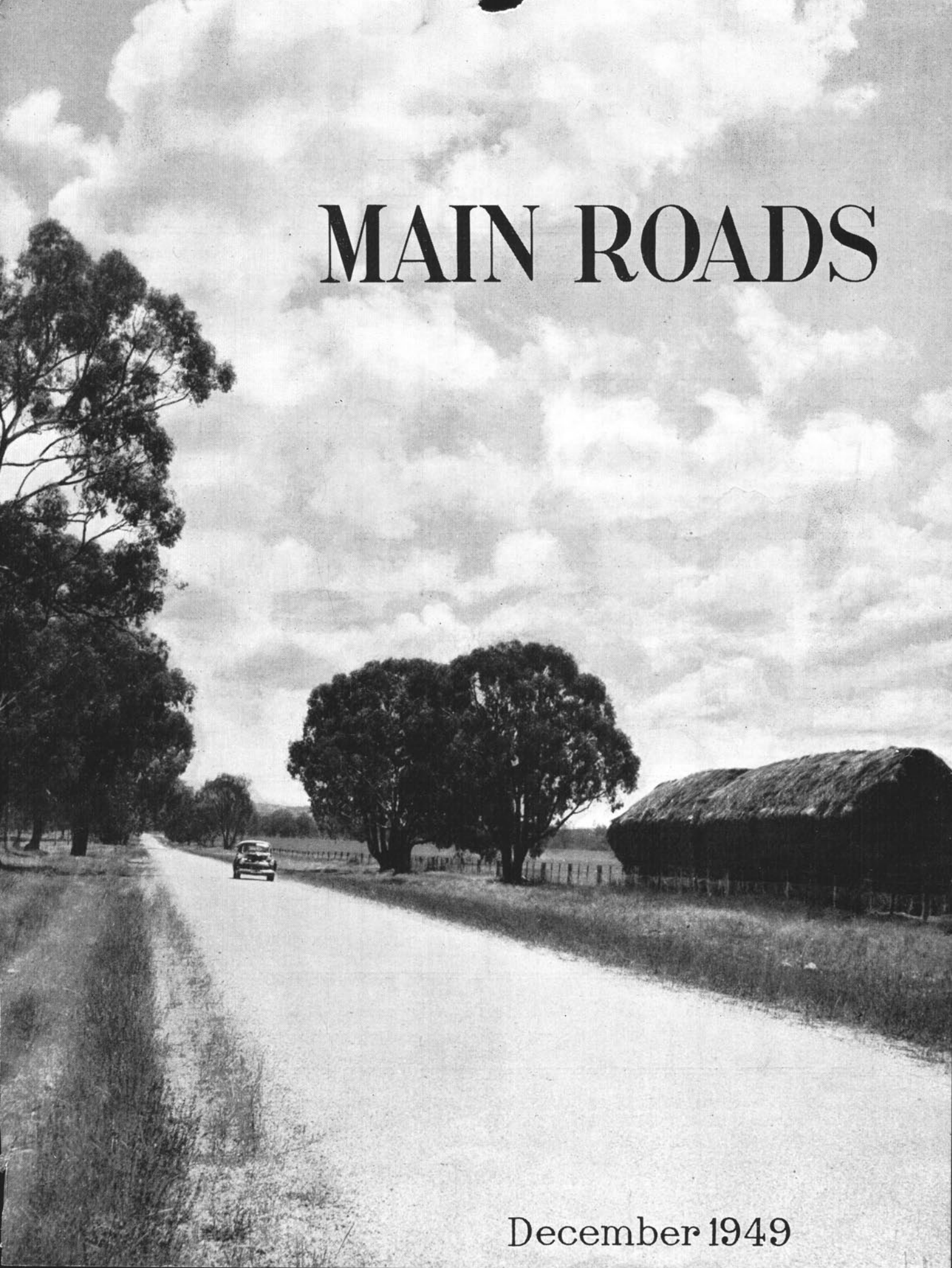
MAIN ROADS



December 1949

MAIN ROADS.

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Cover Page.

A Scene on the Holbrook-Wagga Road (M.R. 211) approximately 8 miles from Holbrook looking towards Wagga. (Work described on Page 53.)

Next Issue: March, 1950.

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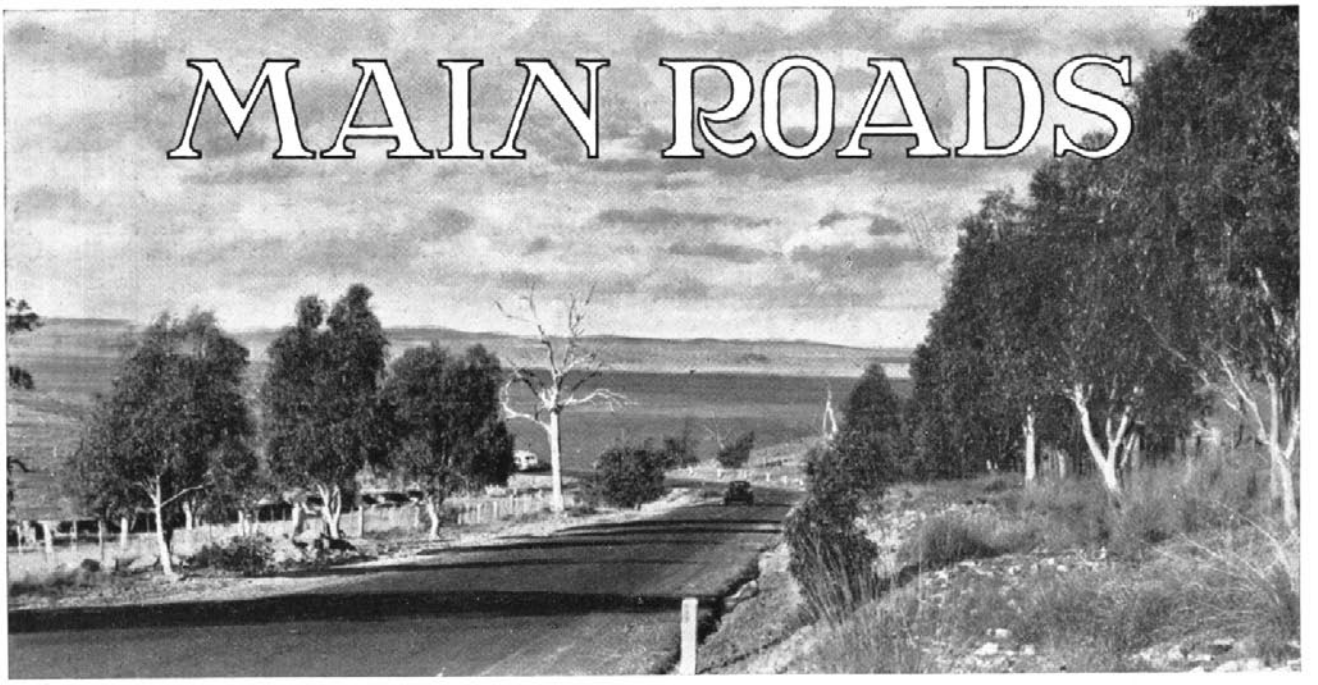

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Aerial Photography.

Twelve Years Use in Road Location.

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This is a description of the methods used by the Department of Main Roads in the location of roads and, in particular, the use of aerial photographs during the past twelve years as an aid in road location under various conditions. An article in "Main Roads" for May, 1940, gave a general description of the taking and use of aerial photographs. Since that time, much further experience has been gained.

In carrying out investigations for the location of roads, the general procedure when using aerial photographs is similar to that followed in earlier years, when the whole of the preliminary investigation was carried out by field inspection and surveys made on the ground. The objective is to determine exactly the most suitable position on the ground of the line along which a road may be constructed in conformity with the best standard and conditions will allow at a cost in keeping with the purpose to be served by the road.

Comprehensive investigations must be carried out in well defined successive stages each designed to narrow the area or strip of country within which the most suitable line will be located. The extent of the investigation required will be dependent upon the length of the proposed road, the nature of the terrain, and conditions in respect of land occupation and use in the area through which the road is to pass.

In the case of relatively short lengths in the more accessible rural areas, locations can probably be determined satisfactorily by the ordinary field methods, although aerial photographs, if already available, would be used. The following remarks are intended to apply primarily to major proposals involving long lengths of roads outside the built-up areas. In such cases, the use of the aeroplane and the survey camera enable new methods to be employed which greatly reduce the amount of field survey work which formerly occupied much time and labour, and enable the investigation to be completed with much greater certainty that the most satisfactory location has been obtained.

Preliminary Organisation. The first step is to define the limits of the area within which the road may be located and for which aerial photographs are required. For this purpose it is necessary to inspect the available maps. The most suitable for the purpose are the

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1 mile to an inch sheets of the military map grid, each showing an area of about 500 square miles, on which the topography is shown in some detail with a contour interval of 50 feet. The present coverage of these maps, however, generally does not extend beyond the more highly developed and closely settled areas. Some additional areas are shown on the 4 mile to an inch map, each sheet covering about 6,000 square miles. These maps do not purport to provide an accurate representation of the topography or to supply much detail, but they show the main features and give a fair idea of relative heights and the general contour of the ground. Outside the areas covered by the military maps it is necessary to make use of the Parish and County maps showing land occupations. These maps are of little value as regards the engineering aspects of the investigation, but at this stage they serve to show the relative plan positions of the terminal points and the more prominent features if any exist.

When reliable topographical maps are available, a study of these maps will reveal the general routes along which grading may be possible, and major obstacles such as large stream crossings to be avoided. The area to be photographed, which must embrace all the possibilities, can then be so defined as to avoid unnecessary photographic coverage. When topographical maps are not available the extent of the area to be considered can only be tentatively indicated. It may be narrowed at this stage by an inspection on the ground or from the air, but generally, if aerial survey is to be carried out specially for the purpose of the road investigation, the limits of the area in such cases would be determined by aerial reconnaissance carried out as a preliminary to the photography.

Examination of vertical photographs using stereoscope and stereometer bar.

Aerial Photography. When the area to be considered has been determined, the next step is to obtain suitable aerial photographs. Requirements in this regard will vary according to the nature of the terrain and extent to which the area has been narrowed by the previous study of available maps. In the absence of topographical maps and where large areas are involved the topographical information required for the selection of possible routes must be provided by the photographs themselves, and for this purpose small-scale photographs with a large coverage are the most suitable. For detailed comparison of alternatives, whether selected on small-scale photographs or on topographical maps, accurate interpretation of ground conditions within a narrow strip is necessary and for this purpose photographs having a larger scale are required. The small-scale photographs may be obtained from the Department of Air if the area in question has already been photographed for mapping purposes, the photographs usually having a mean scale not larger than 1/25,000. If the area has not been covered, arrangements are made for the necessary photography to be carried out by contract in conformity with a specification designed to suit the requirements of the road investigation.

The width of area to be photographed is dependent upon the length of the proposed road and the amount of information on available maps or obtained by prior aerial reconnaissance. Where there is good topographical map coverage the width of the strip may not exceed 2 or 3 miles which can be covered with a single run of photographs. In other cases if a long length of road is to be located it may be necessary to obtain small-scale photography covering widths up to 20 miles.

The specification for aerial photography used by the Department of Main Roads has been modified from time to time as a result of experience. With a view to economy both in the cost of aerial survey and subsequent operations, it now provides for a contact scale of 1/25,000 when topographical information is lacking and a contact scale of 1/12,000 or larger when the area to be considered can be reduced to a narrow strip. When the smaller contact scale is provided for, photographs with the larger scale may be obtained by enlargement or, if necessary, by further photography of a narrow strip containing the route selected after examination of the small scale photographs.

The specification provides for vertical photography and for the supply of negatives and three sets of contact prints (9 in. x 9 in. format), with 60% fore-and-aft overlap and 30% lateral overlap on a prescribed mean scale of an area defined on a plan, the boundaries in some cases being subject to a preliminary air reconnaissance. For small scale photography the focal length of camera lens is 6 inches and for the larger scale 8¼ inches or 10 inches, the latter only for areas containing extremely steep and broken country. The period during which photography may be carried out commences about 4 hours after sunrise and ends about 4 hours before sunset. The tolerances allowable are—

Fore-and-aft overlaps ± 5%, Lateral ± 10%.
Crabbing 10 degrees (from line of flight).
Tilt maximum 2 degrees.
Variation in mean scale 2% in excess of that caused by variation in relief.

With the specification, the contractor is supplied with such particulars of the area as are available, including the mean ground heights to be assumed for the whole or for different parts to determine the flying height required to secure the prescribed mean scale.

Also a map or plan which needs to show the boundaries of the area to be photographed, if they can be defined, in relation to some landmarks identifiable from the air—either natural features, roads or tracks. In other cases, the contract provides for preliminary reconnaissance flight by a Departmental Officer, who will then decide the limits of the area and indicate them in relation to landmarks observed at the time.

Compiling Mosaic by Azimuth lines.

When the photographs are supplied by the contractor they are immediately examined as to conformity with the terms of the specification. If unacceptable in respect of any part of the area, that part must be re-photographed. As soon as satisfactory photographs are available one set is used to make mosaics. The method used is designed to produce a mosaic in which the pictures are so oriented that a straight line generally along the line of flight in any run of the included photographs will correspond with a straight line on the ground. The objective is to provide a basis for plotting on an azimuth common to all photographs in the mosaic. Although, in areas of high relief, the method results in small sections being duplicated, these can be readily detected and marked in some way. Any disadvantage arising from this cause is outweighed by the usefulness of the mosaic as a map, particularly in the case of unmapped areas of low relief where the duplication of detail is not apparent and the features appear in their proper plan positions.

Reconnaissance. As defined in Wellington's "The Economic Theory of the Location of Railways," reconnaissance is "the art of discerning the physical possibilities of a region by the aid of the eye alone." In modern practice reconnaissance may be made by direct observation from the air, but it can be carried out much more conveniently and deliberately and with better results by viewing the country as represented on aerial photographs.

In the case of a major road proposal the mosaics are laid out so that the whole area between fixed points on the location can be viewed at once. The fixed points may be the terminals or any other two points through which the road is to pass. The high ranges or other barriers will be immediately apparent and, by observing the shape and direction of the natural features, a number of possible routes may be selected and roughly marked on the mosaics. In this process some parts of the area will be excluded from consideration by reason of obvious barriers. The area to be considered may then be narrowed further by a rapid stereoscopic examination of photographs covering the location roughly marked on the mosaics. When the country along each is viewed in relief and the relative heights and slopes observed, the number of possibilities may be reduced and additional areas eliminated from consideration.

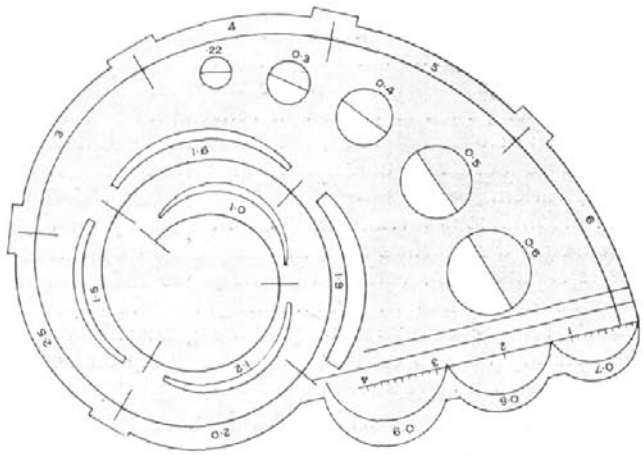
In mountainous terrain the possibilities may be very obscure on the mosaics and, in the preliminary stereoscopic examination, variation in the photo scale due to extreme differences in ground heights will operate against reliable estimates of possible grades. It will be necessary then to construct a feature map on which the features can be shown in their proper plan position.

Preliminary Survey. This includes the necessary photogrammetry carried out in the office as well as such rapid surveys made on the ground as may be necessary to determine the practicability of the various alternatives from the point of view of grading or to ascertain the conditions at major stream crossings and at places where drainage, soil or other conditions may affect the suitability of the route tentatively selected as a result of reconnaissance.

The more elaborate photogrammetric equipment used for plotting and contouring from aerial photographs has not so far been used by the Department of Main Roads. In the absence of any previously determined ground heights in most places where major road investigations are required, such instruments could not be operated to advantage. In areas of difficult mountainous terrain a feature map is prepared by plotting from the photographs using the Arundel method. The scale of the plot is determined by reference to any points of known plan position which can be identified on the photographs and plotted on the feature map. In the areas of low relief the mosaics serve as a feature map.

The possible locations selected on the mosaics, with the assistance of the feature plan where necessary, are critically examined under the stereoscope. In some areas of low relief the most suitable location can be fixed approximately by this means. In mountainous areas it may be necessary to make some preliminary survey on the ground. Where grades are in doubt the relative height of points which control the grading may be ascertained by aneroid observation or the grade between the points ascertained by a rapid clinometer traverse. Information would be obtained at the same time about any drainage or soil conditions which may affect the practicability or suitability of a route. If there are several points of known height which can be identified on the photographs, the relative heights of points which control the grade may be determined by means of a Cambridge Stereo-Comparator. This instrument is also used to determine the amount of tilt in the photographs and, when the tilt has been ascertained additional ground heights can be determined where required, using a simple stereoscope and stereometer bar. In general, it is found that points of known height control are not available, and in most cases it is

more economical to obtain relative heights where required on the location than to establish height control to enable the more elaborate instruments to be used.



Transparent template used under stereoscope to ascertain appropriate curves.

By detailed stereoscopic examination of the photographs supplemented by ground observations where necessary, the possibilities selected on the mosaics will be reduced to one or more practicable routes. At this stage or earlier a decision must be made as to the appropriate design speed standard having regard to the sight distance which can be provided. The sight distance is dependent upon the degree of curvature on closed horizontal curves, and is ascertained in the following manner. Curves of various radii are engraved on celluloid or other transparent medium on the scale of the photographs. With a pair of photographs placed in correspondence under the stereoscope the celluloid is superimposed and different curves tried on the relief model until one is found to fit the contour of the ground. In practice the previous stereoscopic examination has suggested the appropriate speed standard and its practicability is proved by trying the minimum closed curve for that standard at the points on the relief model where the required curvature is in doubt.

When the design speed standard has been decided the approximate position of the road centre line is marked on the photographs. A preliminary marking is drawn along the grade as estimated with the photographs viewed stereoscopically; the curves which best fit the contour on the grade are then firmly marked using transparent curves under the stereoscope, and the tangents then drawn between them.

When the approximate location has been marked on the contact prints, the line is transferred to the mosaic. Two or more alternatives may be shown and the respective lengths and alignments may be observed in relation to the conditions of land occupation and use as they appear on the mosaic. This comparison, considered in relation to approximate grades which are known, may enable a decision to be reached as to the most suitable line.

Trial Survey.—This is a survey of a narrow strip along the line or lines selected in the manner described, for the purpose of representing on a plan the contour of the area within the strip, with particulars of conditions which would affect the construction of a road within the strip.

The Surveyor is supplied with a copy of the mosaic with the lines marked on it, together with copies of the photographs. The survey is made with tacheometer or stadia theodolite. The line is identified on the ground from detail appearing on the photographs and the traverse laid down along the line. The survey must cover a width sufficient to include all earthworks and catch drains and obtain the information required to prepare a plan showing contours at 5 ft. intervals; the geological formation, the natural drainage and soil conditions and all man-made improvements or obstructions. In general the plan is drawn to a scale of 100 ft. to an inch, but a scale of 50 ft. to an inch may be used where the location is on steeply-sloping ground.

Office Examination.—The purpose of the office examination is, firstly, to determine the best position for the centre line of the road within the contoured strip, with due regard to all the information represented on the plan of the trial survey; secondly, to enable a decision to be reached as to the most suitable of the alternatives, if any. For this latter purpose, preliminary designs and estimates of cost are prepared from the information shown on the contour plan, and alternatives are then compared in regard to alignment, grading, sight distance and cost.

ROAD INVESTIGATIONS CARRIED OUT BY DEPARTMENT OF MAIN ROADS.

Aerial surveys were first made by the Department in 1937 for investigation of the location of the Gwydir Highway between Grafton and Glen Innes. In the length of 108 miles, the existing road passes through the very hilly and mountainous country along the western slopes of the Great Dividing Range, which is crossed at an elevation of about 3,500 feet above sea level. Owing to inferior alignment and severe grades on a length of about 70 miles, the road was generally unsuitable for heavy transport, and traffic generally on this route between the Coast and the interior was greatly restricted.

The investigation was commenced in 1935, using ground methods only and attention was first directed to the location of a satisfactory route for the main ascent to the New England Tableland. No satisfactory ascent could be found in the vicinity of the existing road. Rising some 3,000 feet from the Mann River, a large stream to be crossed, the broken country along the eastern slopes of the Range presented extreme difficulties. After extensive field reconnaissance and preliminary surveys, occupying a survey party for about eight months, a line was located on a length of about 25 miles, including the main ascent, along which satisfactory grades could be obtained. However, it involved a long length of very winding alignment and of costly works and, owing to the difficulties of access in this area, there remained a doubt whether this location was the best the country would allow.

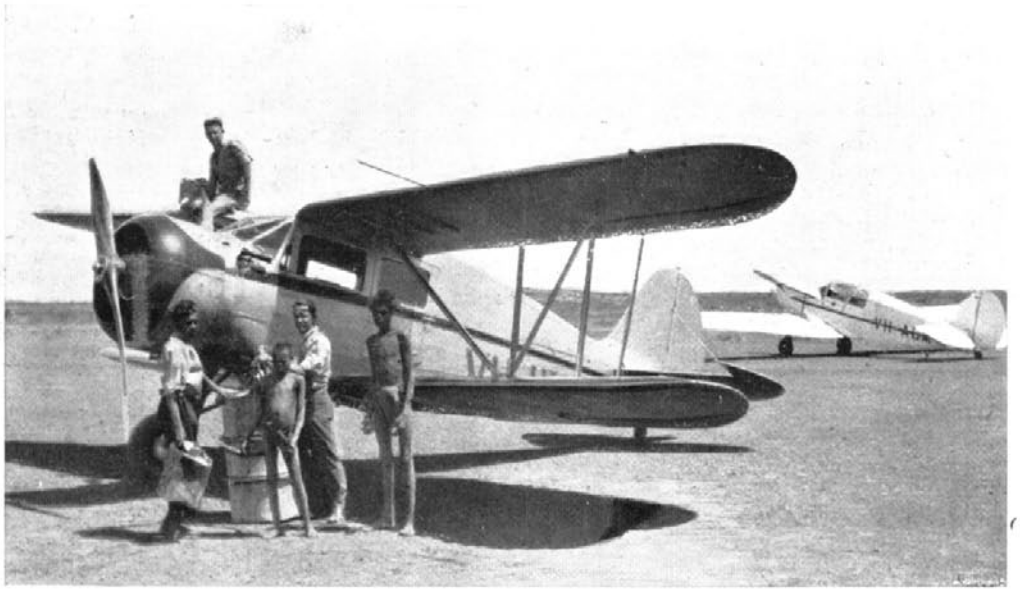
Arrangements were then made for aerial photography of an area of about 450 square miles, embracing

Mosaic showing existing road in lower part of photo. and proposed location by white line at top of photo.

only the most promising section of the difficult country. Stereoscopic examination of the photographs indicated a number of possible alternatives to the one previously located, and two of these when further investigated were found to have advantages in regard to length and construction cost. There is little doubt that the alternatives referred to would have been discovered eventually if the ground investigations had been continued, and the aerial photography carried out in this case probably had its greatest value in demonstrating the advantages to be gained from its use. These became so apparent that arrangements were made for aerial photography of a much larger area, embracing the whole length of the route as an aid to the investigation of the location on the remainder of the length. A satisfactory deviation about 73 miles in length was ultimately located generally in conformity with 50 m.p.h. standards except in the main ascent to the Tableland. With this deviation, when constructed throughout, the distance between Grafton and Glen Innes will be reduced by about 8 miles.

Since 1937 aerial photography has been carried out as required for investigation of the locations of State Highways chiefly, and other main roads not previously improved to a satisfactory standard. In the case of the State Highways, lengths generally not less than 100 miles are provided for in individual contracts, so that general standards may be determined before sectional improvement is to be undertaken. Of a total length of 3,000 miles of main road in this State for which photographic coverage has been obtained, photography of about 1,800 miles has been carried out specially for the Department of Main Roads by contract. Photographs covering the remaining length of about 1,200 miles have been obtained as a result of aerial surveys carried out by other authorities for mapping or other purposes. As the photography in this latter case frequently does not conform to the terms of the specification of the Department of Main Roads, it is generally less satisfactory for road engineering investigations and in some cases is suitable for use only in the preliminary stages.

Prior to carrying out aerial photography of existing roads a preliminary reconnaissance is made and, where the necessary improvements will not involve wide departure from the road in use, work is usually confined to single runs of vertical photographs in the form of a traverse. In such a case the lines of flight must be so arranged that the road will appear in the middle section of every run, and not farther from the flight line than a quarter of the width of the photographs. Wider coverage, up to about 20 miles, is obtained over lengths where it appears that extensive deviation may be required.



Aircraft used for Aerial Photography in Northern Territory, 1941.

When photographs covering a highway route have been obtained and mosaics compiled, the included length is divided into sections, the terminal points of which are the more important towns or other fixed points such as large bridges, through which the permanent location is to pass. The conditions along the route are then studied section by section, the photographs being examined stereoscopically, and conclusions reached as to the appropriate design speed standard for each section, having regard to the conditions on the whole of the length and the nature and amount of traffic to be served. Uniformity of standard on a section may not be practicable owing to conditions of terrain, but in the many borderline cases the standard to be adopted should be decided with reference to the standards generally obtainable on the route.

After conclusions in regard to standards have been reached, the location of the whole of each section is fixed approximately, and marked on the mosaics after preliminary survey has been made in the manner previously described. Where complete reconstruction is not to be put in hand immediately, action may be suspended at this stage. The progress made, however, is sufficient to make it possible to ensure that any rebuilding of bridges or other improvement works required, pending complete reconstruction of the road later, will be carried out to accord with a satisfactory permanent location.

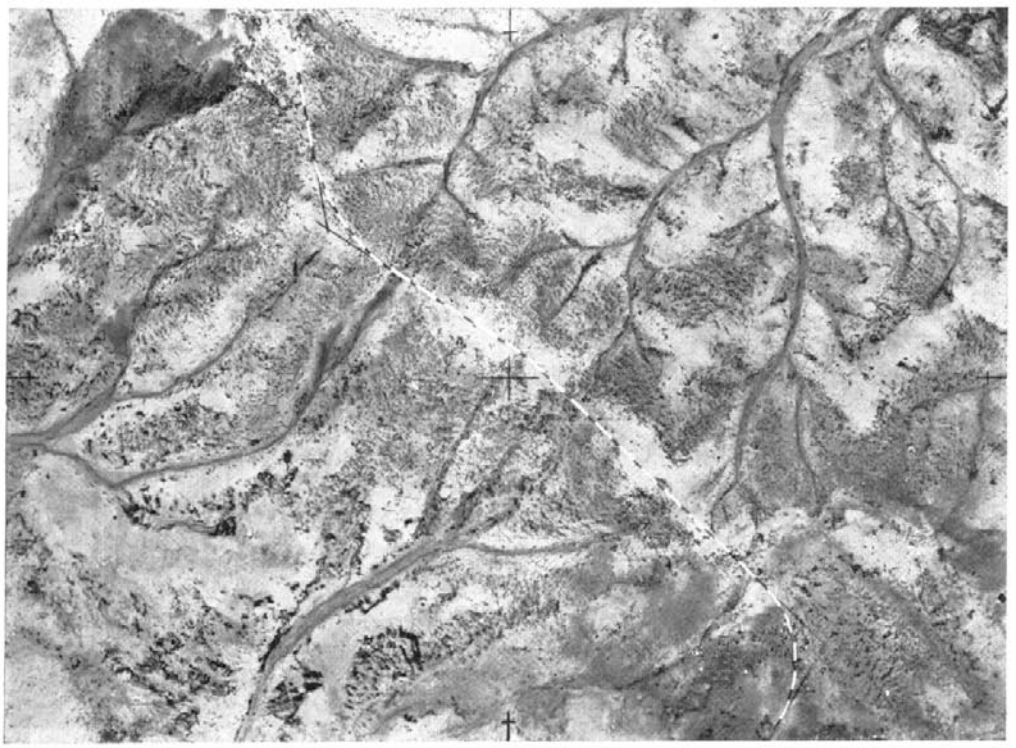
Northern Territory.—As further illustrating the advantages of aerial photography for road location purposes, mention may be made of the location during 1941 of part of the Stuart Highway in the Northern Territory between Darwin and Larrimah, a distance of 325 miles.

Typical rough country near Hayes Creek, Northern Territory, approximately 113 miles south of Darwin. Quartzite ridge abutting on flooded ground.

Scours caused by heavy rains.

The most urgently needed section, between Darwin and Adelaide River, was first dealt with. There was already a lightly formed road on this length of about 72 miles and after an aerial reconnaissance and field inspections occupying four days there appeared to be no substantially better route and the location of the existing track was adopted with only minor alteration.

On the remaining length of about 250 miles from Adelaide River to Larrimah there was no road, the means of land communication being the narrow-gauge railway. An inspection along the route of the railway revealed that it traversed flat to undulating country but crossed considerable lengths of flooded ground and a great many watercourses, including large rivers. The rapid construction of an all-weather road in the vicinity of the railway route was considered impracticable at any reasonable cost.



Location of new road, shown by broken white line, to avoid damage by scours.

The available maps were of value only as a guide to the approximate position of large streams and a limited number of other features, none having been fixed by survey. Aerial reconnaissance was made over a wide area on both sides of the railway. Between Adelaide River and Pine Creek, about 80 miles, the flooded areas are wider to the east of the railway and extend for many miles. To the west of the railway on this length the country generally is hilly and in parts rough and broken. There appeared to be no continuity in the ridges. The pattern of the natural drainage system was obscure and, with the heads of watercourses appearing to extend into the catchments of other streams, few clearly-defined watersheds could be observed. The broken country to the west of the railway offered the only prospect of an all-weather road but contained many difficulties.

For another 140 miles the country is progressively less broken to the west and less subject to flooding to the east of the railway, the major obstacles on this part being six large streams flowing generally at right angles to the route. There were numerous lesser difficulties on this part, but over the remaining 30 miles to Larrimah no obstances were apparent.

Attempts were made to inspect some sections to verify the impressions gained by air reconnaissance. The difficulties of access were such, however, that little useful information was obtained and field inspection was discontinued.

After further air reconnaissance a strip of country was selected as the area within which an all-weather road might be located and arrangements made for aerial photography. It was necessary in this case to make preliminary flights to point out the limits of the area to the aircraft crew, as there was no suitable map on which it could be defined. By this means it was practicable to confine the photography to the minimum coverage required. The photography (vertical) extended over a length of about 230 miles between Adelaide River and Warloch, with a width varying from about 6 miles down to 2 miles in places. A lens of 8¼ in. focal length was used at a height estimated to give a mean scale of 20 chains to an inch.

On account of the urgency of the work, after the photographs became available only one day was occupied in stereoscopic examination before pegging was commenced on a line located on the photographs. With two survey parties and a small staff at base at Pine Creek, location and survey then proceeded continuously. A length of 200 miles, including the whole of the difficult country, was located and pegged on the ground in a period of eight weeks from the receipt of the photographs. The remaining length also was located in that period but not pegged until later. In carrying out this work little difficulty was experienced in obtaining satisfactory grades except in a few places. The difference in height between the lowest and the highest point on the road does not exceed 1,000 feet.

On a considerable length the country along the route is characterised by steep broken-backed ridges of sandstone, quartzite or slates alternating with areas of low-lying badly-drained country, with parts subject to flooding during the wet season. The location was necessarily kept to the lower levels and difficulty was experienced in finding passages through the broken ridgey country and also in finding continuous lengths of sound ground in the low-lying areas. Only by careful study of the photographs under the stereoscope and accurate interpretation of ground surface conditions, were these difficulties overcome.

It was necessary to locate the road so that it could be constructed rapidly. This required that drainage structures be kept to a minimum and the watercourses were headed where practicable, sometimes at the expense of the road alignment. The lesser watercourse, which in many cases are dry for most of the year, were crossed at sites suitable for the construction of causeways. At the larger streams high-level bridge sites were located except at the crossings of the Margaret, Adelaide, Ferguson and Katherine Rivers, where very large structures would have been required. In the case of these streams the road was located so as to be near the railway bridges with a view to the use of the railway bridge by road traffic if necessary in time of flood. Nearby sites were selected for low-level bridges for general use.

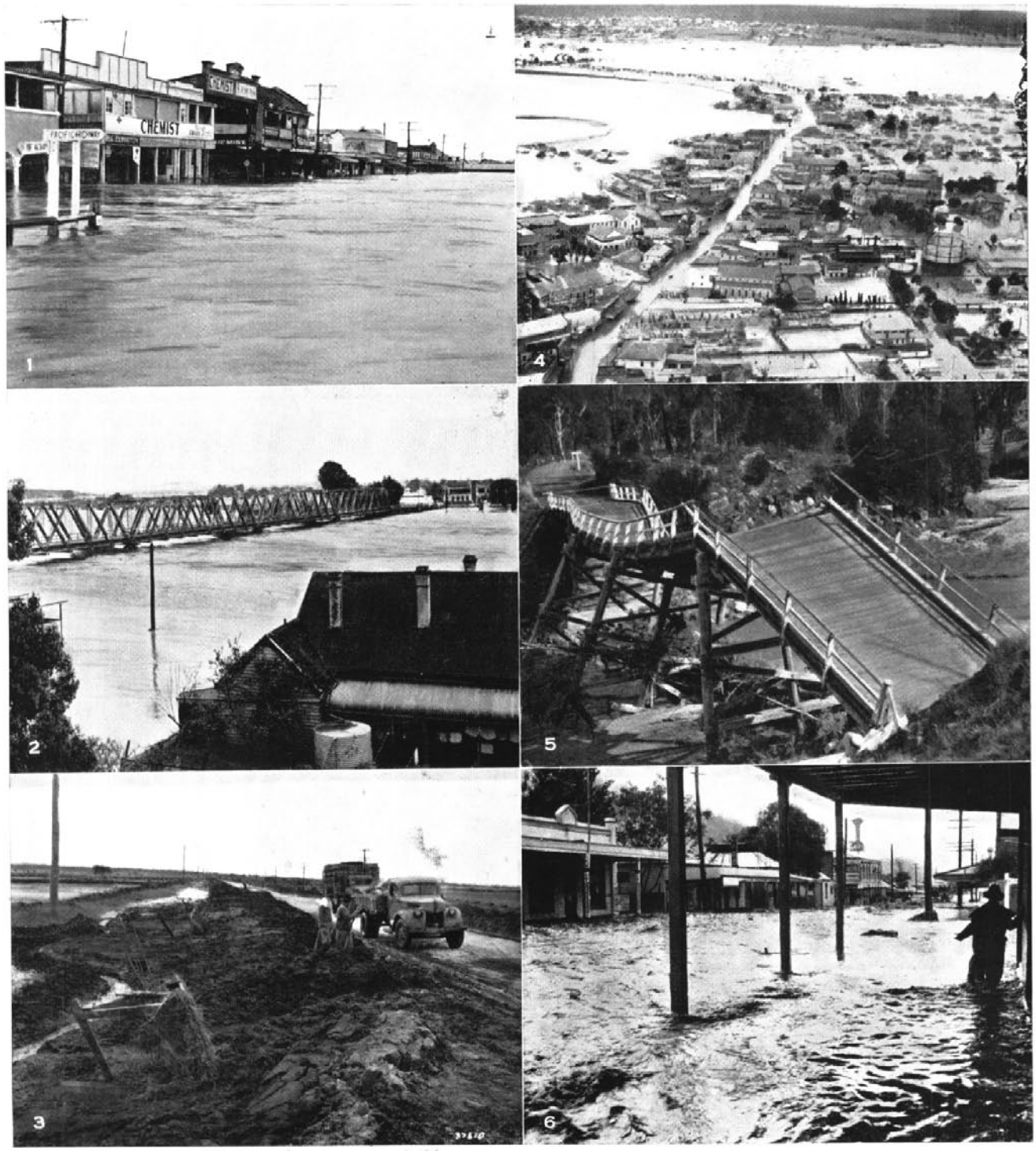
Western Division.—The advantages of aerial photography for location in areas of low relief where drainage constitutes a serious problem was fully demonstrated by the work carried out in the Northern Territory. The experience gained has enabled the Department to find a solution for some of the major drainage troubles on roads in the Western Division of the State. An important case in point is the road from Broken Hill to Tibooburra, near the Queensland border. Although the route lies in one of the driest parts of the State with average rainfall only 7 to 9 inches, the area is subject to relatively heavy precipitations at intervals and occasional flood rains. In an area practically devoid of protective vegetation and subject to erosion by wind, the storm and flood rains have been the cause of serious interruption of traffic.

In 1945 aerial photography was carried out over the whole length of 240 miles from Broken Hill to the Queensland border. In the absence of topographical information the strip to be photographed was selected by preliminary air reconnaissance extending over a wide area. On the ground where the country is only slightly undulating the pattern of the natural drainage systems is difficult to determine, but viewed from the air as they appear on the photographs the watercourses are clearly defined, as also are the limits of areas subject to occasional flooding.

A length of about 48 miles between Sandy Creek and Cobham Lake has been located so as to avoid all but the large stream crossing and sections about 39 miles in length between Sandy Creek and Palgamurtie Tank had been constructed prior to the record floods which occurred early in 1949. Although the original road on this section was submerged for many miles the new formation was affected only to a very minor degree.

Other roads in the Western Division have since been photographed prior to reconstruction, and have confirmed the great benefit to be obtained from aerial photography in relatively flat inland country.

FLOOD EFFECTS ON MAIN ROADS, 1949.



1. **Pacific Highway passing through Kempsey business centre, August, 1949.** [Photo. by courtesy of E. McNeil, Kempsey.
2. **Pacific Highway. Flood in Macleay River passing under Kempsey Bridge, August, 1949.** [Photo. by courtesy of E. McNeil, Kempsey.
3. **Pacific Highway north of Kempsey. Accumulation of silt after floods, August, 1949.**
4. **New England Highway passing through business centre of City of Maitland, August, 1949.** [Photo. by courtesy of *Newcastle Herald.*
5. **Damage to McDonald River Bridge on Singleton-Putty Road during floods, June, 1949.**
6. **New England Highway, Murrurundi, October, 1949.** [Photo. by courtesy of W. J. Sutton, Murrurundi.

*24682—2

Improved Rock Drilling Technique.

PROMISING RESULTS IN TESTS OF TUNGSTEN CARBIDE TIPPED DRILL BITS.

It is about thirty years since scientists discovered that an extremely hard compound could be produced by heating powdered metallic tungsten with carbon. The material originally produced was too brittle for industrial use, but following further research, it was found that by adding cobalt as a binder, the metal was suitable for dies for wire drawing and as inserts for tools used for machining cast iron.

A later development, which included an increase in the cobalt content and titanium and tantalum carbides as binding agents, gave a material suitable for the high-speed machining of steel. It is in this form that tungsten carbide is perhaps best known. In the early thirties, Germany experimented with the application of tungsten carbide to rock drilling, and drill bits with tungsten carbide inserts were used extensively by that country during the war.

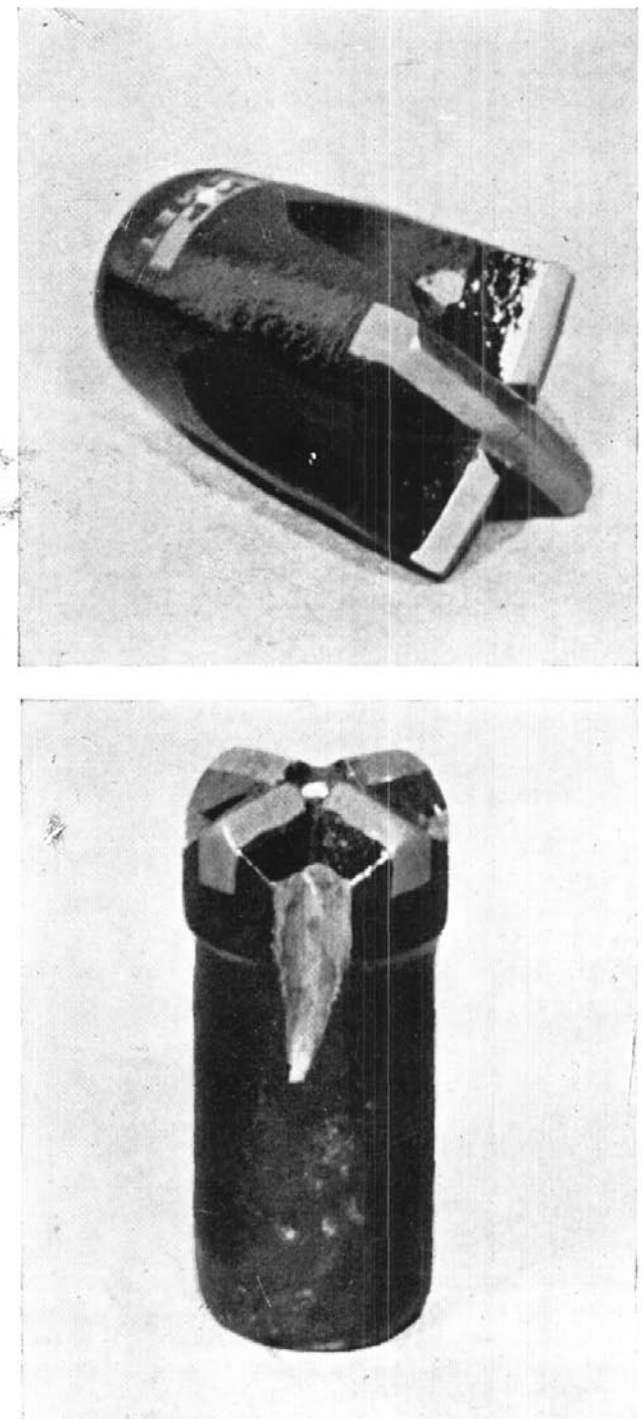
It is only since the war that rock drill bits with tungsten-carbide tips have become available on the local market. Imported and locally made bits, both with screw and taper attachment, and tipped steel are now being used, but still on a relatively limited scale.

The use by the Department of Main Roads of the tungsten carbide detachable, tapered, drill bits indicates that substantial savings can be made in drilling costs by this means, particularly in the harder rocks such as diorite and granite, an increase in the drilling rate of three to five times that of the ordinary steel drill being possible. The reduction in the cost of drilling was found to be approximately the inverse of the drilling speed.

The first drilling tests in hard rock were in a very hard silicified shale. Further tests were then made in diorite and aplite. The comparative results of the tungsten carbide tipped bits and ordinary drill steels were as follow:—

	Ordinary Drill Steels.		Tungsten Carbide Tipped Bits.	
	Diorite.	Aplite.	Diorite.	Aplite.
Penetration rate ins./min. ...	1¼	3½	6½	8
Footage between regrinds	8 ins.	6½ ins.	19 ft.	25 ft.
Footage/day/ machine	19 ft.	45 ft.	110 ft.	134 ft.

The average life of the tungsten carbide tipped bits tested was of the order of 200 feet in the class of rock being drilled. These results were obtained under test conditions and, while not perhaps representative of



Types of Tungsten Carbide Bits.

normal practice, they were sufficiently conclusive to indicate that drilling could be considerably speeded up and costs substantially lowered.

Tests were then carried out in granite, and comparative results of the ordinary drill steels and the tipped bits were as follow:—

	Ordinary Drill Steels.	Tipped Bits.
Penetration rate—ins./min.	2	6
Footage between regrinds	8 ins.	Max. of order of 200 ft.
Footage/day/machine ...	34	105

The average life of a number of tungsten carbide tipped bits of different makes used in this test was of the order of 300 feet, and some bits drilled in excess of 500 feet, with a maximum of over 700 feet.

These results have been so encouraging, that full scale work using the tipped bits is now being undertaken, but sufficient use has not yet been made of them in normal practice for results to be quoted.

All drilling has so far been done with the detachable taper-fit bit. In early work, failure of the bit body by shearing at the bottom of the socket or splitting up the skirt was frequent. Brazing failures of the tungsten carbide insert, or shattering of the insert also took place before much wear of the tungsten carbide had occurred. However, as more experience was gained and the quality of the bits improved, better results were obtained, but so far no bit has been used to the extent that all of the usable portion of the tungsten carbide insert has been expended.

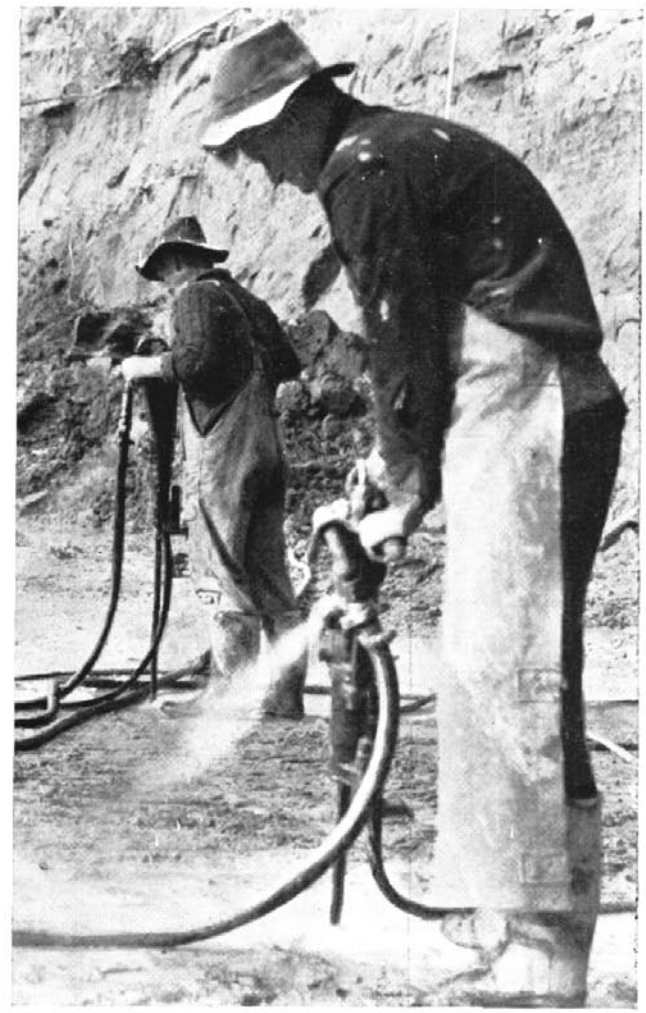
To date all drilling has been carried out with the jackhammers in normal use on the Department's works. These are of approximately 45 lb. weight and operate at 1,800 to 2,000 blows per minute. It may be that better results will be achieved with lighter and faster hammers, but it is evident that good results can be obtained with the equipment now in use.

Average air pressures have been about 80 lb. per square inch at the compressor, but more investigation is required to determine the best working pressure, which may vary with the type of jackhammer and the class of rock.

The bits used have been of the cross bit or eccentric cross bit type, and diameters have been 1⅜ in. and 1½ in. The circumferential wear on the bits is slow, and many feet may be drilled before it is impossible to "follow" an old bit with a new one of the same nominal size. Drill holes are therefore of uniform gauge, and the diameter of the hole can be kept to a minimum size suitable to the size of explosive in use.

Compared with the use of ordinary sharpened drill steels and detachable steel bits, the tungsten carbide bit is a precision tool and must be treated as such. For good results it is essential that the operator should be trained in its use, and close supervision of drilling should be given. The skill and concentration of the operator is most important. For example, dropping of a steel with bit attached down the drill hole so that the tip strikes hard on the rock can fracture the insert and result in premature failure. Allowing the machine to bounce can have similar results. Holding the machine at an incline to the drill hole can result in extra stress on the tips. From the time drilling starts the operator must concentrate on his job; he must keep the drill straight with the line of the hole, and must maintain an even pressure, and if any irregularity of drilling occurs, he must stop immediately to avoid damage to the bit. In addition, if an insert fractures, the drill hole must be blown out before proceeding with another bit, as fragments of the tungsten carbide can cause early fracturing of the following bit. If the hole is shallow, it pays to abandon it and start another. Starting (collaring) a hole at quarter to half throttle is another necessary precaution to avoid undue stress on the inserts.

Normal high carbon drill steels have been used for drill stems. This steel is designed to provide a cutting edge which can be hardened sufficiently, but yet not be so brittle as to fracture under repeated blows of the hammer. At the same time, the shank end needs to be soft enough to avoid damage to drill chucks and pistons. With the use of detachable bits or hard inserts in the



Drilling in Progress.

rod, the steel does not do the cutting, but it must be capable of withstanding the fatigue of repeated blows. It has been found that, using tungsten carbide tipped bits on ordinary drill steel rods, failure frequently occurs near the collar of the rod, or on the tapered end of the rod to which the bit is attached. The latter type of failure is particularly objectionable as "fishing" out the bit is difficult and slow, and the cost of each bit is relatively high. At present, there seems little choice for drill rods between ordinary high carbon drill steel and costly alloy steels, but local manufacturers are turning their attention to the production of special steels suitable for stems for use with the tungsten carbide tipped bit.

Removal of the taper-fit bit from the steel is done by laying the bit on a hard unyielding base, *e.g.*, a steel rail, and striking the body of the bit with a soft hammer. The bit body is momentarily expanded and frees itself from the rod. The inexperienced operator may "hammer" the bit, leading to distortion of the body, with the result that the taper is altered or early failure of the bit body occurs. Removal of the bit from the steel is a knack which is not easy to acquire. It is good practice to remove bits only when this is essential, due to the steel breaking, or when the bit requires regrinding. Manufacturers have adopted different tapers, generally between 3 degrees and 4 degrees, and if more than one make of bit is used, it is essential that steels be kept separate.

Regrinding of bits is done on a silicon carbide grinding wheel. A normal pedestal grinder may be used. A roughing grade of silicon carbide (such as 39/60 I. or J. Australian Abrasive) is used to bring the inserts back to their correct shape and a finishing wheel (such as 39/120 I. or J. Australian Abrasive) for removal of grinding marks. The object of regrinding is merely to restore the cutting edges to their original shape, and it should be done when there is a noticeable lowering of the drilling speed.

Preparation of tapers is done in a lathe, a ring gauge or new bit being used as a check. After cutting the taper, fine emery should be used to remove machining marks. No firm evidence is yet available as to whether the tapered end of the steel should or should not be heat treated.

There are many difficulties to be overcome and much to be learned in regard to the use of the tungsten carbide tipped bits. However, there is little doubt that their introduction to rock drilling, particularly in the harder rocks, is a great advance in rock excavation work.

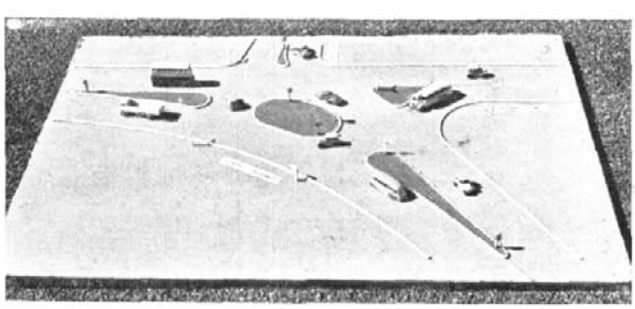
Road Safety Exhibition.

Display by Department of Main Roads.

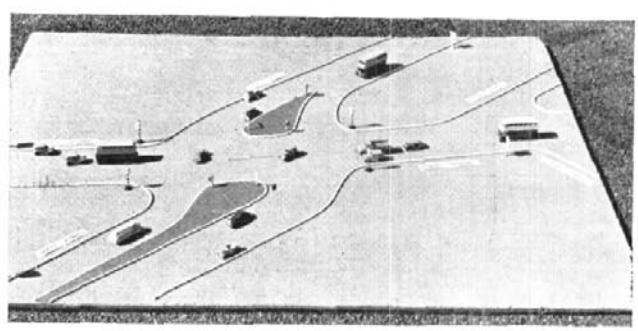
The Department of Main Roads displayed several exhibits at the recent Exhibition of the Road Safety Council of New South Wales. The exhibition was held at the Sydney Town Hall from the 29th August until the 10th September, 1949.

One of the Department of Main Roads exhibits was the model, illustrated on page 47, of proposed improvements on the southern approach to the Sydney Harbour Bridge. A model of a proposed expressway on the western side of the central business area of Sydney was also displayed.

Other exhibits of the Department of Main Roads are illustrated hereunder, and relate to traffic line-marking, and to the improved lay-out of main road intersections by use of traffic safety islands.



This model illustrates a method of treating a "Y" junction by providing traffic safety islands to direct approaching traffic into proper channels. The islands also afford refuge to pedestrians, and shield vehicles from cross traffic.



The Cross Roads shown above have been provided with safety traffic islands serving the same purposes as in the case of the "Y" junction. Traffic is assisted also by automatic signals controlling crossing movements.

Display Board and Traffic Line Marking model.

Improved Toll Facilities, Sydney Harbour Bridge.

With the growth of traffic over the Sydney Harbour Bridge, delays have been occurring at the toll barrier, especially at the morning and evening peak hours. Action is therefore being taken to construct a longer barrier with sufficient openings not only to meet present requirements, but also to provide for further traffic growth.

The existing toll barrier has six traffic lanes. At the present time, during the morning peak hour, 8.10 a.m. to 9.10 a.m., when five lanes are available for inwards traffic, about 3,400 vehicles pass the barrier. About 3,100 vehicles pass during the evening peak hour, from 5 p.m. to 6 p.m.

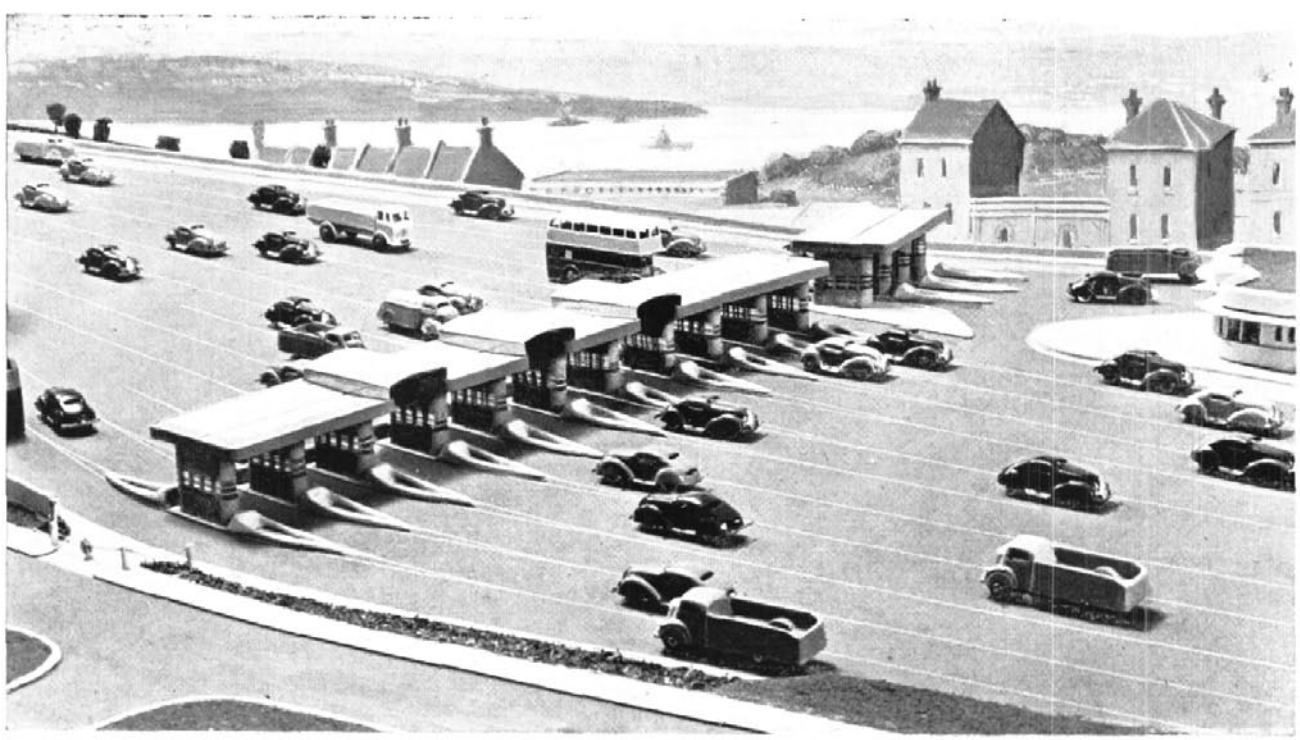
The new barrier will be about 400 feet south of the existing barrier, *i.e.*, closer to the City, and will provide for twelve lanes of traffic. In addition, room is available for a further four lanes to be provided later on the turn-out to the Quay overhead roadway, which is being constructed to take traffic to the eastern and southern sectors of the City.

Of the twelve lanes, eight will each have 12 feet vertical clearance, two will have 15 feet, and the remaining two, on the ends of the barrier, will not be roofed and therefore will be available for especially high loads as well as for general traffic.

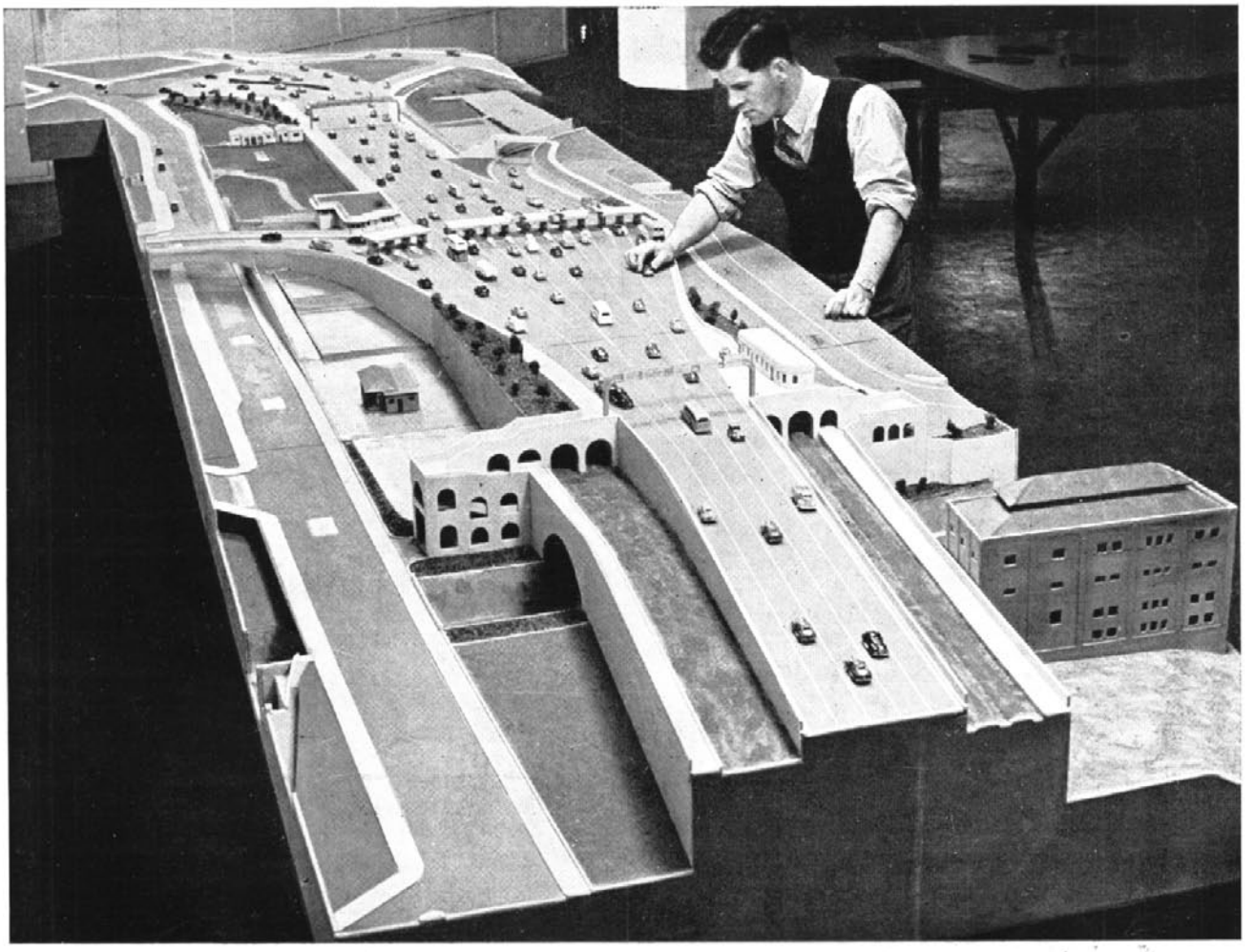
There has been some delay in the erection of the new toll barrier on account of the impracticability of obtaining tenders for the steel-framed structure originally designed. A design using timber framing has now been prepared, and the barrier is being built in portable sections, at the Department of Main Road workshops. The roadway of the Bradfield Highway is being widened to accommodate the longer barrier.

The cabins will be rectangular with semi-circular ends, and the upper half of each will consist mainly of safety glass. Maximum practicable protection both of cabins and of occupants will be secured by the construction of concrete prows specially designed to guide vehicles safely through the barrier lanes. All except the two outer lanes will be provided with large "Open" and "Closed" signs in neon tubing. Arrangements are being made for intercommunication between collectors and supervisors.

The present "comb" of yellow traffic lines painted on the road pavement approaching the existing toll barrier will be reproduced at the new barrier, to guide traffic to the various openings. Other traffic lines in approach will be provided so that there should be no grounds for hesitation by drivers, or unexpected crossing or jockeying movement of vehicles.



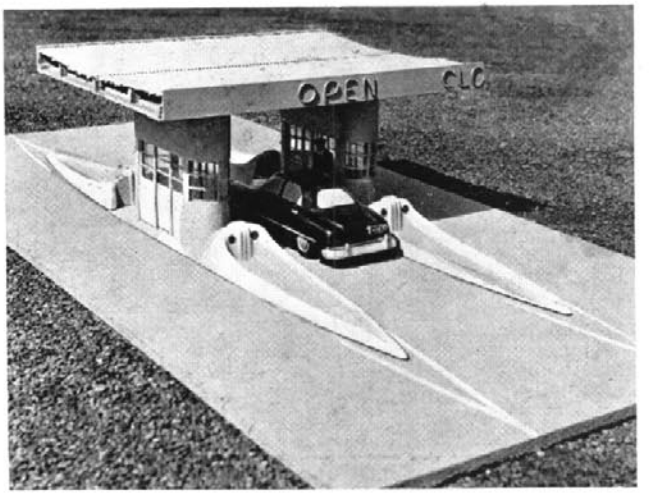
The new Toll Barrier as it will appear when constructed.



Bradfield Highway looking south from southern end of Sydney Harbour Bridge showing model of new Toll Barrier.

General lighting of the barrier and surroundings will be by kerbside standard lamps of design similar to those now on the bridge approaches. The spacing of the lamps and their power are being arranged to meet the special requirements of the site.

It is anticipated that the new toll barrier, except for the section over the incomplete Quay roadway, will be in use early in 1950.



Model of Toll Cabin with protecting prows.

The New Spit Bridge—Details of design.

The existing bridge at The Spit was designed and built in 1924 by the Sydney Harbour Trust on behalf of the Manly Municipal Council. It was a toll bridge until 1930. After the toll was removed, the bridge passed to the control of the Department of Main Roads.

For some years now the Spit Bridge has been unable to carry peak road traffic without considerable delay. The time taken to open and close the bridge for harbour traffic also adds to the congestion. The bridge itself has deteriorated and is approaching the end of its useful life.

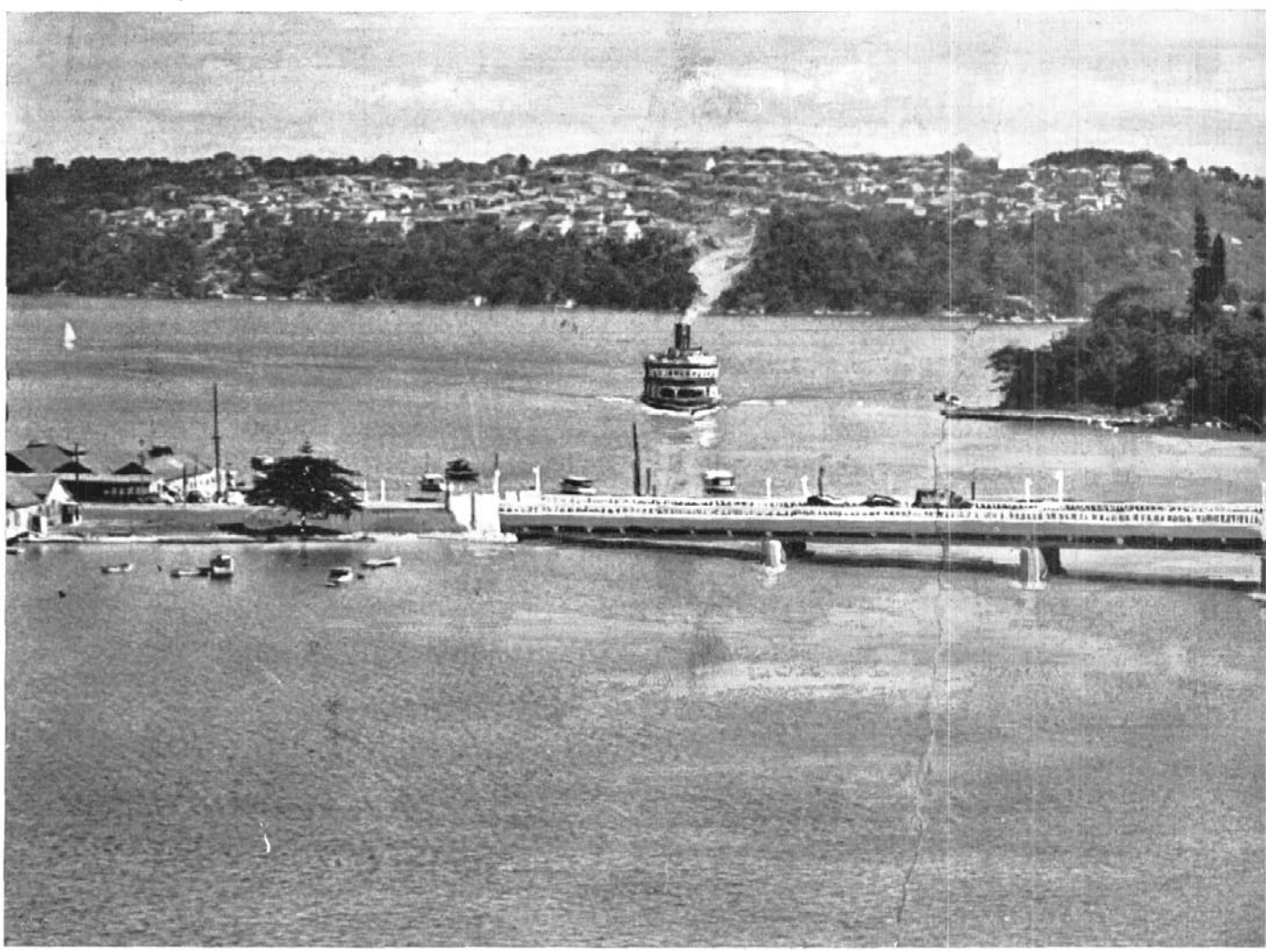
Tenders will shortly be called for the construction of a new bridge more than twice the width of the present bridge, to be situated just downstream from the existing bridge. The new bridge will be a more substantial structure, and of better appearance. The existing poorly aligned approach on the southern side will be improved, and ultimately a new approach road will be built on the north side leading to Sydney road and the Wakehurst Parkway.

Brief particulars of the new bridge are as follows:—

Length: 745 feet.

Width: Carriageway 44 feet; two 5-ft. footways.

Grade: Uniform at 2 2/3%, rising towards the north.



An artist's impression of the new br

Clearance for shipping—

(a) Through fixed Spans: Vertical, 24 feet; horizontal, 88 feet;

(b) Through opening Span when open: Vertical, unlimited; horizontal, 80 feet.

The substructure will consist of concrete, some piers founded on rock at depths varying up to 100 feet below water level, and some on concrete piles.

The superstructure will be wholly of steel and will include seven 100-feet spans of plate girder type. Shop work will be welded, and field work riveted.

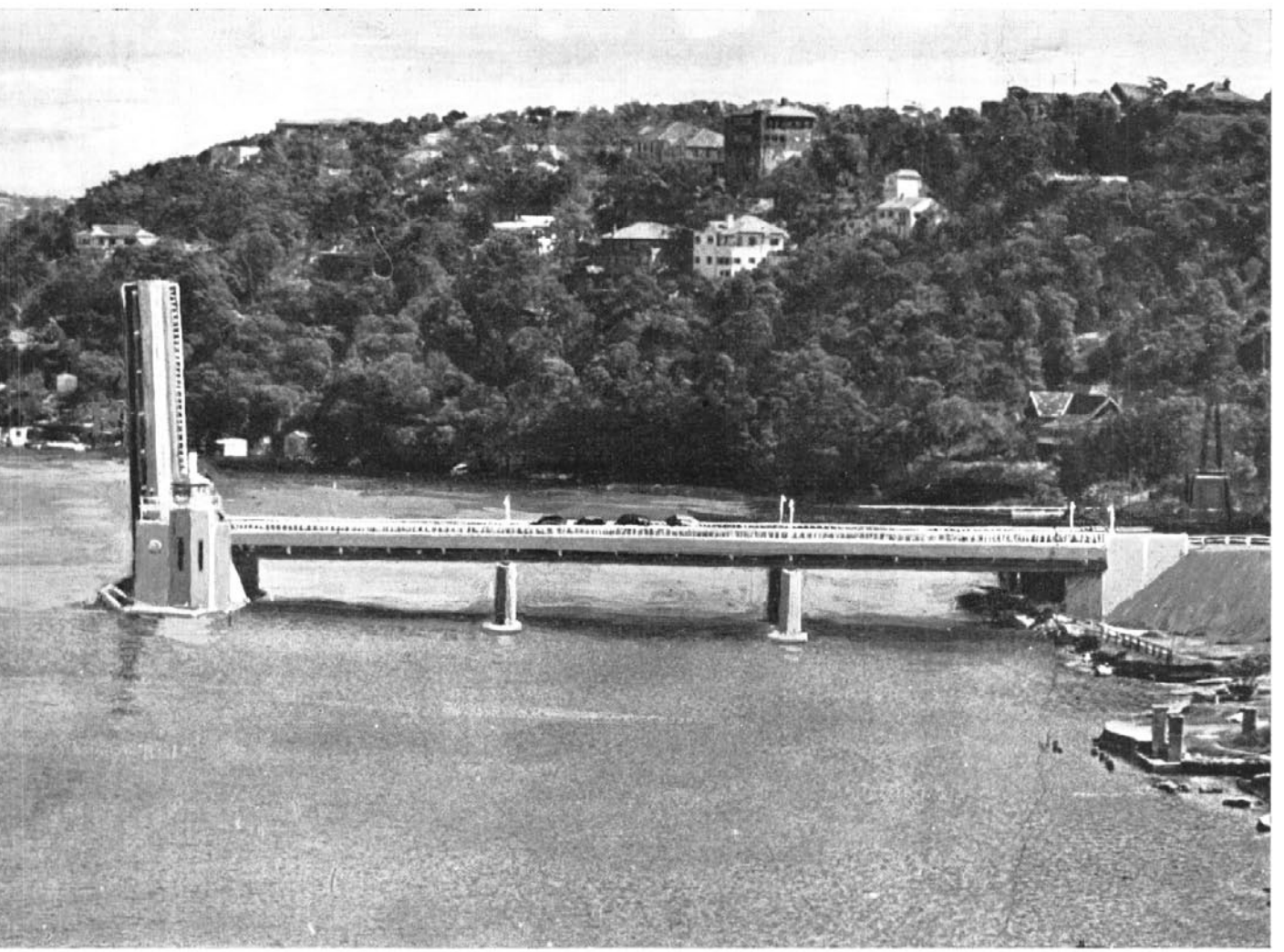
The footways will be carried on curved brackets cantilevered from the outside main girders.

All steelwork will be painted light grey, except the handrail which will be aluminium coloured to assist night visibility.

There will be room for four lanes of vehicular traffic. Protective railing will be installed between the carriageway and the footways to keep pedestrians off the carriageway. Road traffic will be controlled by standard red, orange and green traffic control lights. A flashing red light will indicate that the roadway is to be closed and the span opened to shipping, and the gates, when shut, will be outlined with neon lights. Shipping will be controlled by red and green lights. The opening span will be operated in under a minute.

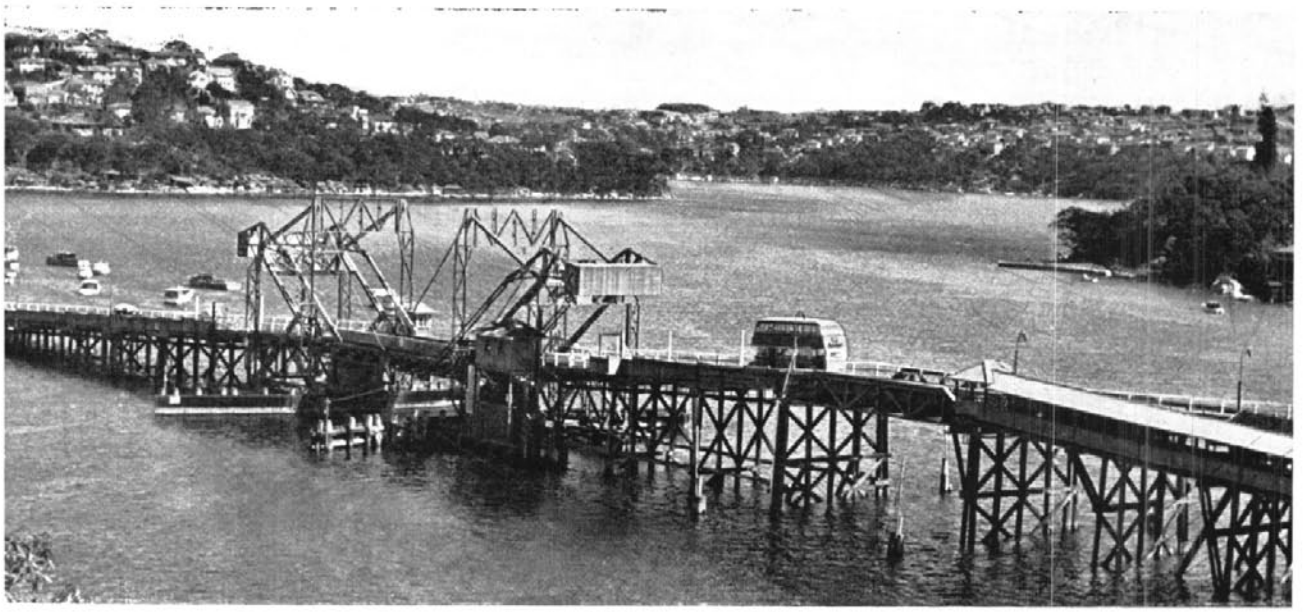
The operation of all lights, gates and opening span will be completely interlocked to ensure the utmost safety, and it is expected that the passage of water craft should not necessitate closing the bridge to road traffic for a longer period than three minutes at any one time.

The opening span will be of the single-leaf bascule type and will be electrically driven. An emergency engine is being provided. The counterweight and machinery will be located below deck and housed in one of the piers. When the opening span is in the closed position its appearance will be identical with that of any fixed span. The control cabin will be hexagonal, and built with ample window space to provide the operator with a good view of both road and harbour traffic.



pit with bascule span in open position.

Because the new and old bridges are in close proximity, the new opening span must necessarily be opposite the existing opening span to provide for harbour traffic during construction. For the same reason the new opening span will require to be erected partly or wholly in the open position.



Existing bridge at The Spit.

PAYMENTS FROM THE ROAD FUNDS FOR PERIOD 1st JULY, 1949, TO 30th SEPTEMBER, 1949.

	Amount Paid.
	£
COUNTY OF CUMBERLAND MAIN ROADS FUND—	
Construction of Roads and Bridges	142,910
Acquisition of Land and Buildings for Road Widening	6,235
Maintenance of Roads and Bridges	128,787
Interest, Exchange and Repayment of Loans	5,664
Other Expenditure	25,674
Total	£309,270
COUNTRY MAIN ROADS FUND—	
Construction of Roads and Bridges	256,040
Acquisition of Land and Buildings for Road Widening	1,840
Maintenance of Roads and Bridges	585,351
Interest, Exchange and Repayment of Loans	886
Purchase and repair of Plant and Motor Vehicles	68,265
Other Expenditure	46,752
Total	£959,134
DEVELOPMENTAL ROADS FUND—	
Construction of Roads and Bridges	16,848
Other Expenditure	792
Total	£17,640
SUMMARY ALL FUNDS—	
Construction of Roads and Bridges	415,798
Acquisition of Land and Buildings for Road Widening	8,075
Maintenance of Roads and Bridges	714,138
Interest, Exchange and Repayment of Loans	6,550
Purchase and Repair of Plant and Motor Vehicles	68,265
Other Expenditure	73,218
Total	£1,286,044

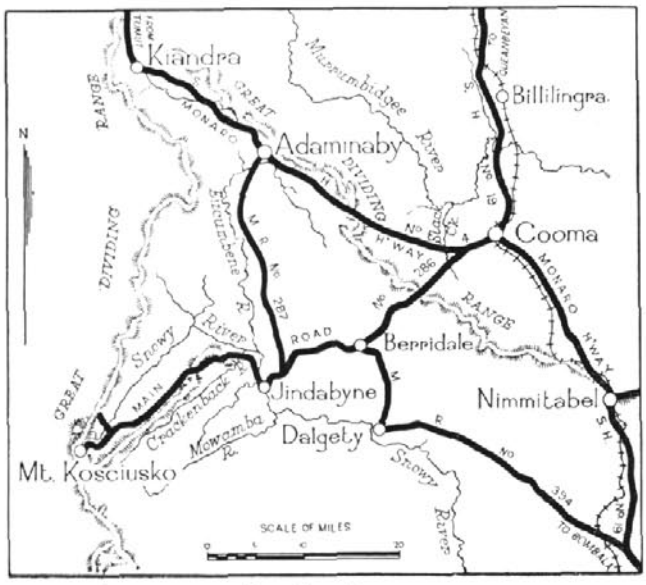
Main Road Reconstruction by Councils. Further Expansion of Bitumen Surfacing.

Shire of Snowy River. Main Road No. 286—Cooma to Mount Kosciusko. Reconstruction from Monaro Highway near Cooma towards Berridale.

The Snowy River Shire Council has completed the reconstruction and bitumen surfacing of the first four miles of that part of Main Road No. 286, extending from Monaro Highway to Berridale, a length of 17 miles. Main Road No. 286 extends from Monaro Highway (State Highway No. 4) at 4.2 miles west of Cooma, generally in a south-westerly direction through the villages of Berridale and Jindabyne to the summit of Mount Kosciusko.

A progressive programme of reconstruction to bring the Cooma-Berridale section of this road to a standard suitable for bituminous surface treatment was considered by the Council and the Department in 1938, and plans were prepared by Council for the section between 4.56 miles and 8.47 miles from Cooma. This section is generally through easy, undulating, grazing country and a general design standard of 50 miles per hour was adopted. Reconstruction, including the provision of a gravel pavement, was carried out in 1941 by Council by contract, at a cost of £5,643.

An open crossing at Slack's Creek about eight miles from Cooma was also eliminated by the construction in 1941 of a small concrete bridge. This bridge, designed by the Department, has a skew of 35 degrees, and consists of three slab spans, each of 20 feet, with a width of 20 feet between kerbs. The work was carried out by the Council by contract at a cost of £1,634.



Locality Map.

M.R. 286 approaching Cooma after reconstruction and bituminous surfacing.

Work could not proceed during the war years, but subsequently strengthening of pavement and bitumen surfacing have been completed. The strengthening and general reconditioning of the pavement was carried out by Council with its own forces. Cover aggregate was obtained from Shellharbour and railed to Cooma, as suitable supplies are not at present readily available in the Monaro area. The bituminous surface treatment work was carried out by the Council by contract. The contract comprised supply, heating, fluxing and spraying of priming tar and binder, together with the spreading and incorporation of cover aggregate. Cover aggregate of ¾ in.-½ in. grading was used to provide a non-skid surface. The strengthening and bituminous surface treatment of the section between 4.56 miles and 8.47 miles from Cooma was completed in January, 1949, at a cost of £6,892, so that with reconstruction work completed in 1941, the total cost amounts to £12,535, excluding the bridge at Slack's Creek.

A short connecting length between the Monaro Highway and the end of the bituminous surface at 4.56 miles is at present being reconstructed by Council in conjunction with similar work being undertaken by the Department and the Monaro Shire Council on the Monaro Highway, and on completion will provide a continuous section of 8½ miles of bituminous pavement from Cooma towards Berridale.

Surveys, together with the preparation of plans, are in hand by Council for the construction of further sections of Main Road No. 286 extending towards Berridale and Jindabyne.

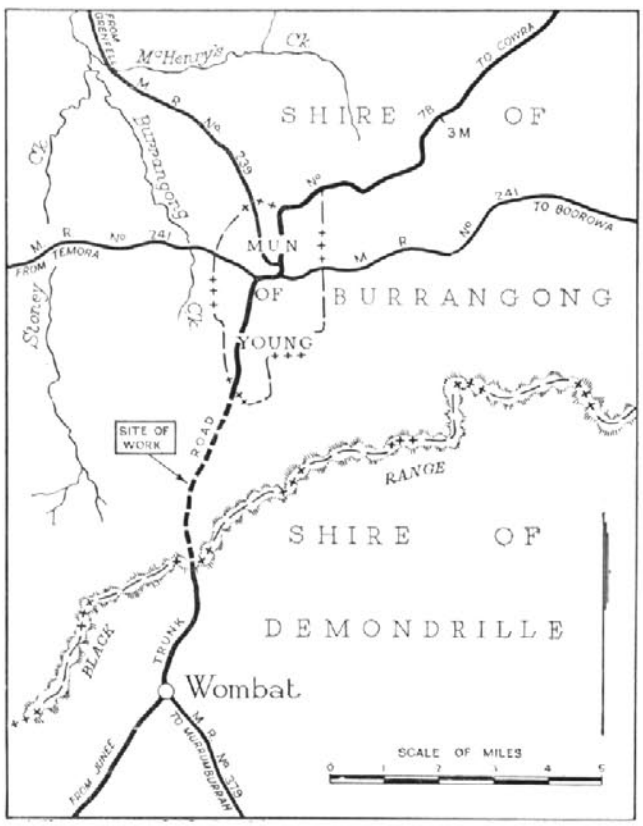
Shire of Burrangong. Trunk Road No. 78. Young-Cootamundra. Reconstruction south of Young.

The Burrangong Shire Council has recently undertaken the reconstruction and bitumen surfacing of 3.25 miles of Trunk Road No. 78 between the Young Municipal boundary at 2.61 miles and the Demondrille Shire boundary at 5.86 miles. Trunk Road No. 78 connects Trunk Road No. 57 near Old Junee and the Mid-Western Highway (State Highway No. 6) at Cowra. With Trunk Road No. 57 it therefore forms an important cross-country link between the Sturt and Mid-Western Highways. It carries heavy local and other traffic, and passes through the large towns of Cootamundra and Young.

The section of road being reconstructed traverses hilly and undulating country with a gradual rise to the Black Range, which forms the Shire boundary. The location of the old road was affected by three rocky spurs, and the alignment was of low standard in this vicinity. In addition there was poor visibility at several crests.

The reconstruction is now in progress, providing for minimum horizontal curvature of 1,200 feet radius with minimum visibility of 650 feet except for a crest of 3.61 miles, where visibility is restricted to 370 feet. The design is for a speed of 50 miles per hour.

At 3.96 miles from Young a narrow two-span timber bridge, dating from 1872, has been replaced by a reinforced concrete box culvert as part of the reconstructions.



Locality Map.

Construction in progress on T.R. 78 south of Young.

A contract has been let by the Council for the road reconstruction, which comprises 20,087 cubic yards of earthwork including 700 cubic yards of rock excavation, 34,400 square yards of gravel pavement constructed to a consolidated thickness of 8 inches, adjustments to fencing, catch drains, guide and fender posts, and clearing, etc. The construction of reinforced concrete box culvert and pipe culverts is being carried out by the Council with its own forces. The estimated cost of the work, excluding bituminous surfacing, is £11,620.

There are a number of small holdings adjacent to Trunk Road No. 78, near Young. Orchards and poultry farming are the main industries. The section of the Trunk Road at present being reconstructed is the most heavily trafficked road in the Burrangong Shire. On completion it will be possible to transport produce to Young more rapidly, and safer and smoother travel will be provided for traffic in all weathers.

The adjacent section of Trunk Road No. 78 in Demondrille Shire is also being strengthened and bitumen surfaced between the Shire boundary and Wombat by the Demondrille Shire Council. Thus by 1950 the whole length of the Trunk Road between Wombat and the northern boundary of Young Municipality should be provided with a bituminous surface.

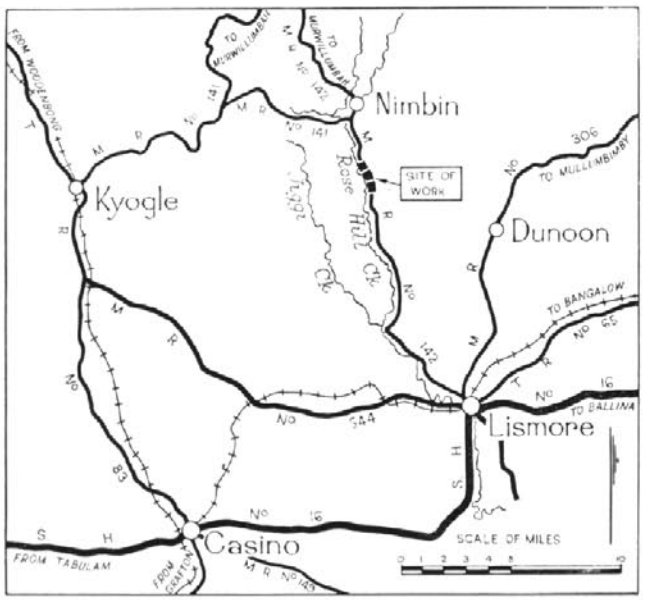
Shire of Terania. Main Road No. 142. Reconstruction on Lismore-Nimbin Road.

The Terania Shire Council is realigning and reconstructing 1.38 miles of Main Road No. 142 between 11.82 and 13.2 miles from Lismore, as a further stage in the progressive improvement of the road from Lismore to Nimbin, 19 miles away. At present the road has a bitumen surface from Lismore to the commencement of this section. The bitumen surface will later be extended over the section now being reconstructed.

This road serves a rich dairying district, and is part of through routes to Murwillumbah and Kyogle. The country is hilly, the rocks varying from sandstone to basalt. The section now being constructed had been gradually improved from a winding track by widening

and improving the pavement surface, but the alignment and grading were inadequate and it was found necessary to deviate for practically the full length.

The work has been designed to the Department's standards for 30 miles per hour, with formation and pavement widths of 24 feet and 16 feet respectively. The 8-inch pavement is made up of a 5-inch base-course of crushed basalt, and a 3-inch fine crushed



Locality Map.

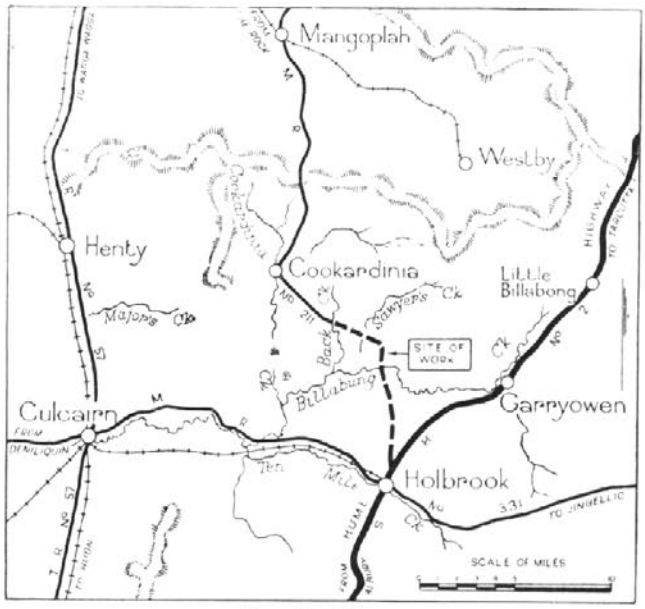
rock surface course. As the local sandstone was not hard enough for a base or surface course, and no gravels or other road-making materials are available, crushed rock from a Council quarry within a mile of the work was used.

The work is being carried out by Council by day labour. The earthworks, which total 13,536 cubic yards, were mainly in sandy soil with sandstone boulders in places. The total estimated cost of the work, not including bituminous surfacing, is £9,324.

Earthworks in progress on M.R. 142 approaching Nimbin.

Shire of Holbrook. Main Road No. 211—Holbrook-Wagga. Bituman surfacing from the Hume Highway (State Highway (No. 2) to Holbrook Shire boundary.

The Holbrook Shire Council and the Department agreed in 1947 to the provision of a bitumen surface on Main Road No. 211 for 9.35 miles, extending from the Hume Highway at Holbrook to the Culcairn Shire boundary at Back Creek.



Locality Map.

The road passes through excellent wheat and grazing country. The country is undulating near Holbrook, and fairly flat near Back Creek.

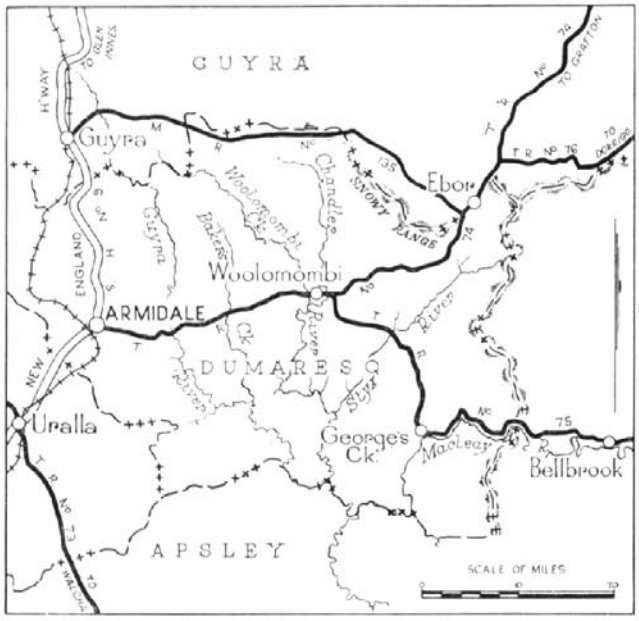
Gravel re-sheeting and improvement to a vertical curve about one mile from Holbrook was commenced about July, 1948. Good quality granite gravels were available locally. Gravel re-sheeting was carried out by the Council by contract and shouldering by the Council's own forces. Bitumen surfacing was carried out early in December, 1948, by the Council by contract.

View of typical section of completed bituminous surfacing on M.R. 211 near Holbrook.

The completed surfaced pavement has good riding qualities, and will give considerably improved service in the form of smooth and dust-free travel. The total cost of the whole work was £11,192.

Shire of Dumaresq. Trunk Road No. 74. Reconstruction from Armidale towards Grafton.

Trunk Road No. 74 traverses Dumaresq Shire from west to east for a distance of approximately 54 miles. From Armidale to 35 miles east, the road follows undulating to steep tableland country consisting of decomposed shale. From 35 miles to 48 miles east it climbs through granite outcrops into the Snowy Range to a height of 5,000 feet some miles south-west of Ebor. Over the remaining 6 miles of the length in the Shire the road passes over a basaltic plateau. Between Armidale and Ebor there are 16 stream crossings of which 15 are already bridged by timber or concrete bridges, whilst a survey is proceeding for a bridge at the sixteenth crossing, over Baker's Creek. The largest structure is a timber truss bridge 193 feet long over the Chandler River near Wollomombi, while altogether there are five bridges more than 100 feet long.



Locality Map.

Progressive improvement in past years has produced a gravel road, with a few isolated sections of bituminous surface, which is open to traffic at all times except in periods of severe flood such as occurred in August, 1949. Recent improvements include a minor realignment 2½ miles from Armidale carried out by Council in 1941, and reconstruction of the most easterly five miles in the Shire by the Department in 1941-42, for the purpose of connecting the then newly constructed Guyra-Ebor Road (Main Road No. 135) to the Ebor-Dorrigo Road (Trunk Road No. 76).

During October, 1947, the improvement of the section from 4½ miles to 8½ miles from Armidale was begun. This work, which is estimated to cost

A section of completed work on T.R. 74 near Armidale.

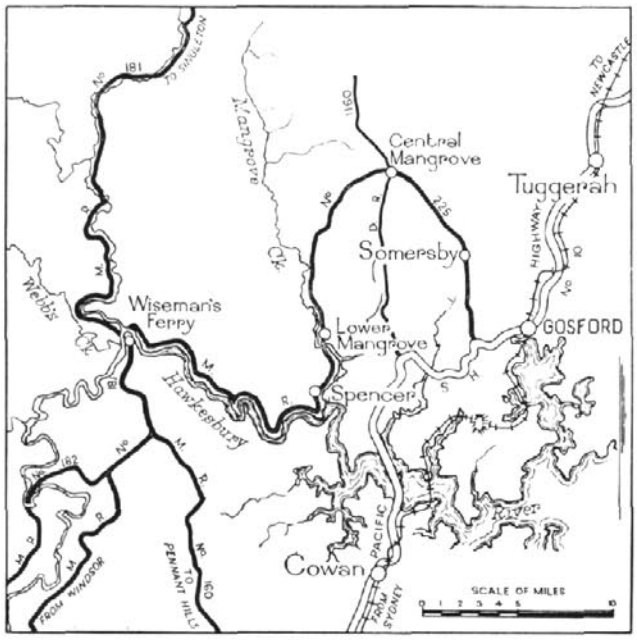
£8,156, provides for construction to a 50-miles-per-hour standard, mainly on new location. It includes clearing, fencing, new concrete pipe culverts, 17,000 cubic yards of earthworks and 37,000 square yards of gravel pavement 18 feet wide. Construction is being undertaken by Council's day-labour organisation. Wherever possible mechanical equipment has been used. The gravel pavement is tentatively fixed at 7 inches consolidated thickness, but as bituminous sealing of this length of road is to follow as soon as construction is completed, tests of both the subgrade and the gravel for pavement are being carried out with a view to the provision of a satisfactory foundation for the bituminous surface. It is proposed to build the pavement in two stages consisting of a base course 4 inches thick to be opened for traffic so that it will be consolidated before being topped with a sufficient thickness of first-class gravel suitable for bituminous sealing.

It is proposed also to proceed later with the reconstruction and sealing of the length from 8½ miles to 12½ miles, and when this is done approximately one-quarter of the length of Trunk Road No. 74 in Dumaresq Shire will have been improved to modern standards.

Shire of Gosford. Main Road No. 225. Improvement near Gosford.

Main Road No. 225 runs from State Highway No. 10 at a point four miles south of Gosford, via Somersby, Central Mangrove, Lower Mangrove and Spencer to Wiseman's Ferry.

The road is tar sealed for a distance of approximately 3¾ miles from its junction with the Highway. As the first step in the general improvement and extension of the tar surfacing throughout the full length of the proclaimed road, the Gosford Shire Council has completed the reconditioning of the gravel pavement between the end of the existing construction at Somersby at 7.7 miles from Gosford to Central Mangrove at 15.5 miles from Gosford, a total length of 7.8 miles. This section traverses the top of a ridge, which has been rapidly developed during recent years for citrus fruit and vegetable growing and poultry farming. It also serves as an outlet for timber from nearby forest areas.



Locality Map.

Prior to improvement, the road consisted of a gravel pavement varying in width from 14 to 16 feet. The pavement has been widened to a uniform width of 18 feet with 4 feet shoulders and the pavement crossfall corrected, the existing grading and alignment being retained. Widening of the formation and installation of additional pipe culverts was commenced by Council during August, 1948. Later a contract was let by the Council for the supply and delivery of gravel, which was obtained from a pit adjacent to the road near Somersby. The total quantity supplied was 11,507 cubic yards at a cost of 6s. per cubic yard including haulage for an average distance of approximately 4 miles. The spreading of the gravel and the widening of the formation was done by Council day labour.

Reconstructed length of M.R. 225 near Central Mangrove prior to bituminous surfacing.

Contracts have been let by the Council for the supply and delivery of aggregate and for the supply, delivery and spraying of tar. No suitable aggregate is obtainable locally, and it was originally intended that crushed slag from Newcastle be railed to Gosford and hauled by road to stockpiles on the roadside. However, because of shortage of rail trucks, it has been found necessary to haul the slag from Newcastle by road.

The total estimated cost of the work is £9,160.

The improvement and surfacing of this section will provide a good all-weather road for the haulage of primary products to the railhead at Gosford. The smooth surface on the new work will minimise damage to farm products being hauled over the road. The elimination of dust will increase the productivity of the orchards adjacent to the road.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the Department during the months of July, August and September, 1949:—

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Canterbury M. ...	167	Reconstruction from Fore Street to Beamish Street in cement concrete	Standard Concrete & Construction Pty. Ltd.	41,868 13 0
Liverpool M. ...	515	Construction of R.C. Culvert over Brickmaker's Creek ¼ M. west of Hume Highway	R. Smith	3,145 0 0

Tenders Accepted by Councils on page 64.

Forest Access Road Completed.

Upper Hastings District.

On behalf of the Forestry Commission of New South Wales, the Department of Main Roads recently completed the urgent construction of 17 miles of access road into the Bril Bril State Forest and Upper Hastings forest area, located about 20 to 25 miles north-west of Wauchope.

Improved access to the Forests was required to permit the use of large stands of both hardwood and softwood, and thereby to assist in meeting the large current demand for timber for housing and other purposes.

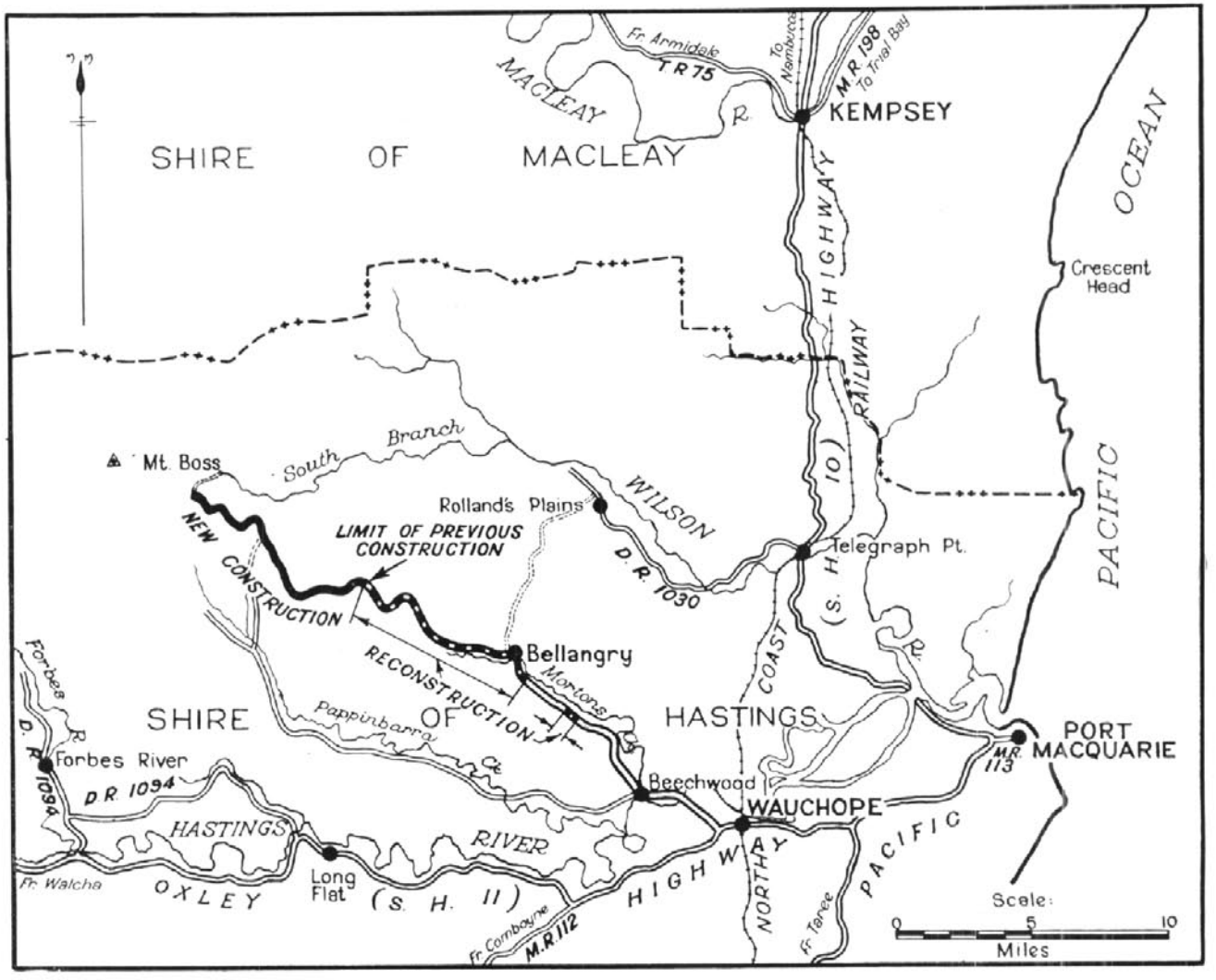
The general location of the access road built is shown on the locality map herewith. The work comprised the reconstruction of 6½ miles of existing road, commencing at Bellangry, 15 miles from Wauchope, and the construction of 9 miles of new road beyond this in the State Forest. In addition, the Department undertook 1½ miles of road reconstruction to the east of Bellangry. Further work on the existing road was carried out by the Hastings Shire Council.

The new forest access road climbs and then follows the range dividing the valleys of the Wilson and Hastings Rivers, passing through continuously steep country, heavily timbered, and in an area of high rainfall. It finally links with an existing forest access road which leads into the valley of the Wilson River.

The route of the new road was marked out by the Forestry Commission, which determined standards of design, as follows:—

Formation Width.—18 feet, widening to 21 feet on minimum radius curves of 100 feet.

Grades.—Up to 11½ per cent. in direction of load, up to 10 per cent. against the load.



Typical forest country in Upper Hastings District as seen from the new road.

Pavement.—Tapered section 6 inches thick in centre and 3 inches on edges.

Crossfall.—1 in 24 with maximum super-elevation of 1 in 16.

ORGANISATION.

In order to build the forest access road, it was necessary for the Department, on account of limitations of available plant and labour, to suspend construction operations on Main Road No. 511, Grafton-Glen Innes, and to transfer the men and plant to the more urgent work.

A depot, including office, staff quarters, workshop, etc., was established near Bellangry, with workmen's camp 3 miles further west.

The workshop established at the depot contained an electric generator to provide for workshop power and to supply current for lighting. Equipment in the workshop included a 10-ft. lathe, an hydraulic press, a pneumatic drill sharpener, an electric welder and several grinders.

The principal plant units used on the work comprised nine crawler tractors, mainly fitted with trail-builder attachments, two motor graders, two 6 cubic yard scrapers, five two-hammer and one one-hammer compressors.

About 60 men were employed.

MARKING OUT.

On account of the steep and timbered nature of the country, marking out the work presented some difficulty. First a walking track was brushed along the centre line. Batters were then set out by scale from cross-sections, checked by instrument in doubtful cases. Batter and recovery pegs were painted in distinctive colours to enable quick recognition. Depths of cuts and fills were marked on red discs placed conveniently as a guide to gangers and plant operators.

CLEARING.

As previously indicated, the country through which the 9 miles of new construction passes, is heavily timbered. Large trees averaged a hundred per mile of road, some being over five feet in diameter. In addition, there were extensive areas of dense brush or rain forest.

The method of clearing used for the first 4 miles of construction was as follows:—The roots of large trees, after being exposed by hand grubbing, were bored with augers and loaded with gelignite A.N. 60. A ground charge of up to 15 lb. of gelignite A.N. 40 was then placed beneath the tree, and all charges were fired simultaneously. This usually felled the tree, shattering the roots sufficiently to enable a heavy duty ripper to clear them from the formation. Where trees did not fall down a slope, they were bull-dozed or

Construction plant engaged in formation work through rain forest.

dragged out of the way. A trail-builder unit followed behind the blasting gang, constructing a pilot track on the line of the top batter, and cleaning off the debris.

The next 3 miles of construction were cleared by contract. The contractor used a tractor fitted with trail-builder and logging winch. Where the slope of the ground permitted, scrub and light timber were removed by dozing. Larger trees were removed by logging winch assisted by blasting where necessary. The sling of the winch rope was fastened about 20 feet up the trunk, and the tractor having retired to a safe distance, the winch set the tree swinging by timed pulls until it worked loose and fell. Where the ground was too steep or rocky for the tractor, hand grubbing and gelignite were resorted to as described previously.

The last 2 miles of clearing were completed in a manner similar to the first 4 miles with the exception that the trail-builder access track was run along the line of bottom batters, not the top. The trail-builder unit then pushed scrub and light timber downwards from the top batter, the operator being aware that, should his machine slide, he could halt it on the bottom access track. This method appeared safer and caused less trouble with thrown tractor tracks, bogged machines and machines sliding into positions whence they had to be dragged out.

A section of new road nearing completion.

EARTHWORKS.

The earthworks, which totalled 150,000 cubic yards, principally comprised excavation from cuts to fills on leads of about 200 feet, and sidecasting. For this reason the use of scoops was limited, and the bulk of the earthworks was carried out by trail-builder. The maximum side-slope of natural surface encountered was 46 degrees, a common average being 30 degrees, and in many cases benching was necessary at the toe of a fill for stability. Low retaining walls of random rubble were constructed at the toes of some fills, and at other points the line was slightly deviated to keep the formation wholly in cutting.

Scoops were employed to place borrowed material over rock cuttings, and on general earthworks opera-

A view on the newly constructed road.

tions where the lead was sufficiently long. A sheepsfoot roller was used for consolidation. Heavy duty power-controlled rippers were used extensively for tearing out stumps, loosening clayey soil and penetrating shale and softened diorite and granite.

Over 6,000 cubic yards of rock were moved by drilling and blasting. The greater part of rock excavation was through diorite, some porphyry and granite also being encountered. Drilling in rock was carried out by 35-lb. weight jackhammers driven by portable air compressors. A star-shaped bit was used, the bits decreasing in diameter by 3/16 of an inch for every 2 feet of drilling. Drills were sharpened at the depot by means of a pneumatic drill sharpening and shanking

machine. In the diorite, the hardest rock encountered, penetration was only 3 inches per drill, and the average footage drilled per day per jackhammer was only 18 feet. Extensive tests were carried out in the course of the work with special tungsten carbide tipped bits, with favourable results.

Catch drains were dug about 10 feet above the batter line on all sloping ground. In general the completed road was only a short distance below the crest of a ridge so that 18-in. diameter concrete pipes were sufficient in nearly every case for cross drainage. Subsoil drains were installed in areas where there was evidence of springs and where heavy wet black or red soil was encountered.

On the reconstruction section between Beechwood and Bellangry, a 20-ft. timber culvert was constructed, a 10-ft. diameter Armco pipe was installed and an 80-ft. low-level timber bridge was constructed across Morton's Creek. The Armco pipes of about 3/16-inch steel corrugated plate were assembled and bolted together on the site and strutted every 5 feet with 6 in. x 4 in. struts until the superimposed fill was consolidated.

PAVEMENT.

Gravel used for pavement consisted of volcanic tuffs, weathered shales and weathered diorite from roadside pits and, where practicable, was hauled by scoop. As the lead increased, lorries were employed, and these were filled by trail-builders using one "chinaman" loader and two side-loading ramps.

STATISTICAL DATA.

Quantities and unit costs for main items are as follows:—

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

Item.	Quantity.	Approx. Unit Cost.
Clearing	63·2 acres	£100 per acre.
Earthworks, including trimming and consolidation.	150,100* cu. yds. (solid measurement).	3s. 8d. per cubic yd.
Pipe culverts ...	3,990 lin. ft. ...	19s. per lin. ft.
Gravel (4½ inches average consolidated thickness).	191,960 sq. yds. ...	9d. per sq. yd.

*Includes 6,500 cubic yards diorite rock which cost £1 3s. per cubic yard to drill and blast.

SUPERVISION.

The design and construction of the work was under the general direction of the Department's Divisional Engineer, Mr. J. H. Mould, and the Resident Engineer, Port Macquarie, Mr. N. F. Hatcher, and later Mr. G. B. Cranna. The engineer in immediate charge of construction work was Mr. F. M. Learmonth, and in the later stages Mr. N. P. O'Grady.

Radio Telephone Communication between Glen Innes and Gibraltar Range.

Progress made with the construction of the new road from Glen Innes to Grafton, Main Road No. 511, Shire of Severn, made it necessary to consider transfer of the local office and depot to a point more centrally situated to the remaining work. A site on Dandahra Creek was selected, providing a good camp site with an abundant supply of good water.

The only means of obtaining land line telephone communication was by extending an existing single-wire party-line for a distance of four to five miles, making a total length of line of twenty-two miles approximately. Service obtained at the existing Gibraltar Range local office from a tapping only 10½ miles out along this line was poor and unreliable.

To test the practicability of wireless communication, an Army Type 109 Set and an Army Type FS. 6 Set were obtained. The 109 Set was purchased without Power Pack with a view to conversion to Mains Operation for use as the Base Station and the FS. 6 Set was obtained complete with Power Pack for battery use in the field.

In October, 1948, permission was obtained from the Postmaster-General's Department to carry out tests under Call Sign VL2DR on a frequency of 4460 Kc/s.

Dandahra Creek is approximately 38 miles air line distance north-east of Glen Innes, and it was decided to test over that distance approximately in a sector north to east.

Uniformly satisfactory results were obtained in a series of one day tests at airline distances of 37 miles north, 37 miles north-east, and 30 miles east of Glen Innes, and for convenience the FS. 6 set was installed temporarily at the Sandy Flat local office on the New England Highway, 37 miles airline north of Glen Innes, for the remainder of the approved test period. A total of 34 calls were made between Glen Innes and Sandy Flat, of which 30 calls were effective. Two calls were ineffective through poor atmospherics and two ineffective due to inexperience of the operators. The tests indicated that considerable interference could be expected from electrical appliances in Glen Innes, but that this interference could be avoided largely by judicious selection of operating times.

The results obtained were considered encouraging enough to justify an application for a permanent licence, particularly as the tests were carried out during the period of seasonal thunderstorms in the area. Licences

Glen Innes Divisional Office Radio Telephone Station VL2KT. Divisional Engineer Mr. L. Hawley operating.

were granted by the Postmaster-General's Department in July, 1949, for radio telephone communication between Divisional Office, Glen Innes, and the Local Office, Dandahra Creek. The principal conditions of the licences are:

(*a*) Both Divisional Office and Local Office installations be treated as fixed stations and both sets to be crystal controlled.

(*b*) The service to be used only for Departmental business connected with road construction.

(*c*) Licences to hold only until such time as the Postmaster-General's Department could provide land line telephone service.

Call signs VL2KT and VL2KU were allotted to Divisional Office and Local Office respectively, and the frequency allotted was that used during the test period, namely 4460 Kc/s.

The installation was placed in formal operation on 9th August, 1949, working to a fixed schedule of calls at 8.45 a.m., 12.45 p.m. and 4 p.m. (3.30 p.m. on Fridays). The Divisional Office receiver is switched on five or ten minutes ahead of schedule time and a call awaited from the Local Office. Divisional Office terminates the call.

During the period 9th August to 12th September, 1949, a total of sixty-two calls were made, of which fifty-eight calls were effective. Effective calls are those in which business was concluded satisfactorily to both parties. Town interference has proved less serious than anticipated, and is not troublesome, as a rule, for the 8.45 a.m. and 12.45 p.m. calls. The noise builds up during the afternoon. The main sources located up to the present time arise from operation of a picture show opposite the Department's office, drink mixers at a milk bar opposite and passing heavy motor vehicles. The picture show operates only occasionally during afternoons. While the drink mixers and passing vehicles necessitate the repeating of portions of messages at times they do not prevent effective communication being carried on. The sources of the most serious interference which at times make radio communication quite impossible for long periods of the day have not yet been located, but are believed to arise from diathermy equipment used by doctors, and welding sets.

Notes on Sets:

No. 109.—The transmitter uses three valves, type 807 for Oscillator, Radio Frequency Amplifier and Modulator, the circuit being more or less conventional, using anode tuning of the Oscillator. Plate modulation is used. Grid leak bias was provided but it was found necessary to modify it to part cathode and part grid leak bias to obtain stable operation with crystal control. The seven-pin crystal socket was altered to a five-pin socket to take a standard crystal. As used in the Army with battery and vibrator high tension supply, separate vibrators are used for the receiver and transmitter. As converted to mains operation, one transformer and a single 5V4G rectifier is used. Microphone current is obtained from a separate 6.3-volt winding, and the alternating current is rectified by 3 meter type 100 milliamp rectifiers in parallel. Wiring has been altered so that the drum-type contactor switch closes the high tension supply directly to the receiver on receive and stand-by positions and open circuits that supply on transmit.

On transmit a relay is operated which closes the high tension supply to the transmitter.

The receiver is a conventional superheterodyne containing six valves, being 6U7G radio frequency amplifier, 6K8G converter, 6U7G intermediate frequency amplifier, 6B6G second detector and 6B6G audio amplifier. A 6J7G valve is used as beat frequency oscillator. An additional 6V6GT valve was added for speaker operation.

FS. 6 Set.—This set is vibrator operated from 6-volt car batteries, it being found that two 6-volt 75 ampere hour car batteries in parallel were required for efficient operation.

The transmitter comprises two 1L5G valves as oscillator and modulator with an 807 valve for radio frequency amplification. The only adjustment made was the insertion of a five-pin ceramic socket for holding the crystal and the elimination of the feed-back coupling condenser used in the self-excited condition. Grid modulation is used.

The receiver is more or less of conventional superheterodyne design incorporating a reflex circuit and comprises the following valves: Converter, 1C7G; intermediate frequency amplifier, 1K7G; second detector, 1K5G; audio amplifier, 1K7G; and beat frequency oscillator, 1C7G. A 6V6GT valve was added for speaker operation and this valve is wired in parallel with the 807 transmitter radio frequency amplified valve. Both the 6V6GT and the 807 valves are alight at all times that the power pack is switched on so as to reduce delay awaiting heating up of the indirectly heated filaments.

Aerial System.—Various types of aerials were tried out during the test period, and finally a doublet half-wave antenna, centre fed with 72 ohm. coaxial cable, was adopted.

Reconstruction of Prince's Highway on northern approach to bridge over George's River.

The Prince's Highway (State Highway No. 1) from Belmore-road (Main Road No. 315) forms the northern approach to the George's River Bridge and as such is part of the main outlet for traffic from Sydney to the South Coast. Vehicular traffic is heavy. At week-ends, tourist traffic to the beaches and other recreation areas of the near South Coast is added to the normal traffic between the City and the rapidly expanding Sutherland-Cronulla District, and the longer distance traffic to Wollongong and points further south.

The old pavement consisted generally of a 20-ft. wide bituminous macadam surface, on poor alignment. It had a somewhat steep crossfall and traffic tended to travel along the centre of the road. The necessity for widening and reconstruction over this length of 5,660 feet became apparent prior to the war, and design was put in hand at that time. Due to war conditions, construction had to be deferred, but some formation work was carried out by Kogarah Municipal Council during 1940/41 to provide access to properties and to obtain sandstone for road purposes elsewhere.

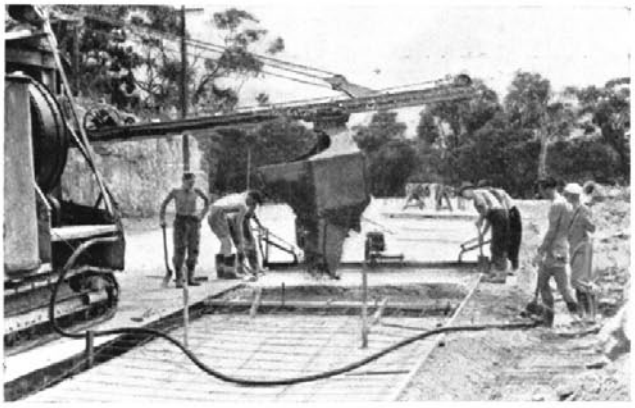
Design.—The design provides for a 60 ft. wide kerbed and guttered carriageway with a 12-ft. wide footpath and for much improved alignment. The pavement is of 1 : 2 : 3 cement concrete, 7 inches thick. For the present the carriageway generally will consist of a central 44-ft. wide strip of concrete pavement, comprising four 11-ft. wide travelling lanes, and two macadam parking lanes constructed with salvaged stone. The concrete pavement is carried out to the full width of 60 ft. at bus stops, most street intersections, and at the junction of Belmore-road (Main Road No. 315) with the Highway.

The original design provided for a circular plot at Belmore-road junction, but the completion of its construction was deferred following observations made of traffic movement at this point. As a result a plan model of an amended lay-out was prepared. All features of design in relation to traffic movement and control were studied in conference with Police and Road Transport Department representatives, following which an amended scheme was prepared. The approved design provides for a central island and four guiding islands, one located at the entrance to each carriageway.

Method of Carrying Out Work.—A depot was established on land near the northern end of the work. At the depot were situated the Local Office, aggregate stock-piles, cement store, explosive magazines, blacksmith's shop and subsidiary buildings. It also included a hutted camp established to accommodate employees from country districts and "new Australians."

The improvement of the alignment of the road involved the moving back of a weatherboard shop, and the demolition of a brick dwelling and public garage. Extensive relocation of public utility services was also necessary. The difficulty of obtaining pipe fittings

Reconstruction in progress on improved alignment.



Pouring of concrete. Vibrating screed in operation in background.

delayed adjustment of services. This, and the fact that diversion of traffic was not possible, resulted in the construction of the pavement being undertaken in short sections so that traffic could be diverted to a section of new pavement, while excavation of the old pavement was being carried out. The specified twenty-one days' curing period had to be allowed for in planning traffic diversion, involving the opening of a new section to traffic.

Approximately 4,000 cu. yds. of excavation had been originally carried out by Kogarah Municipal Council. A further 29,300 cu. yds. of excavation was required to complete the work. Eighty per cent. of this was sandstone. The proximity of buildings created difficulties and limited the size of blasting charges to a maximum of 5 lb., and to as little as ¼ lb. in some places. A skimmer shovel was used for loading spoil and for rough formation work.

Due to the shortage of ½-in. diameter mild steel for edge and corner bars, a strip of bar-mat reinforcement 4 feet wide was placed at the ends of each slab to prevent corner cracks, which are usually prevented by the corner bars.

The plant employed in concreting operations consisted of three bucket loaders equipped with measuring hoppers, a 27 cu. ft. paver, and a vibrating screed.

When the road width permitted, the paver was located near the longitudinal formwork and fed with dry batches from open trucks loaded at the depot by the bucket loaders. When this was not possible, the paver was set up in the depot as a central mix plant, and double batches of wet concrete were delivered to the forms in open trucks. This was avoided so far as possible, as the aggregate tends to segregate in the open trucks and hand-spreading from trucks is slow.

Final packing and levelling of the concrete was carried out by two to three passes of a vibrator mounted on a screed board, followed by transverse screeding with a long-handled float. The surface was then finished by dragging longitudinally with wet hessian.

When the surface of the slab was sufficiently hard to withstand the curing material without damage, the concrete was covered with sand, loam or earth to a depth of two (2) inches. This covering was kept moist for at least ten (10) days and remained on the concrete for at least fourteen (14) days. Traffic was not permitted on the concrete for at least seven (7) days after the removal of this covering.

Supervision.—Construction is under the general direction of the Department's Metropolitan Engineer, Mr. F. W. Laws. The Engineer in immediate charge is Mr. R. J. Milner.

Section of completed pavement.

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for Period 1st July, 1949, to 30th September, 1949.

Income.	£
Road Tolls	106,704
Contributions—	
Railway Passengers	32,989
Tramway Passengers	2,525
Omnibus Passengers	2,188
Rent from Properties	3,086
Miscellaneous	94
	£147,586

Expenditure.	£	£
Cost of collecting road tolls		7,193
Maintenance and minor improvements		15,823
Alterations to archways		1,723
Administrative Expenses		620
Loan Charges—	£	
Interest	60,250	
Exchange	6,000	
Sinking Fund	17,250	
Management Expenses	325	
		83,825
Miscellaneous		490
		£109,674

Visitors from Overseas.

A Civil Engineer from India, Mr. B. P. Patel, and a Technical Assistant from British North Borneo, Mr. C. P. Jayasuriya, are at present attached to the Department of Main Roads to study New South Wales methods of road planning, construction and maintenance. They will be with the Department for periods of four and five months respectively. Both have been awarded fellowships financed by the United Nations Organisation. The arrangements for the visits are in the hands of the Commonwealth Office of Education.

Mr. Patel is a roads engineer of the Indian Central Government stationed at Calcutta. He is a Bachelor of Civil Engineering of the University of Bombay. The fellowship which brought him to Australia is one awarded to technicians from under-developed countries. Such fellowships are intended to afford opportunities to observe and study in countries having an advanced level of technical competence.

Mr. Jayasuriya is an officer of the Government Service in the Colony of North Borneo, where he is engaged on building and civil engineering works. The United Nations Organisation fellowship under which he came to Australia is one awarded by the Commonwealth Government to various countries of East Asia to assist in the rehabilitation of war devastated areas, and to help in their development on the lines of advanced countries.

Mr. B. P. Patel.

Mr. C. P. Jayasuriya.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the respective Councils during the months of July, August and September, 1949.

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Baulkham Hills S.	160	Supply and delivery of 6,882 c. yds. gravel...	J. and A. Lighezzolo...	2,610 14 8
,, ...	160	Supply and delivery of 4,928 c. yds. gravel...	Ray Fitzpatrick and Co.	3,695 0 0
,, ...	160	Supply and delivery of 7,983 c. yds. dolorite	Blue Metal and Gravel Pty. Ltd.	5,288 14 9
,, ...	160	Supply and delivery of 2,694 tons aggregate	,, ,, ...	2,947 12 6
,, ...	160	Supply and application of 25,344 gals. of priming tar and 41,818 gals. of tar bitumen.	Australian Gas-Light Co.	3,817 9 4
Boomi S. ...	232	Supply, delivery and spreading of 6,400 c. yds. of loam ...	Muggleton Bros. ...	1,626 13 4
Carrathool S. ...	244	Supply, delivery and spreading gravel	Hardie & Co.	1,085 0 0
,, ...	387	,, ,, ,, ...	,, ...	1,377 10 0
,, ...	321	,, ,, ,, ...	,, ...	2,145 0 0
Colo S.	1194	Road construction between 1 m. 3,100 feet and 2 m. 1,800 feet.	J. and A. Lighezzolo ...	2,914 12 6
Cudgegong S. ...	216	Construction of approaches to bridge over Goorangore Creek.	A. C. Stephen and Sons	1,770 13 3
Culcairn S. ...	57	Supply and delivery of 4,680 c. yds. gravel...	T. G. Kirk	1,333 10 0
Gilgandra S. ...	18	Supply and delivery of 4,530 c. yds. gravel between 36 m. and 58.3 m. from Coonamble.	E. W. Hall	1,352 8 4
Goobang S. ...	1162	Supply, delivery and spreading gravel, 5 m. 2,789 feet to 9 m. 2,835 feet.	E. Short	1,490 19 0
,, ...		Supply, delivery and spreading gravel at various locations on Main Roads 57, 61, 233, 234, 238, 348 and 350.	,, ...	8,102 7 4
Gosford S. ...	...	Sealing and resealing Main Roads 225, 336, 504 and 505...	B.H.P. By-Products Pty. Ltd.	4,715 16 11
Hume S.	125	Supply, delivery and spreading 5,400 c. yds. gravel ...	H. A. Lea	1,350 0 0
Illabo S.	3060	Construction three-cell reinforced concrete culvert and approaches.	C. S. McCarthy ...	2,846 15 6
,, ...	57	Reconstruction 11 m. 307 feet to 15 m. 3,100 feet from Mitchell Shire Boundary.	G. A. Metcalfe and W. E. Grainger.	6,001 19 6
Kearsley S. ...	218 220	Supply and delivery of aggregate	Beavis Bros.	1,261 5 0
,, ...	218 220	Supply and spraying of coke oven tar	B.H.P. By-Products Pty. Ltd.	1,717 3 8
Liverpool Plains S.	55 72	Gravel resheeting 16.5 m. of road, including supply, delivery and spreading 20,781 c. yds.	H. T. Roach	9,340 7 6
Macintyre S. ...	134 135 130 137 187	Supply and delivery into stockpiles of 5,320 c. yds. crushed aggregate.	C. J. Chesterfield Constructions Ltd.	7,073 3 0
Mitchell S. ...	...	Supply and delivery of 4,500 c. yds. gravel, Wagga-Narrandera Road.	F. A. Delaney	1,170 13 3
Patrick Plains S.	128 213	Bitumen surfacing	B.H.P. By-Products Pty. Ltd.	1,057 10 11
Port Stephens S.	108	Supply and delivery of gravel	W. and M. Kennedy...	2,042 5 0
Severn S. ...	9	Reconstruction and realignment 432 m. 4,200 feet to 435 m. 3,500 feet.	Frost and Spriggs ...	6,562 18 0
Shoalhaven S. ...	1196	Construction of 4 m. 2,002 feet in three sections	J. Cater...	5,097 10 0
Timbrebongie S....	342	Supply and delivery 3,600 c. yds. gravel	R. E. Scarce	1,080 0 0
Tomki S. ...	1125	Replacement of McLennan's Bridge over Middle Creek ...	Kennedy Bros. ...	1,933 11 6
Wakool S. ...	319	Supply and delivery of aggregate at approximately 1 m. ...	S. G. Weekley	1,752 10 0
Walgett S. ...	12 329	Gravel resheeting 10 m. of road, including supply, delivery and spreading 10,400 c. yds.	Orkell Bros.	5,113 6 8
Waugoola S. ...	78	Resheeting with gravel 8 c. yds. per chain at various locations.	K J. Mackie	1,131 0 0
Wingadee S. ...	...	Supply, delivery and spreading 20,720 c. yds. sandy loam at various locations on Main Roads 129, 202, 205 and 383.	McClellan and Death ...	3,083 0 0

Tenders Accepted by Department, page 55.

Sydney: Alfred Henry Pettifer, Government Printer—1949.

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, 3 inches thick. (Revised, September, 1936.)
125* Cement Concrete Pavement (April, 1939) and Plan and Cross-section A 1147 (March, 1932).
466 Bituminous Flush Seals and Reseals—Fluxing of Binders. (January, 1949.)

GENERAL.

342* Cover Sheet for Specifications, Council Contract. (Revised, April, 1939.)
24B* General Conditions of Contract, Council Contract. (Revised, August, 1948.)
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.

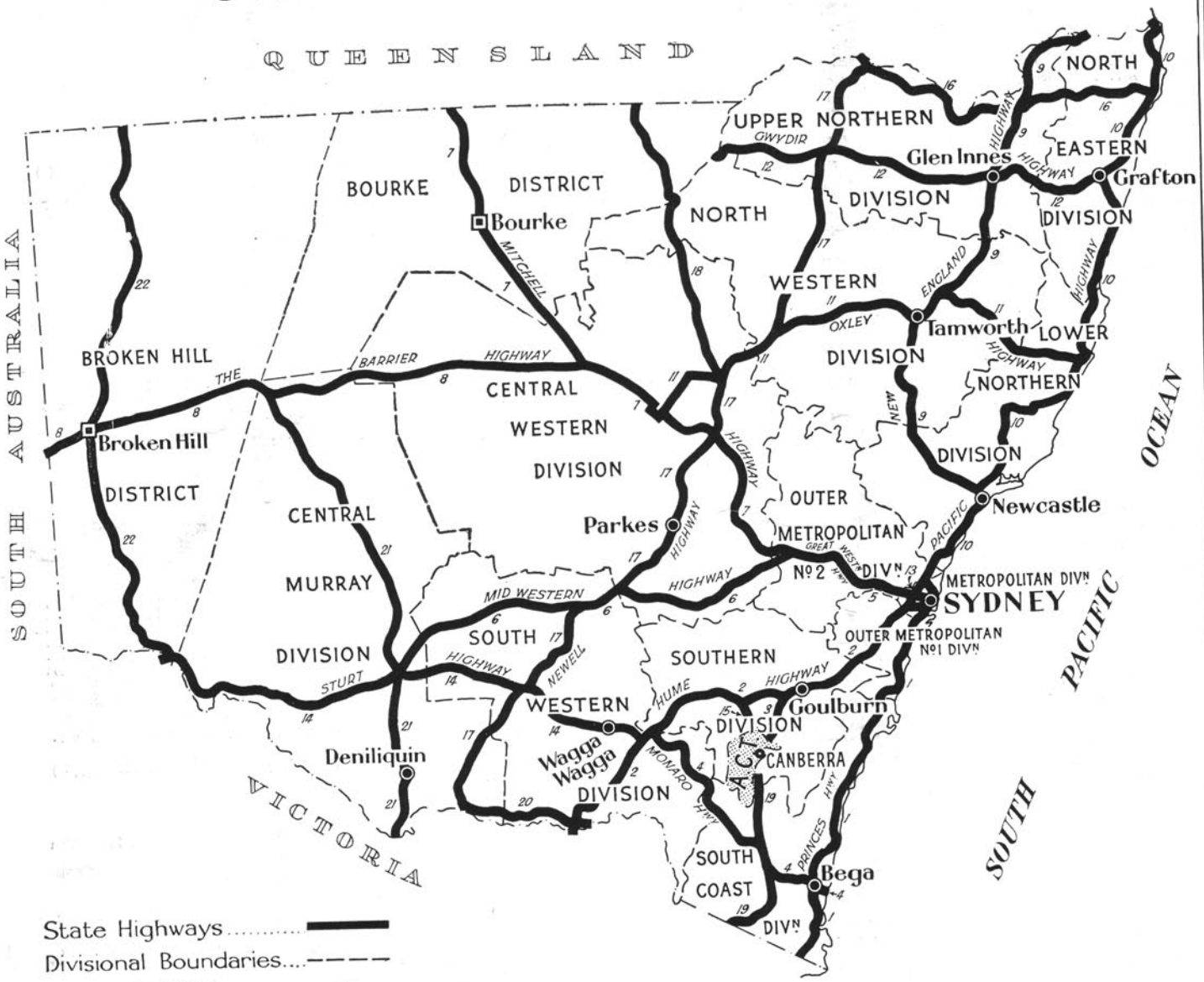
142 Split Post and Rail Fencing and Drawing (A 43).
141* Post and Wire Fencing (Revised, December, 1947) and Drawings (a) Plain (A 494); (*b*) Rabbit-proof (A 498); (*c*) Flood gate (A 316).
143 Ordnance Fencing (Revised, February, 1934) and Drawing A 7 (Revised, November, 1939.)
144 Chain Wire Protection 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 2847 Rod Sounding Apparatus. (1945.)
A 2995 Rod Sounding Apparatus, with tripod (1947).
25* Pipe Culverts and Headwalls (Revised, December, 1939) and drawings, Single Rows of Pipes, 15 in. to 21 in. dia. (A 143*), 2–3 ft. dia. (A 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).
A 311 Concrete Arch Culvert, 5 ft. high. (1931.)
A 314 Concrete Arch Culvert, 10 ft. high. (1931.)
206* Reinforced Concrete Culvert (Revised, February, 1948) and instruction sheets (A 305, A 359, A 306, A 304).
A 1832 Cast-in-Place Concrete Pipe Culverts. (1942.)
A 309* Concrete Culvert Posts. (Revised, June, 1937.)
300 Pile Drivers, specification for 25 ft., and drawings for 50 ft. (A 209) 40 ft. (A 253), and 25 ft. portable (A 1148).
A 1886 Arrangement of Bolting Planks for various widths of deck. (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, 16 ft. (A71), 18 ft. (A 68), 20 ft. (A 70) and 22 ft. (A 1761). (Amended August, 1946.)
A 1226 and A 1165 Low Level Timber Bridges, instruction sheets for 16 feet, and 18ft. between kerbs. (1932.)
A 1222, A 1166, and A 1223 Single Span Timber Culverts, instruction sheets for 16 ft., 18 ft. and 20 ft. between kerbs. (1931.)
139* Timber Culvert and drawings, 1 ft. 6 in. high (A 427), 2 ft (A 428), 3 ft. (A 429), 4 ft. (A 430), 5 ft. to 8 ft. high, (A 431). (1928.)
326 Extermination of Termites in Timber Bridges. (Revised, October, 1940).
A 222* Pipe Handrailing Details. (Revised, July, 1947.)
350 Reinforced Concrete Bridge. (Revised, January, 1946.)
495 Design of Forms and Falsework for Concrete Bridge Construction (September, 1947.)

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

State Highway System
of the
State of New South Wales



State Highways .....
Divisional Boundaries ....
Divisional Offices .....

SCALE
50 0 50 100 150 200

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