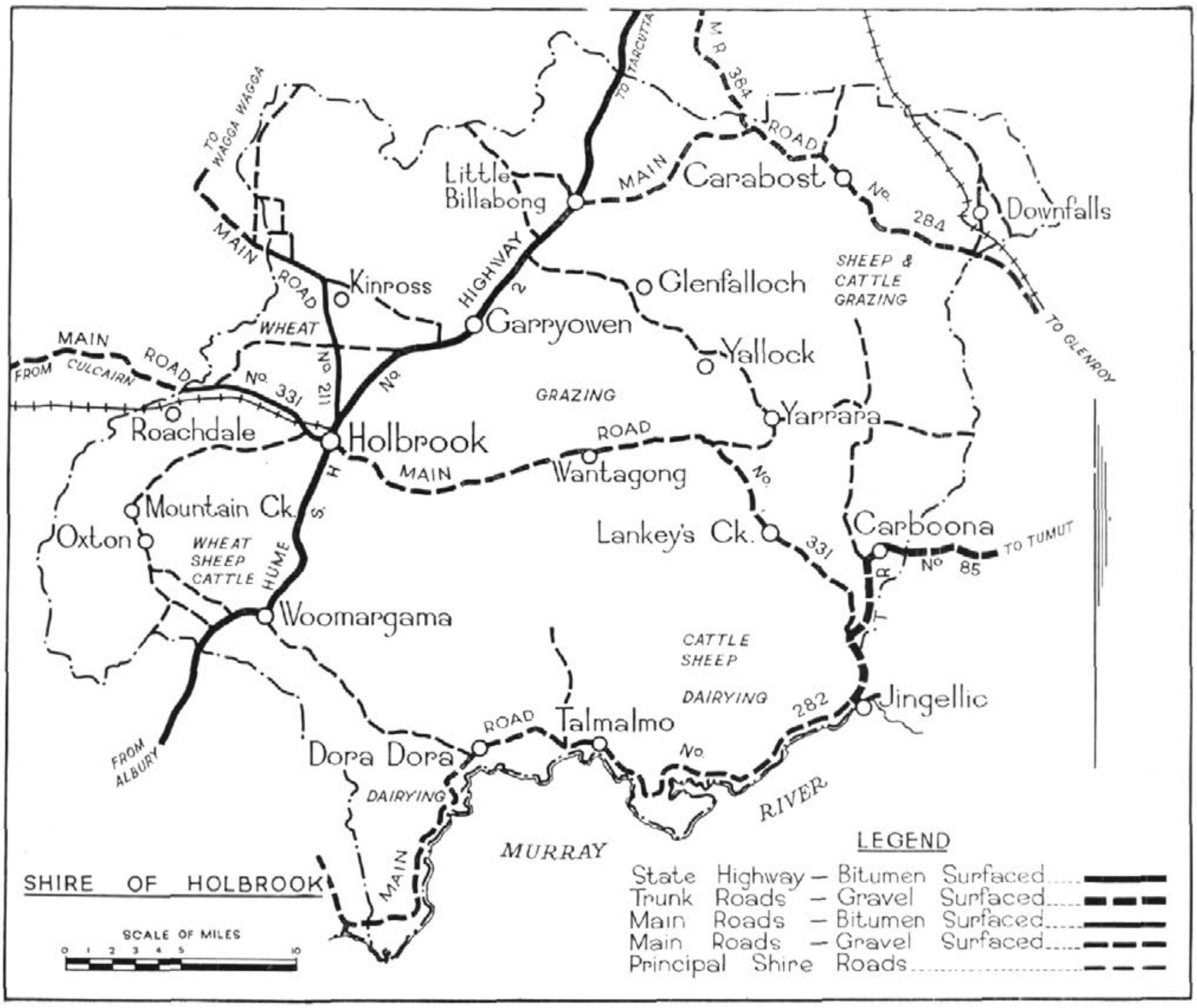
By J. R. Beck, Shire Engineer, Holbrook Shire Council.

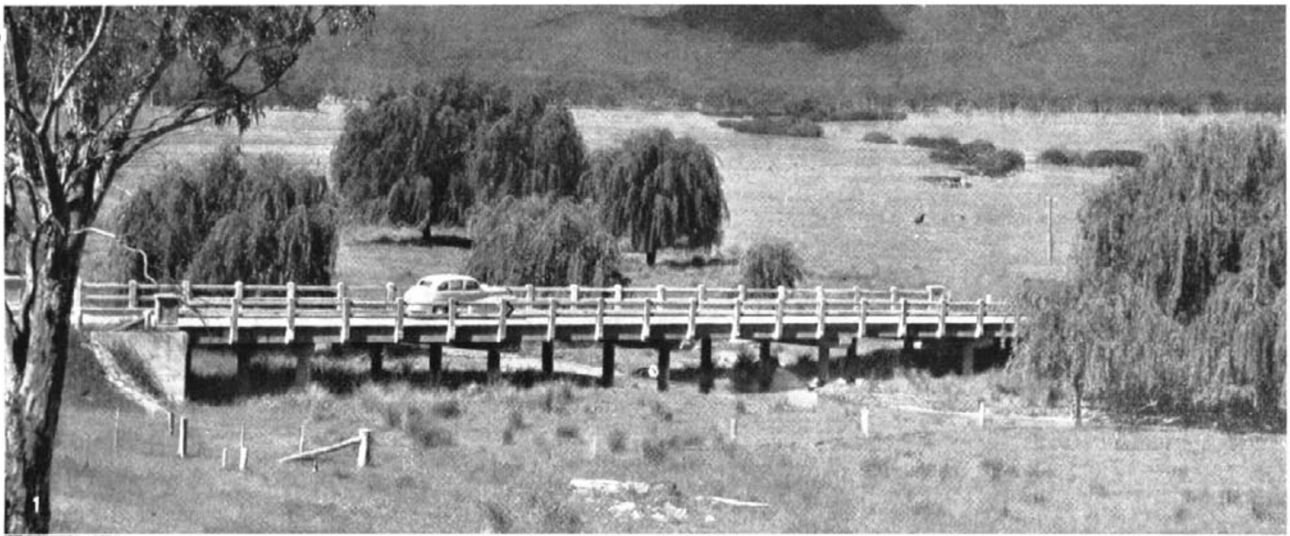
During the past thirteen years the main road system in the Shire of Holbrook has been vastly improved to keep pace with local economic development.

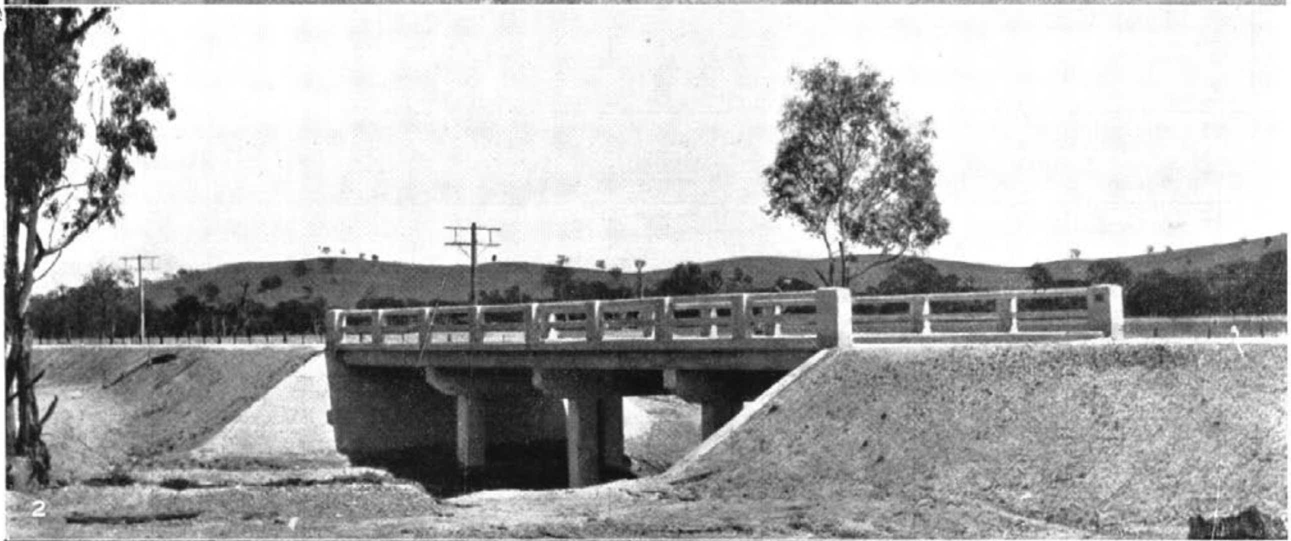
Like most of the Eastern Riverina of which it is a part, the flat western portion of the Shire is particularly suited to grazing, wheat and dairy farming; and the average rainfall of 28 inches makes possible large-scale pasture improvement and soil conservation.

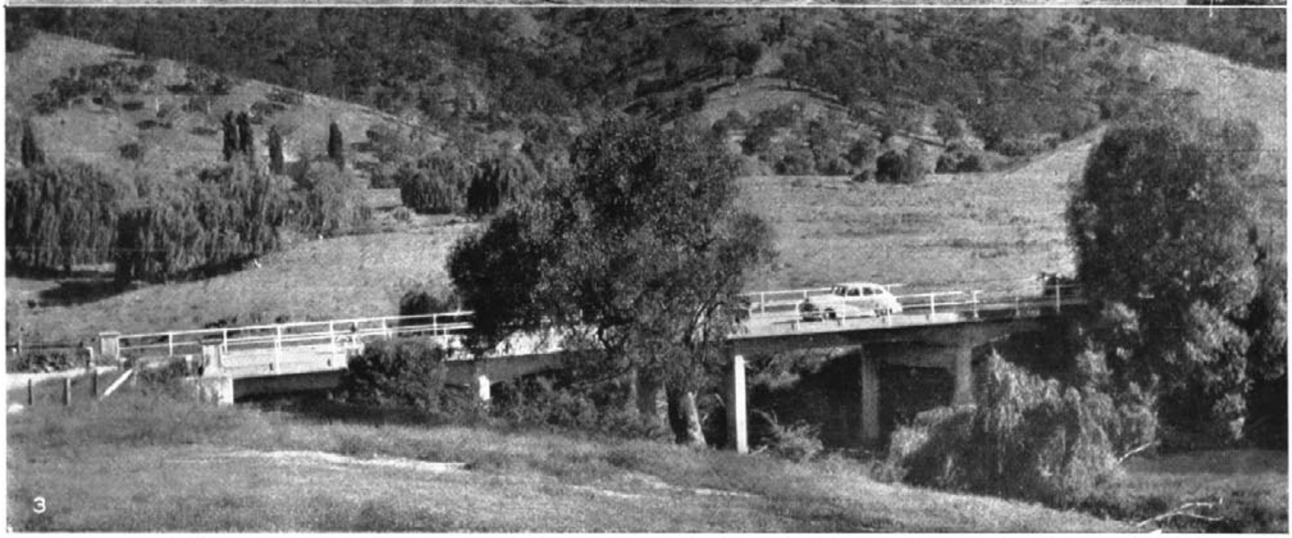
These economic activities depend largely on transport facilities for livestock, produce and machinery. However, the Shire possesses only one railhead, that at Holbrook itself. Most transport moves by road to the railheads at Albury and Wagga Wagga.

Until about 1930 the five principal roads serving the Shire— those between Holbrook and Wagga Wagga (Now M.R. No. 211), Jingellic and the Hume Highway (now M.R. No. 278), Tumbarumba and the Hume Highway (now M.R. No. 284), Jingellic and Culcairn (now M.R. No. 331), and Carabost and the Sturt Highway (now M.R. No. 384)—were for the most part only earth-formed; the numerous open water crossings were a perpetual source of inconvenience and delay to traffic; and timber bridges and culverts had









1. Bridge over Basin Creek on M.R. 282 44 m. from Albury.
2. Bridge over Ralvona Creek on M.R. 331 5 m. west of Holbrook.
3. Bridge over Jingellic Creek on M.R. 282 at Jingellic.

seriously deteriorated. The only pavemented sections in the Shire were a few short lengths of waterbound macadam.

In 1936 Council embarked on a programme of progressive improvement, beginning with the replacement of dangerous timber bridges and culverts. Later, a start was made on eliminating the open crossings, and bitumen surfacing the main roads.

The result of this programme has been that ten major bridges (all of them concrete, except one) and twenty-eight box culverts have been constructed; causeways have been replaced by precast and pipe culverts, 450 of which have so far been installed; and 17 miles of surfacing has been carried out on Main Roads Nos. 211 and 331 west of Holbrook.

Although post-war shortages of materials have seriously impeded Council's operations, few timber bridges and causeways now remain.

A further 13 miles of surfacing is planned for 1950 and 1951, the next road to be treated being the Holbrook-Jingellic Section of Main Road No. 331.

Council's plant, which now consists of one R4 Caterpillar tractor dozer, a 2 yds. wheel scoop, a motor lorry, one light and two medium power graders and a concrete mixer, is to be supplemented during 1950 by a heavy duty power grader, a 50 h.p. tractor dozer, a 4 cu. yds. carryall scoop, and an additional motor lorry.

There are sixteen men in the day-labour organisation, which carries out minor culvert and improvement works. Major works and improvements are carried out by contract.

Although Council's progressive policy has been of great economic assistance to the Shire, there yet remains much to do. Increasing local production, together with the recent subdivision of several large estates for soldier settlement, has resulted in more traffic on the Shire's Main Roads. Council has, therefore undertaken a further construction programme which will cost an estimated £38,000.

The following table shows Council's expenditure for each year since 1935:—

TABLE OF ANNUAL EXPENDITURE—YEARS 1936-49.

Year.	Bridges and Approaches.		Construction Box Culverts and Approaches.		Reshaping and strengthening Gravel Bitumen Surfacing.		Maintenance and Improvement.	
	Department.	Council.	Department.	Council.	Department.	Council.	Department.	Council.
	£	£	£	£	£	£	£	£
1936 ...	5,100	1,700	3,540	1,770	......	......	2,444	1,222
1937 ...	5,700	1,900	......	......	......	......	2,890	1,445
1938 ...	......	......	2,700	1,350	......	......	4,620	2,310
1939 ...	1,800	600	266	133	......	......	3,480	1,740
1940 ...	4,500	1,500	1,680	840	......	......	3,300	1,650
1941 ...	......	......	260	130	......	......	5,510	2,755
1942 ...	......	......	......	......	......	......	2,146	1,073
1943 ...	......	......	......	......	......	......	2,758	1,379
1944 ...	......	......	......	......	......	......	3,000	1,500
1945 ...	......	......	......	......	......	......	3,100	1,550
1946 ...	2,400	800	......	......	......	......	4,220	2,110
1947 ...	......	......	......	......	2,600	1,300	4,700	2,350
1948 ...	......	......	2,040	1,020	7,462	3,731	6,520	3,260
1949 ...	3,300	1,100	......	......	4,912	2,456	7,500	3,750
	£22,800	£7,600	£10,486	£5,243	£14,974	£7,487	£56,188	£28,094

Total length of bridges, 1,018 feet; 29 culverts built.

SUMMARY.

	£
Bridges	30,400
Construction	15,729
Bitumen Surfacing	22,461
Maintenance and Improvement	84,282
	£152,872

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, June, 1949.
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, June, 1949.)
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, May, 1949.)
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, December, 1948.)
122 Surfacing with Tar. (Revised, January, 1949.)
145 Surfacing with Bitumen. (Revised, January, 1949.)
93 Re-surfacing with Tar. (Revised, January, 1949.)
94 Re-surfacing with Bitumen. (Revised, January, 1949.)
230 Tar or Bitumen Penetration Macadam, Surface Course, 2 inches thick. (Revised, December, 1936.)
66 Tar or Bitumen Penetration Macadam, Surface Course, 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. (January, 1949.)

GENERAL.

342 Cover Sheet for Specifications, Council Contract. (Revised, April, 1939.)
24B General Conditions of Contract, Council Contract. (Revised, December, 1949.)
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, December, 1948.)
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 (Revised, January, 1948.)
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 Crossing (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.

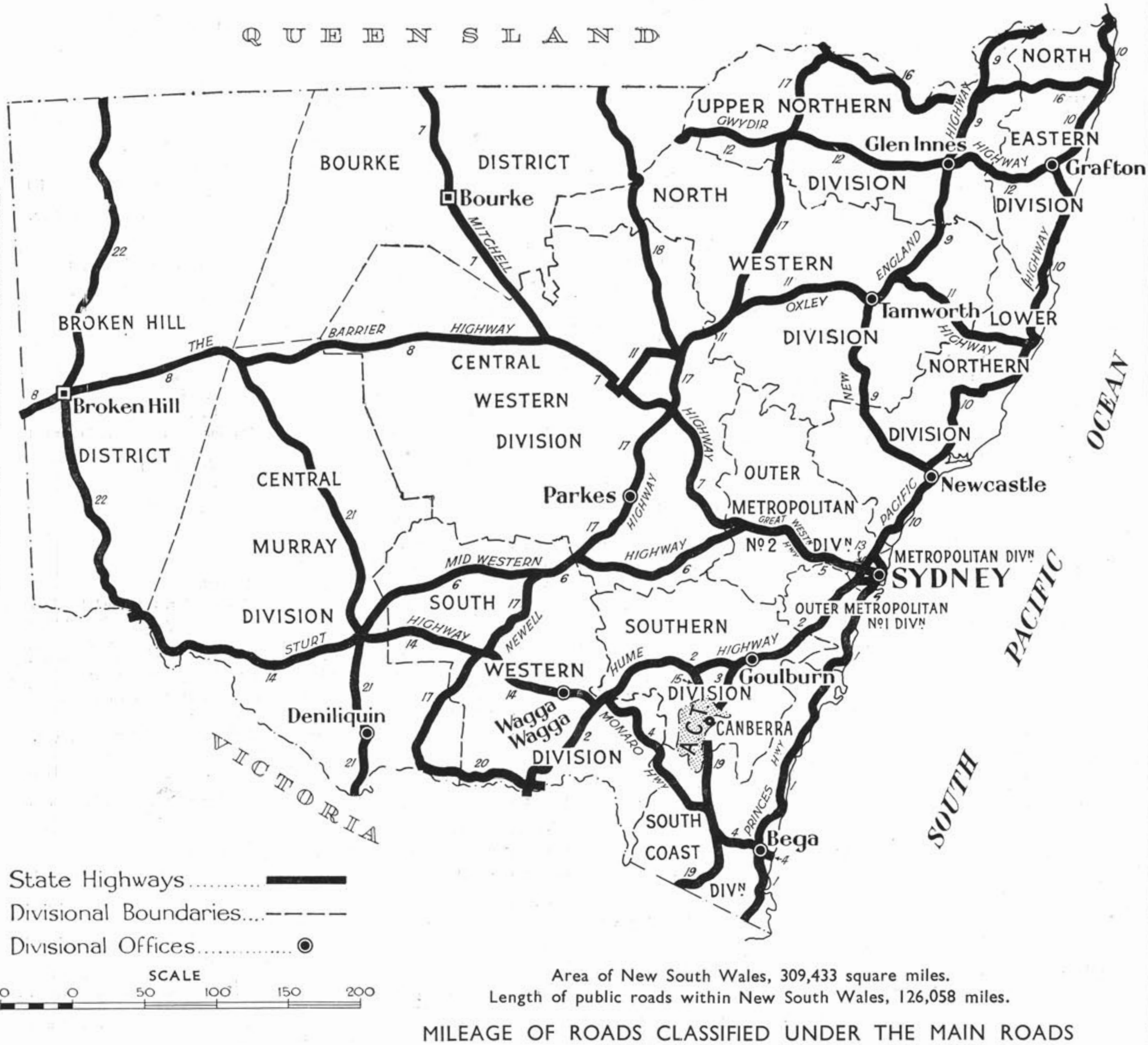
142 Split Post and Rail Fencing and Drawing (A 43).
141 Post and Wire Fencing (Revised, December, 1947) and Drawings (a) Plain (A 494); (*b*) Rabbit-proof (A 498); (*c*) Flood gate (A 316).
143 Ordnance Fencing (Revised, February 1934) and Drawing A 7. (Revised, November, 1939.)
144 Chain Wire Protection 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). (1948.)
A 4A Standard Bridge Loading (instruction for dead-end Developmental Roads.) (Revised, 1938.)
18 Data for Bridge Design. (Revised, November, 1948.)
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. (1949.)
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 139), 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 Pipe Culverts for 3 ft. dia. or less. (Revised, December, 1947.
138 Pre-Cast Concrete Box Culvert (Revised, February, 1948) 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).
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. (Revised, September, 1948.)
A 45 Timber Bridge, Standard Details. (Revised, May, 1949.)
A 1791 Timber Beam Skew Bridge Details. (1941.)
164 Timber Beam Bridge (Revised, April, 1947) and instruction sheets, 12 ft. (A 3469), 20 ft. (A 70) revised, May, 1949, and 22 ft. (A 1761). revised, May, 1949.)
A 1226 and A 1165 Low Level Timber Bridges, instruction sheets for 16 feet, and 18ft. between kerbs. (1932.)
A 1223 (Revised, May, 1949) and A 3472 (Revised, May, 1949) Single Span Timber Culverts instruction sheets for 20 ft. and 22 ft. between kerbs.
139 Timber Culvert and drawings, 1 ft. 6 in. high (A 427), 2 ft. (A 428), 3 ft. (A 429), 4 ft. (Revised, Jan., 1950) (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, April, 1948.)
495 Design of Forms and Falsework for Concrete Bridge Construction. (September, 1947.)

All Standards 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, 1949.

State Highways	6,519
Trunk Roads	3,745
Main Roads	12,707
Secondary Roads (County of Cumberland only)	69
Developmental Roads	2,939
	25,979
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	2,335
TOTAL ...	28,314