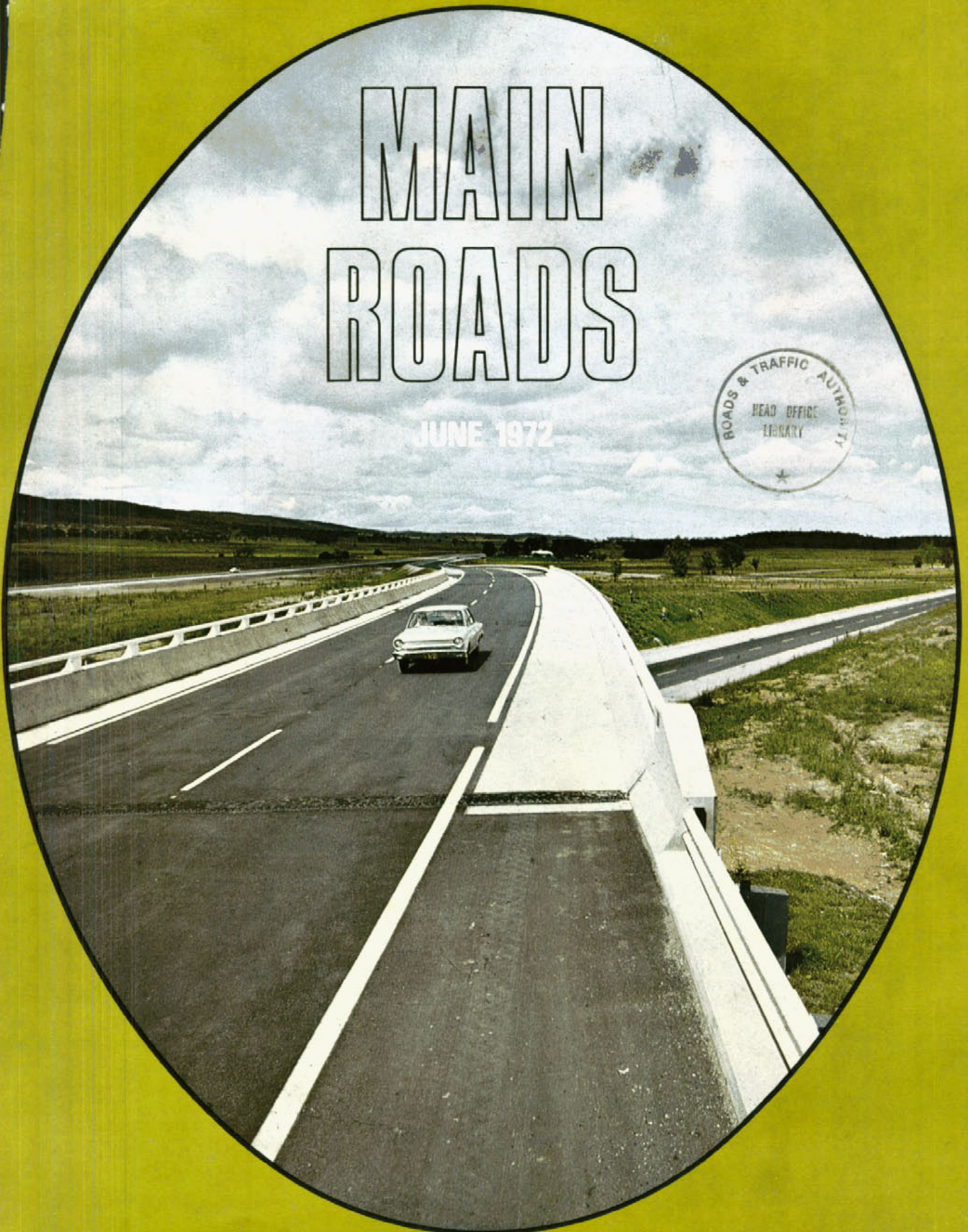
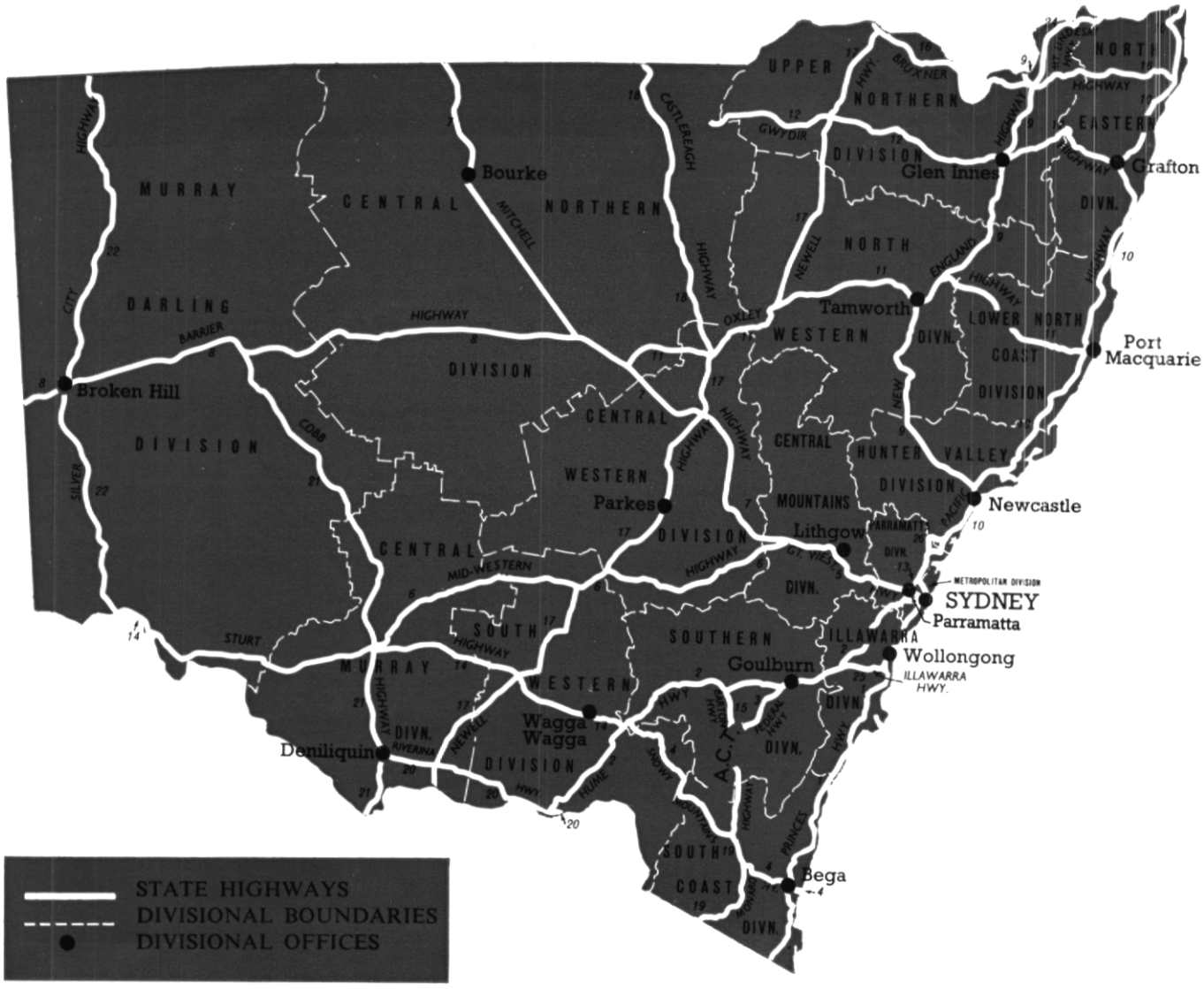
MAIN ROADS

JUNE 1972





Area of New South Wales—309,433 square miles

Length of public roads within New South Wales—129,745 miles

Population of New South Wales at 31st March, 1971—4,653,000 (estimated)

Number of vehicles registered in New South Wales at 30th June, 1971—2,009,831

ROAD CLASSIFICATIONS AND MILEAGES IN NEW SOUTH WALES

Mileage of Main, Tourist and Developmental Roads, as at 30th June, 1971

Expressways	27
State Highways	6,536
Trunk Roads	4,332
Ordinary Main Roads	11,513
Secondary Roads (County of Cumberland only)	170
Tourist Roads	243
Developmental Roads	2,670
	25,491
Unclassified roads, in western part of State, coming within the provisions of the Main Roads Act	1,569
TOTAL	27,060

MAIN ROADS

JOURNAL OF THE DEPARTMENT OF MAIN ROADS, NEW SOUTH WALES

JUNE, 1972

VOLUME 37 NUMBER 4

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R. J. S. Thomas

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Front Cover: Sparkling in the sunshine, this new overbridge carries Canberra–Sydney traffic—smoothly and safely—from the Federal Highway to the Hume Highway, south of Goulburn (see article commencing on next page

Back Cover: Reconstruction work on the Oxley Highway will soon bring improvements for travellers

—at the junction with the Newell Highway,
3·5 miles northeast of Coonabarabran (top),
—at 21 miles east of Walcha (centre left), and
—at 13 miles east of Walcha (centre right and bottom)

BEST FOOT FORWARD

Without a doubt the Hume Highway is one of the most historic routes in Australia. Just over 150 years ago, a new line of road was cut south of the Cowpastures (near Camden) using convict labour. The party consisted of one overseer, one guard or guide, one clerk, one bullock-driver and eleven labourers. Each man was supplied with one blanket, one jacket, two pairs of trousers, two shirts and *five pairs of shoes*.

In those days, roadmaking was a rough "occupation" that invariably meant aching arms and fatigued feet. With unskilled and often reluctant workers, it was not always successful. On a tour of inspection in 1820, Governor Macquarie noted that "the access to the top of the Cookbundoon Range is very steep, rocky and difficult owing to the bad construction of the Road up it, the Turnings or Traverses being very short and abrupt.

By February, 1821, the 75 mile route had been completed at a cost of £280 3s. 8d., including the erection of six bridges. In comparison, it recently cost the Department $3·26 million to complete 6·5 miles of dual carriageways south of Goulburn and an interchange with the Federal Highway (see details next page). On the Hume Highway, each mile of new dual carriageway is currently costing about $400,000 excluding major bridgeworks.

During the last five years, the Department has spent $16·4 million on construction works (excluding routine maintenance) on the Hume Highway between Camden and Albury. During the next five years it expects to spend a further $24 million.

It is proposed that the South Western Expressway (on which construction has commenced from Cross Roads near Liverpool to near Campbelltown), rather than the Hume Highway, will carry through traffic from Sydney to just north of Mittagong. From there to the Victorian border all new highway work is being designed as dual carriageways with two lanes in each direction.

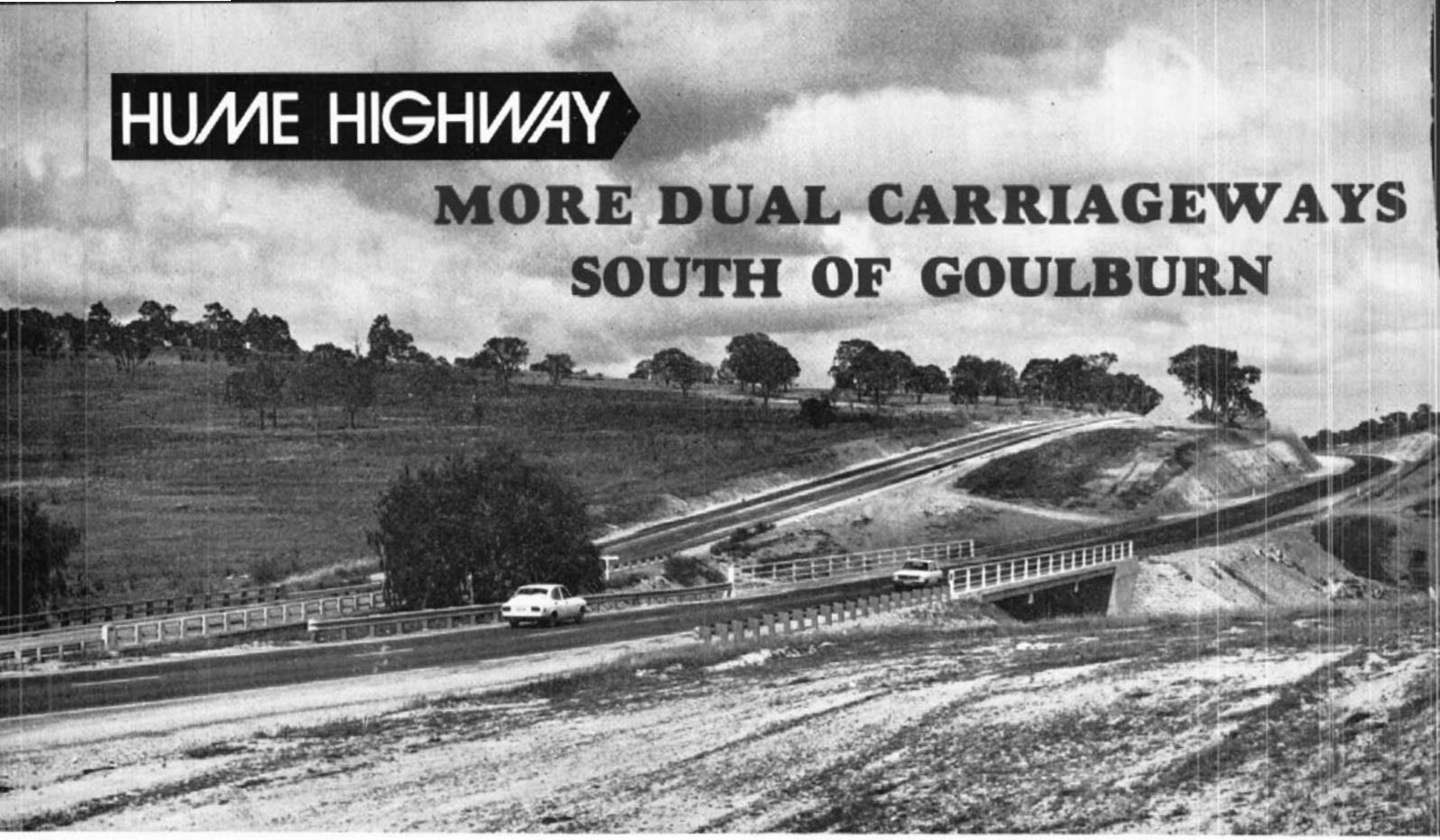
It does not detract from the importance of the Hume Highway to say that it is not the only major route in the State. There are 25 other proclaimed highways, all demanding reconstruction and maintenance . . . not to mention the expressways, trunk roads, tourist roads, developmental roads, etc. The need to find additional finance for main roads works is outlined in more detail in an article commencing on page 102.

Although it is evident that available finance is insufficient to allow the Department's ideals for the programming of improvements to be achieved, it is hoped that the Department's use of what resources *are* available means that motorists are getting the maximum value for their money.

To early roadmaking gangs, public service was their *penalty*. Today, it is our *pleasure*. The Department's skilled staff and employees are all eager to provide the community with the best road facilities possible. Even though the Department does not issue them with "*five pairs of shoes*", they still put their best foot forward.

HUME HIGHWAY

MORE DUAL CARRIAGEWAYS SOUTH OF GOULBURN



On 5th May, 1972, the Minister for Highways, the Hon. P. H. Morton, M.L.A., officially opened to traffic 6·5 miles of new dual carriageways on the Hume Highway, south of Goulburn.

The completed work extends from 2·3 to 8·8 miles south of Goulburn commencing at the end of the principal street system in Goulburn at Finlay Road (near the Workers' Arena) and terminating about 1·25 miles south of the old Federal Highway junction. In addition there are over 1·6 miles of dual carriageways extending from the Hume Highway along the Federal Highway towards Canberra.

Each of the dual carriageways is 24 feet wide flanked by wide sealed shoulders. In the overall work there are 33·2 lane miles of road, of which 27 lane miles are new construction. The balance of 6·2 lane miles is made up of sections of the old highway which were incorporated into the new work. It was necessary to:

- duplicate bridges over Run o' Waters Creek at approximately 3 and 7 miles south of Goulburn;
- provide two new bridges over the Main Southern Railway Line at 4·5 miles south of Goulburn;
- and also construct an overpass bridge at the junction of the Federal and Hume Highways 7·5 miles south of Goulburn.

The total length of new bridges constructed was 908 feet. The total cost of all road and bridge works was approximately $3·26 million.

Construction

The majority of the work on this programme was carried out by the Department's own forces, under the control of the Goulburn Works Office.

Work began on the project at the end of July, 1969, with the commencement of clearing for the new interchange.

Above:
New bridge over Run o' Waters Creek, 3 miles south of Goulburn, photographed when traffic was temporarily using the new northbound carriageway as a two-lane road

Left:
Construction of twin bridges over the Main Southern Railway Line near Yarra. Whereas road bridges generally used to be "square on" to railway lines, these bridges are at the unusually oblique angle of 60°

Some of the principal quantities involved in the project (including the overpass and interchange) were:

Earthworks:
Approx. 1,000,000 cubic yards.

Pipe and Box Culverts:
13,400 linear feet.

Pavement: 423,000 square yards.

Concrete: 3,700 cubic yards.

Steel guardrail: 5·45 miles.

Land acquired for road reserve:
230 acres.

Bridgeworks included the following:

- Run o' Waters Creek,
at 3 miles south of Goulburn.
Length: 122 feet.
Construction by Department.
Prestressed concrete planks supplied by Humes Ltd.

- Run o' Waters Creek,
at 7 miles south of Goulburn.
Length: 160 feet.
Construction by Department.
Prestressed concrete planks supplied by Humes Ltd.

- Railway Overbridges.
Each 168 feet long and 33 feet wide.
Construction by Department.
Steel fabricated by Normoyle Pty Ltd of Young.

- Overpass at Federal Highway junction.
Length: 290 feet.
Foundations by Department.
Superstructure by Central Constructions Pty Ltd.

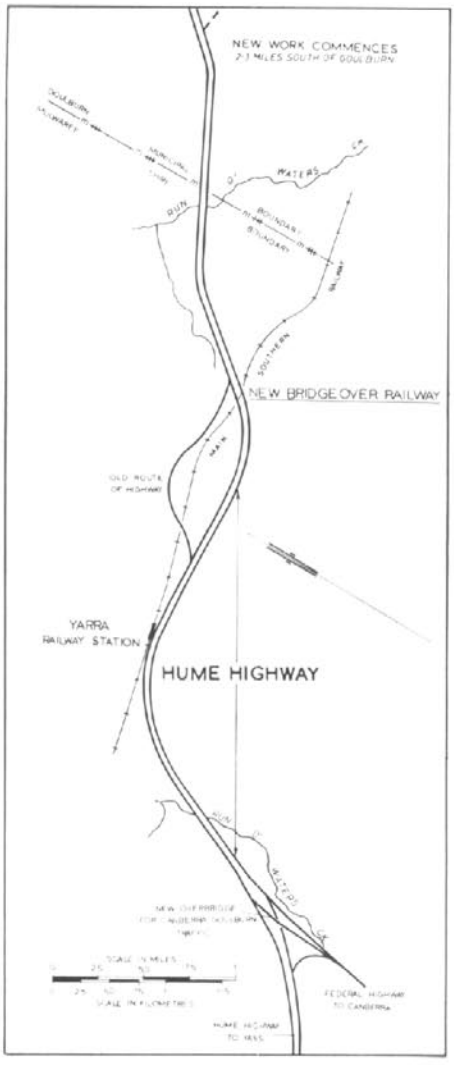
(see other details on pages 100–101)

Landscaping

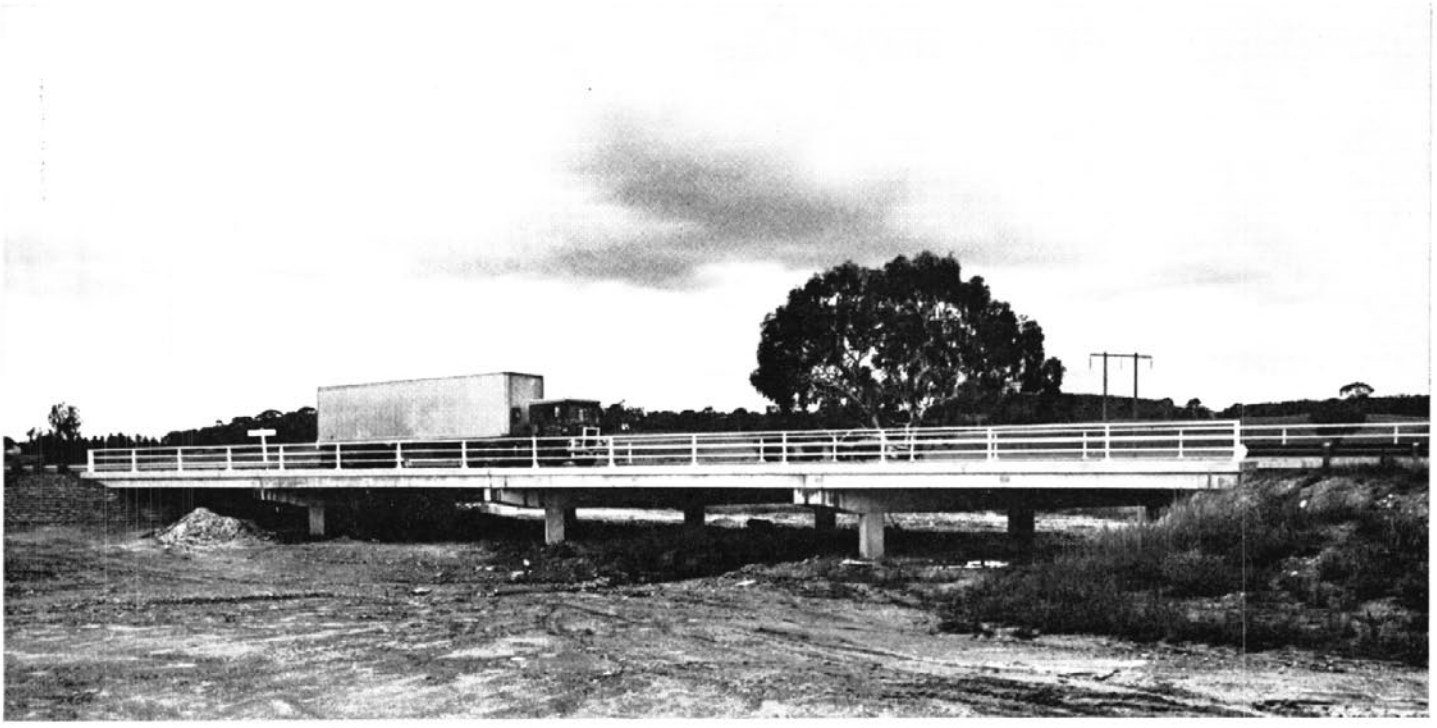
The construction of a work of such proportions is not usually possible without some scarring of the surrounding landscape. Bearing this in mind, the Department paid particular attention to the aesthetics of the design so that the roadway and bridge structures harmonised with the natural features and allowed disturbance to be kept to a minimum. Existing trees were retained wherever possible and, in addition, over 2,300 new trees have been planted; the majority in the vicinity of the interchange.

On completion of adjacent works, many acres of land have been smoothed over and planted with grass and ground cover. However, it will be some time before the full effect of this work will become apparent. The area between the roadways has been contoured and arrangements were made for the batters of the cuttings to be grassed.

The Soil Conservation Service assisted with some of the work, such as the spraying of cut and fill slopes and scour protection in selected drainage areas. The Department has met the full cost of all landscaping and conservation activities.



Duplicated crossing at Run o' Waters Creek (7 miles south of Goulburn) to carry northbound traffic



HUME HIGHWAY

NEW JUNCTION WITH FEDERAL HIGHWAY

The old and the new. Above is the Canberra turn-off as it was in 1957. The view on the left is looking down from the new overbridge to the southbound carriageway of the Hume Highway, showing the extremely wide median which has been landscaped and planted with numerous trees

This information supplements the brief details given on the preceding pages.

The Federal Highway leading to Canberra leaves the Hume Highway at 7·5 miles south of Goulburn (that is, about 137 miles from Sydney). Previously, the two highways junctioned with an at-grade "Y" type intersection. This required traffic joining the Hume Highway from the Federal Highway to stop before proceeding along the Hume Highway. The annual average daily traffic at the junction in 1969 was 5,300 vehicles on the Goulburn leg, 3,020 on the Yass leg and 2,780 on the Canberra leg. It was decided that grade-separation should be provided at the junction and that this work should eventually link dual carriageways on the Federal Highway with dual carriageways on the Hume Highway.

The new junction was designed by the Department. To carry Canberra–Goulburn traffic through the junction without conflict, an overbridge has been constructed over the southbound carriageway (Goulburn–Yass) of the Hume Highway. This overbridge was also designed by the Department.

The design generally allows for two 12 feet wide travelling lanes in each direction with a sealed 10 feet wide shoulder adjacent to the outer pavement and a sealed 10 feet wide shoulder adjacent to the median. The construction of the interchange, excluding the overbridge, required the following general quantities of materials*:

340,000 cubic yards of earthworks,
5,300 linear feet of pipe culverts,
200,000 square yards of pavement,
1,250 cubic yards of concrete,
1·5 miles of corrugated steel guardrail,
110 acres of road reserve.

(* *These figures are included in the total quantities listed on page* 99.)

Work commenced on the junction from Goulburn Works Office in July, 1969. Clearing was a minor part of the work and posed no problems. However, care had to be taken during clearing to leave standing as many existing trees as possible so that they could form part of the general landscaping of the area.

The interchange was constructed largely in filling with a total of 250,000 cubic yards of material required to be "borrowed". This "borrow" was

Crossing without conflict. Southbound Hume Highway traffic passing beneath the new overpass, which carries Canberra–Goulburn traffic.

obtained from the major cutting on the construction of the dual carriageways on the Hume Highway between Goulburn and the junction. The material was excavated by ripping with heavy bulldozers, loaded with front-end loaders and delivered to the job by truck. The drainage of the junction had to provide for the natural flow through the area, stormwater falling onto the formation, and underground flows. Drainage was achieved by the construction of box and pipe culverts, pavement drains, open drains and a cast-in-place concrete table drain below the overbridge.

The pavement was constructed of natural gravel, hauled approximately 5 miles to the site. This natural gravel was laid in two layers each 4 inches thick and compacted with grid rollers, sheeps-foot rollers and heavy vibrating rollers. The pavement was sealed with a hot bitumen surface dressing, with $\frac{3}{4}$ inch and $\frac{3}{8}$ inch aggregate. A contrasting aggregate was used on the shoulders to assist motorists to distinguish them from the travelling lanes. The design has allowed for the later provision of an asphaltic concrete surface.

Road furnishings provided at the intersection consist of corrugated steel guardrails along the edges of all fills, advance direction signs, direction signs at the diverging areas, reassurance direction signs, warning signs and advance warning signs. Traffic line-marking and pavement markings included arrows, edge lines, centre lines, chevron markings and pavement reflectors.

As mentioned previously, it was necessary to construct a bridge to carry Canberra–Goulburn traffic from the Federal Highway over the southbound Goulburn–Yass traffic on the Hume Highway. Because of the layout of the junction, this bridge has to be on a curve and the roadway below it is also curved. The bridge was designed by the Department, as a post-tensioned continuous concrete structure. It has two elliptical single column piers supporting a concrete box girder with a width between kerbs of 33 feet. The overall length of the bridge is 290 feet and the structure was post-tensioned by sixteen high tensile steel cables located in the outer webs of the concrete box. The pier footings and the abutments were constructed by the Department's own forces, whereas a contract was let for the construction of the pier columns and the superstructure. This latter work was undertaken by Central Constructions Pty Ltd at a contract price of $139,999.

The completed overbridge was opened to traffic on 15th September, 1971.

The whole work at the new junction comprises 6·4 miles of new 24 feet wide bitumen surface. Roadworks cost approximately $1,323,000, the major items being:

Earthworks	$450,000
Pavement	$150,000
Drainage	$100,000

When the cost of the overbridge (about $175,000) is included, the total cost of the interchange becomes approximately $1,500,000.

HUME HIGHWAY

RECENTLY COMPLETED WORKS IN DEPARTMENT'S SOUTHERN DIVISION

Dual carriageways have been constructed from Boxer's Creek to Governor's Hill, 48·6 to 51·1 miles south of Mittagong. These improvements on the northern approaches to Goulburn have provided approximately 3 miles of dual carriageways and have included the construction of a new bridge over Boxer's Creek. The whole work was carried out by the Department's own forces, centred at Goulburn Works Office, at a cost of $750,000.

The construction of a new reinforced concrete bridge over Daisy Bed Creek, between 53 and 55 miles south of Yass, was completed by contract in 1971. The approaches were constructed by the Department's own forces from Yass Works Office. The new bridge replaced an old timber structure and the total cost was $285,000.

OTHER WORKS NOW IN PROGRESS

The Department is constructing dual carriageways on a deviation of the Hume Highway at Bowning between 7·5 and 10·3 miles south of Yass. This work is estimated to cost $900,000 and will be completed in 1973. It includes the construction of two new bridges over Bowning Creek and tenders for these bridges closed in March, 1972.

Construction by Goulburn Works Office has recently commenced on dual carriageways between 41·7 and 46·4 miles south of Mittagong (12·3 to 7·6 miles north of Goulburn). This work will join with the existing section of dual carriageways north of Goulburn.

PROPOSED FUTURE WORKS IN DEPARTMENT'S SOUTHERN DIVISION

During 1972-73, it is proposed to:

- continue the construction of dual carriageways on the Hume Highway between 41·7 and 46·4 miles south of Mittagong;
- extend the dual carriageways southwards from the Federal Highway interchange for a further 0·75 mile;
- extend the deviation under construction at Bowning for a further 4 miles towards Yass;
- construct a new bridge and approaches over Big Ben Creek between 3·9 and 5 miles south of Gundagai. Tenders for this bridge closed in April, 1972.

In addition, designs for the following works on the Hume Highway are in progress and it is anticipated that these works could be commenced during the next 3 years.

- The construction of dual carriageways at North Goulburn, including the construction of new bridges over the Main Southern Railway Line, the Crookwell Branch Railway Line and over Mulwaree Ponds. This section will link up with the already constructed dual carriageways at Boxer's Creek and the extension of this work to Narambulla Creek (which, at present, is in progress).
- The construction of a major deviation at Gundagai, including a new bridge over the Murrumbidgee River at Gundagai. This project is estimated to cost about $6,000,000 and will provide a traffic relief route around the busy town centre of Gundagai.
- Design is in progress also for the extension of dual carriageways on the Federal Highway from the junction with the Hume Highway towards Collector ●

Colour photographs of the new work appear on the centre pages and on the front cover of this issue.

For those who wish to look into earlier developments, an article on the history of the Hume Highway (Sydney to Albury) appeared in the June, 1948 issue of "Main Roads" (Vol. 13, No. 4, pages 122–126) and an interesting article on "A Review of Improvements, 1925–1935" appeared in the August, 1936 issue (Vol. 7, No. 4, pages 121–126).

Two articles in the Journal of the Royal Australian Historical Society give valuable summaries of roadworks undertaken in the 1800's. One by Mr Frank Walker, entitled "The Southern Road", was published in Vol. 3, Pt 8, 1916, p. 375, while the other by Mr James Jervis, entitled "The Great South Road", was published in Vol. 25, Pt 5, 1939, p. 412.

An article on recent improvements over Razorback Range, with brief historical references, appeared in the September, 1971 issue of "Main Roads" (Vol. 37, No. 1, pages 4–7). The Department also has available for loan or screening (through the Public Relations Section) an 11-minute silent 16 mm movie film, produced in 1928, of "The Construction of Razorback Deviation".

FINDING FINANCE FOR MAIN ROADS WORKS

☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆

Late in November, 1971 the Minister for Local Government and Minister for Highways, Hon. P. H. Morton, M.L.A., addressed the Lower House of the Parliament of New South Wales in support of the Motor Traffic, Transport and Main Roads (Amendment) Bill, which provided for increases in motor vehicle taxation. The Bill was subsequently passed and was assented to by the Governor on 14th December, 1971, together with the Motor Vehicles (Taxation) Act, 1971, to which it is related. The following extract has been edited from Mr Morton's speech to the Legislative Assembly, in which he explained why extra money had to be raised.

☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆

"The finance to be raised by the Bill now before the House will be used to maintain and improve the vast network of main roads in the State of New South Wales. As Minister for Highways, therefore, I am strongly in favour of the measures being taken.

The Department of Main Roads is planning for a 100 per cent increase in the number of vehicles on New South Wales' roads in 10 years. People cannot be prevented from buying motor cars and the Government must cater for this modern means of transport. The Department of Main Roads has a major task and is facing up to it squarely.

In the financial year ended 30th June, 1971, the gross expenditure by the Department in all its activities was $132,000,000. This included about $13,000,000 which was required for administration, debt servicing and similar fixed charges.

The total number of people engaged on main road projects in New South Wales is in the vicinity of 15,000. This is made up of:

- 3,500 staff engaged in the Department's operations;
- 6,100 field employees engaged by the Department on maintenance and construction works; and
- 1,600 employed by contractors to the Department. Additionally, Councils throughout the State employ more than 3,700 persons on main road works.

It is an historic fact that the road problems of New South Wales commence with Sydney, the oldest city of the Commonwealth and located in the most difficult terrain of any of the State capitals. As well as these geographic disabilities, the originally narrow streets have made conditions difficult in coping with traffic. More in Sydney than anywhere else have governments had to

provide funds for the purchase of land for the widening of the surface arterial street system before contemplating an expressway system for through traffic.

Moreover, New South Wales is a large State in a large land and outside the principal cities the population is very thinly spread. Australia now rates third, after the United States of America and Canada, in ownership of motor vehicles. In New South Wales there are 430 motor vehicles per 1,000 of population or one motor vehicle for every 2·3 persons. It is essential therefore that we have a vital and energetic programme of roadworks for the good and prosperity of all citizens in this State, irrespective of the environment under which they live, whether it be in the country or in the city.

* * * *

There are a number of very good reasons why I, and indeed every other thinking member of this House, should commend the Government in its desire to increase the effort in the road building programme despite the magnificent progress that has been made over the past 6 years. Of these reasons, the three most cogent from the road builder's point of view are as follows:

- The first is the need to replace the funds which will not be available for main road works when the Government's undertaking to discontinue the levy on Councils in the County of Cumberland (under section 11 of the Main Roads Act), and to relieve country Councils from their present contributions is implemented on 1st January, 1972."

  [*Under section* 11 *of the Main Roads Act*, 1924, *the Commissioner has been empowered annually to issue a requisition on each Council in the County of Cumberland with respect to a rate on all property within Council's area at* 5/24*ths of a cent in the dollar on the Unimproved Capital Value on rateable land (with a limit on the amount from each Council area related to between* 10 *and* 15 *per cent of the total rate revenue*).

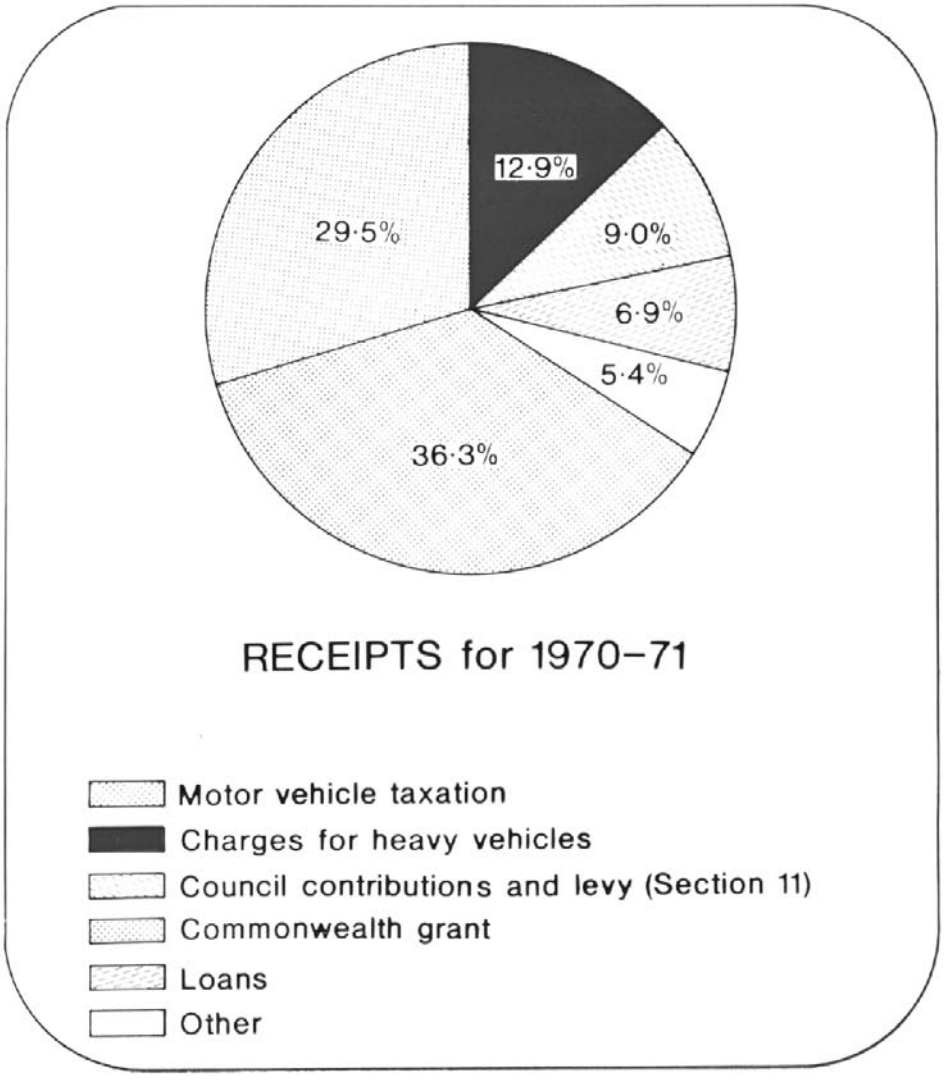
  Country Councils have generally been required to contribute one-quarter of the cost of maintenance and road construction on Trunk Roads, while on Ordinary Main Roads they have contributed one-third of the cost of maintenance and road construction and one-quarter of the cost of bridge construction.]
- "The second reason is the need to achieve the quotas set by the Commonwealth Aid Roads Act, 1969, as the amount that must be expended or set aside for expenditure each year on roadworks by the State from its own resources.
- The third reason is that because of cost rises resulting from steep increases in wages, the existing income of the Department of Main Roads from all sources is insufficient to enable the State Highways and the Main Roads System generally throughout the State to be improved to keep pace with the increasing number of motor vehicles using them.

* * * *

Having outlined the three major reasons why it is necessary to increase motor vehicle taxation rates, I shall now expand them.

1. Earlier this year (1971) the Government announced a plan to assist municipal and shire ratepayers with regard to the operations of the Department of Main Roads. This relief will result in a reduction of $17,000,000 in the year 1972 in the funds available for works on the Main Roads System. It is of vital significance that the section 11 contribution is the only source of revenue for road building, apart from motor vehicle taxation, which can be spent on all phases of the Department's activities.

Under the present legislation, the money made available by the Commonwealth (under the Commonwealth Aid Roads Act, 1969) for expenditure on the major urban and rural roads can be spent only on the construction or reconstruction of these arterial roads, and must be approved by the Minister for Shipping and Transport. No part of this money is available for maintenance or administrative costs. Similarly, the revenue from road maintenance tax must be spent entirely on the maintenance of main roads and no part is available for improvement or administrative costs. The truth of the matter is that unless the section 11 contribution is replaced by money that



can be spent on main road activities generally, the County of Cumberland Main Roads Fund would collapse, because fixed charges for administration, loan servicing and the like could not be met.

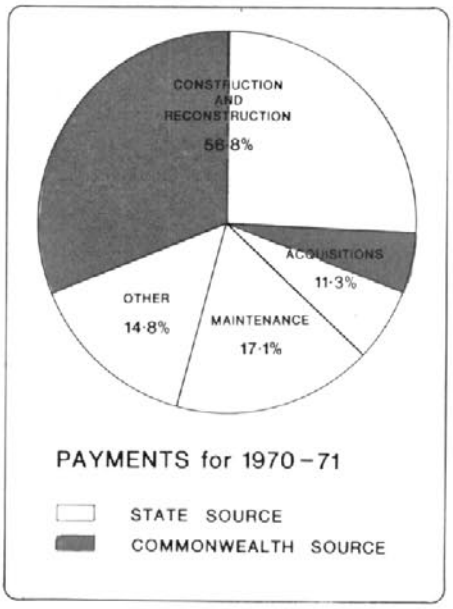
For the year 1972, the $17,000,000 relief to ratepayers represents a loss of about $11,400,000 to the County of Cumberland Main Roads Fund and about $5,600,000 to the Country Main Roads Fund. The diversion of this amount from the finance available to the Department of Main Roads would inevitably have disastrous effects on the main roads works programme and on the economy of the State's transport system. Therefore, this loss to the Department must be made good for the well being of the whole State and it is necessary for the Government to turn to the road users themselves.

* * * *

2. Under the Commonwealth Aid Roads Act, 1969, the State is required to expend, or set aside for expenditure on roadworks, funds from State resources to match quotas set by the Commonwealth Government. These quotas are based on annual increases in motor vehicle registrations. In effect, each State is required to increase each year its expenditure on roads from its own resources at the same rate at which motor vehicle registrations have increased. I emphasise that the increases relate to numbers of vehicles, including motor cycles, and not to the quantity of the revenue received from registration fees.

The quota set by the Commonwealth for expenditure from State resources during the first two financial years, 1969–70 and 1970–71, under this Act was met by using loan funds totalling $21,850,000, as the State source revenues for roadworks fell short by that amount. It should not be forgotten that vehicle registration fees have not increased, in the main, since 1963. In fact, some have not increased since 1956.

With the withdrawal of the section 11 levy income, in addition to the existing shortfall of State source revenues, there will be a total deficiency of about $70,000,000 in these revenues to meet the expenditure quota over the remaining 3 years of the Commonwealth Act. The continued use of loan funds to make up this deficiency would not be a satisfactory solution, as the Department's present loan charges are already about $4,000,000 per annum. In simple terms, this means a deferment of $4,000,000 worth of work each year in order to repay the loans already raised. It is proposed, for the present, only to use loan funds to complete toll works already in hand.



A detailed statement of the Department's Receipts and Payments for the year ended 30th June, 1971 was published in the March, 1972 issue of "Main Roads" (Vol. 37, No. 3, pages 88–89).

To avoid further dependence on loan moneys, it is imperative that the State procure additional revenue to meet the expenditure quota set by the Commonwealth for each of the remaining 3 years of the Act. This is because the Act provides that the State must pay to the Commonwealth the difference between the expenditure quota and the amount actually expended (or set aside for expenditure) on roadworks from State resources, or such less amount as the Commonwealth Treasurer determines.

* * * *

3. Since the last increase in motor vehicle taxation rates on 1st January, 1963, these rates have not been varied while works costs have increased by more than 34 per cent during the same period. The annual cost rise was of the order of 4 to 4·5 per cent until the year 1970–71, when it increased to about 8 per cent. It is likely to be higher still in 1971–72. During the past 8 years the average wage in New South Wales has risen 77 per cent.

Although the annual increase in the number of registered vehicles is about 6·5 per cent, the actual increase in motor vehicle taxation receipts is in the order of only 4 per cent. This difference is due to the growing popularity of lighter cars and motor cycles and this trend appears likely to become even more significant. Motor vehicle taxation expressed as an average amount per vehicle has progressively decreased from $19.96 in 1963–64 to $18.28 in 1970–71 which, if expressed in 1963–64 money values, is only $13.71 per vehicle per annum.

The combined effect of these two factors, therefore, is to seriously reduce the Department's ability to improve the Main Roads System to cope with the rapidly growing number of vehicles using that System. The true value of the revenue available to the Department of Main Roads from motor vehicle taxation has now been reduced to a stage where it is worth only slightly more than that received in 1963–64 (which was the first full year of collections following the increase in motor vehicle taxation rates effective from 1st January, 1963). During the same period the number of motor vehicles in use has increased by 70 per cent."

[*It is important to note that motor vehicle registration charges are made up of a fee and a tax.*

The revenue from registration and certain other fees is paid into the Road Transport and Traffic Fund and is used to meet the cost of police supervision of traffic, of providing traffic control lights and other road safety facilities and general administration costs of the Department of Motor Transport.

The tax collected on taxi cabs, buses and other public vehicles in the Sydney, Newcastle and Wollongong transport districts is paid into the Public Vehicles Fund. Some of it is then distributed to Councils in the transport districts for work on roads used by buses and the remainder goes towards the cost of providing traffic facilities for these vehicles.

However, in the past, the major portion of the revenue from motor vehicle taxation has gone into the County of Cumberland and Country Main Roads Funds, on a 20%–80% basis, for use by the Department of Main Roads on road and bridge construction and maintenance throughout the State.]

"Over the past 3 years, loan borrowings by the Department for works other than toll works have, in the main, been directed to the country so as to ensure

that the undertaking given by the Government when the current Commonwealth arrangements were completed would be kept. This undertaking was that the amount of expenditure from all sources in the country areas of the State, excluding Sydney, Newcastle and Wollongong Statistical Areas, would in total be not less than that for 1968–69 compounded at a rate of 5 per cent per annum for the 5 years ending 30th June, 1974. This undertaking is being fulfilled.

Apart from the difficulty now being experienced by the Department of Main Roads in servicing past loans, there is the problem of providing sufficient loan funds to meet the rapidly increasing needs of other sections of the Government's works programme. Substitution of revenue for road building in place of loans, therefore, will have the dual effect of increasing the capacity to finance road building and at the same time releasing loan money for expenditure on other essential capital works, such as hospitals and schools.

The total revenue needed to replace loan funds in the Country Main Roads Fund is $5,000,000, so that the combined effect of eliminating ratepayers' contributions and eliminating the loans would lead to a reduction of $11,400,000 in the County of Cumberland Main Roads Fund and $10,600,000 in the Country Main Roads Fund.

It is reasonable, therefore, that the replacement revenue raised in this regard should be shared equally between the County of Cumberland Main Roads Fund and the Country Main Roads Fund. The tax levy under the first schedule of the Bill is designed for this purpose. Of course, the proceeds of the increases in motor vehicle taxation weight tax under the second schedule of the Bill will be apportioned between the County of Cumberland Main Roads Fund and the Country Main Roads Fund, on the existing 20 per cent–80 per cent basis.

The finance available for expenditure on main roads in the country, following approval to the measures now before the House, will be about $20,000,000 greater during the next 2½ years than it would have been in the absence of this Bill. This will give great assistance to the employment situation in rural areas.

The whole of the additional funds arising from increased motor vehicle taxation rates (*as distinct from registration and other fees*) will be applied to work already in hand or planned by the Department of Main Roads. Within the next 3 years (i.e. during the term of the present Commonwealth Aid Roads Act), the total cost of this programme will be $409,000,000 of which $193,000,000 will be spent in the County of Cumberland and $216,000,000 in the country. This is a staggering programme, but it relates to very necessary works planned to improve the Main Roads System commensurate with the needs. Because finance would just not be available it does not include all the desirable works. In fact, it is clear from surveys carried out already that expenditure by 1973–74 will fall short of the real needs of the Main Roads System by $1,370 million.

The programme for the 3 years ending June, 1974, includes major highway works estimated to cost:
$11,000,000 for the Great Western Highway;
$15,000,000 for the New England Highway;
$18,000,000 for the Prince's Highway;
$27,000,000 for the Pacific Highway;
and no less than $36,000,000 for the Hume Highway. No one can say that this is in any way unnecessary, especially in relation to road safety. Insofar as expressways are concerned, the 3 year programme provides for works estimated to cost:
$9,000,000 for the Eastern Distributor and Eastern Expressway;
$32,000,000 for the Western Distributor and Western Expressway;
$13,000,000 for the South Western Expressway;
$26,000,000 for the Southern Expressway; and
$67,000,000 for the Sydney-Newcastle Expressway.

In addition, many works are required on Trunk Roads and Ordinary Main Roads throughout the State. All these works must proceed.

If we are to maintain a standard of progress and development commensurate with our standing as the premier State, we must have more money and, as the services to be expanded are for the motorist, he unfortunately has to be the one to foot the bill.

In this particular instance, as I have also stressed, if the Commonwealth Government were to return the whole of the petrol tax to the States there would be no need to introduce this Bill. The undisputed fact remains, however, that as things now stand there is just no alternative to the introduction of the measures in the Bill, to ensure the development of our Main Roads System in keeping with the growing needs of the community" ●

MINISTER FOR HIGHWAYS TO RETIRE

By the time this issue of "Main Roads" is printed, the Hon. P. H. Morton, M.L.A., will have retired from the position of Minister for Local Government and Minister for Highways. He will have completed 25 years in Parliament and 7 years as ministerial head of this Department. Announcing his retirement as from 16th June, 1972, Mr Morton said:

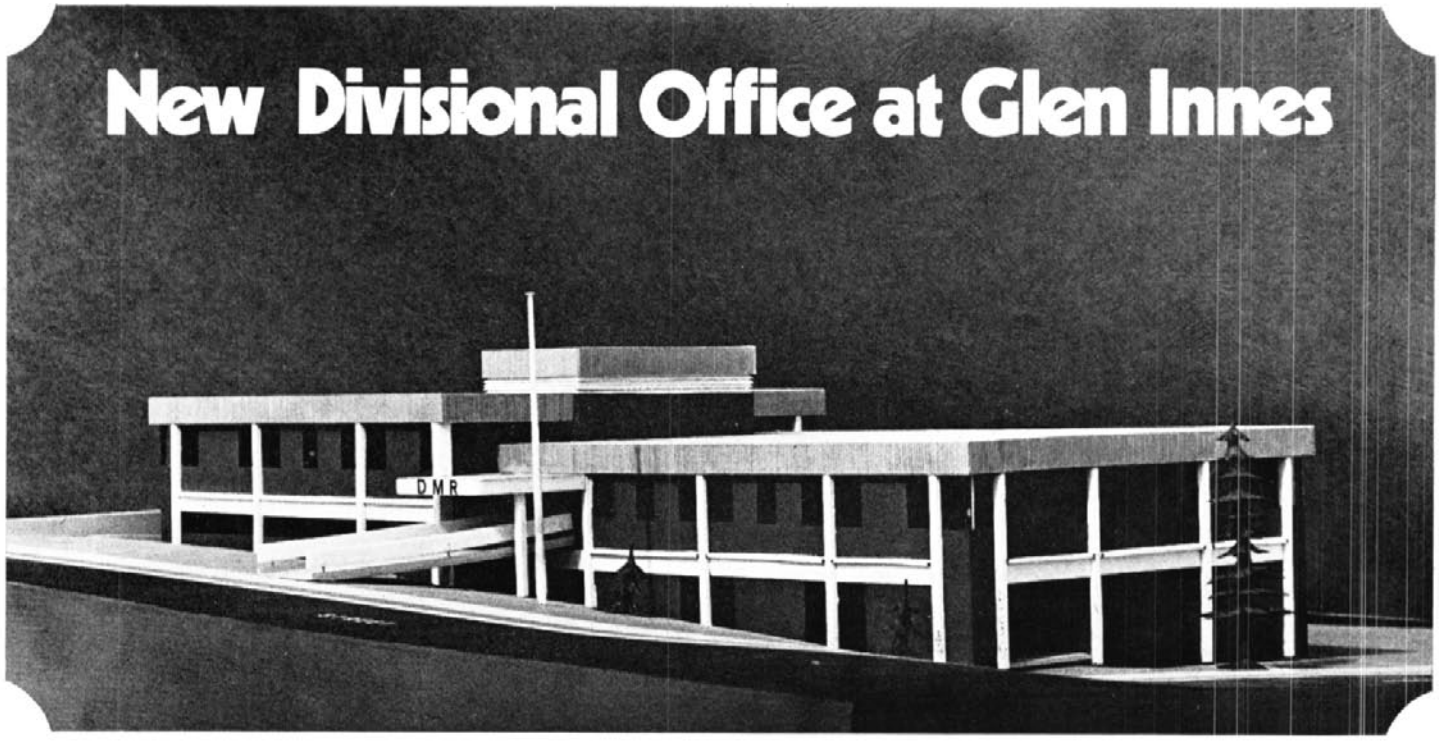
"During my occupancy of the Ministries of Local Government and of Highways, I have participated in a period of rapid development and dynamic progress."

* * * *

Mr Morton was born and educated at Lismore. He entered local government activities in 1945 when he joined Mosman Municipal Council. A year later he became Mayor and soon after, on 3rd May, 1947, he was elected to Parliament as Liberal Member of the Legislative Assembly for Mosman. Mr Morton has held this seat continuously since then.

In September, 1951, having been Mayor for 5 years, he retired from Mosman Council. He was Leader of the Opposition from 20th September, 1955 to 17th July, 1959 and was appointed Minister for Local Government and Minister for Highways on 13th May, 1965, after the present Government came to office ●

New Divisional Office at Glen Innes



A new divisional office building at Glen Innes is now under construction for the Department. The office will be located on the Gwydir Highway, at the corner of Ferguson and Grey Streets, and will replace the present office at 134–136 Meade Street as the headquarters of the Department's Upper Northern Division.

The general layout plan was prepared in the Department's Architectural Section, while the elevation was produced by consulting architects, R. J. Magoffin and Son of Sydney and Armidale. In December, 1971, prospective tenderers for construction were invited to register, prior to the calling of tenders. Early in April, 1972, a contract was let to Hardy Marr Constructions Pty Ltd of Glen Innes for the construction of the office at a cost of $369,880.

The new building will be an air-conditioned, two-storey, brick and reinforced concrete structure, having approximately 19,000 square feet of space. It should be completed by April of next year.

COUNCIL CENTENARY

The Department is pleased that construction of these new offices will take place during the Glen Innes Centenary year—perhaps it can be regarded as an act of celebration.

It is generally accepted that the district now embraced by Glen Innes was discovered by two stockmen, Duval and Chandler, in about 1835. However, it was not until 17th June, 1872 that the Governor of New South Wales, Sir Hercules Robinson, proclaimed it a municipality. Glen Innes Town Hall, which has been listed by the National Trust (having, among other points of interest, a foundation stone laid by Sir Henry Parkes in 1887), will be the centre of centenary activities throughout the year.

The state of communications in the Glen Innes area approximately one hundred years ago was noted by F. F. Bailliere in his Gazetteer of New South Wales (1870).

"The nearest places to Glen Innes are Wellingrove, 12 miles W.; Inverell, 40 miles in the same direction; Severn, or Dundee, 16 miles; and Deepwater, 28 miles N., both on the great North road; Ashford, 65 miles NW.; and Stonehenge, 8 miles S. With these places the communication is by horse, dray, or hired vehicle only, the mails being carried on horseback twice or thrice a week. With Sydney, 363 miles SSE., the communication is by mail coach from Armidale to Singleton, thence to Newcastle by mail, and thence by steamer, or by horse along the Newton Boyd line of road, now under survey (90 miles) to Grafton, and thence by steamer, the latter being the shorter route. . . There is no coach or carrying office in the township, as no coaches run to it; but the establishment of a line of coaches between Armidale and Tenterfield, a distance of 120 miles, passing through Glen Innes for the conveyance of mails and passengers, has long been a felt want."

* * * *

Twenty years later in 1890 a Sydney Morning Herald reporter wrote . . .

"In the matter of pretentious and architecturally interesting buildings Glen Innes is remarkably well off. The Bank of New South Wales, the Commercial Bank, and the A.J.S. Bank have very splendid buildings indeed, and they in themselves give the main thoroughfare a substantial appearance. This is equally true of Mr Utz's store, Tattersall's, the Great Central, the Commercial, the Royal, and Railway Hotels, and many other buildings.

But, strange to say, while private enterprise has done so much to bring into existence a superior class of building, the Government offices are, perhaps, the worst housed institutions in any town of pretensions in the country. The court house, the lands office, *the roads office*, the police barracks and the post and telegraph office are perfect hovels. . ."

The Department's new modern offices should certainly help to change the image of Government buildings in Glen Innes to something more impressive than those of the last century. Not only will they provide improved working conditions and more efficient facilities for Departmental staff—they will also be a striking addition to the commercial centre of Glen Innes and should help to promote further development in this very pleasant and important New England town ●

NEW LINK ROAD AT STRATHFIELD

On 22nd March, 1972, a short deviation of Ring Road No. 3 at Strathfield was opened to traffic. The new route allows motorists to by-pass busy Strathfield Square, adjacent to the railway station, and the previously congested northern end of The Boulevarde.

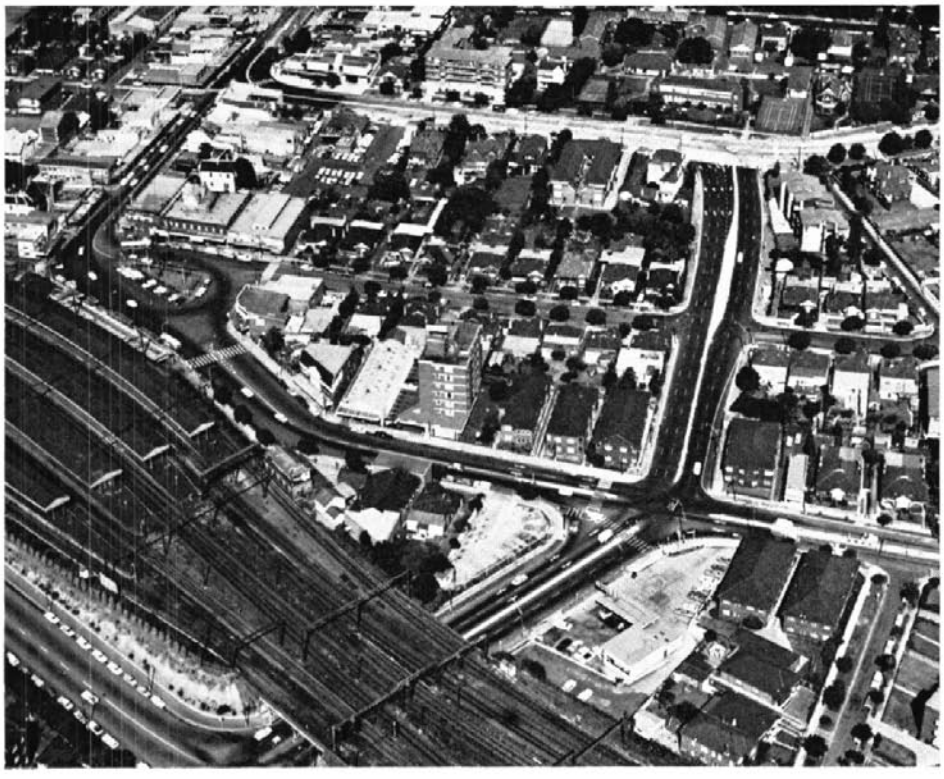
The new route links Raw Square and The Boulevarde, via Redmyre Road. A new section of road to connect the existing Albert and Redmyre Roads was constructed by Strathfield Municipal Council with the aid of a grant from the Department. At Council's request the new road, which connects with Raw Square, will also be known by that name.

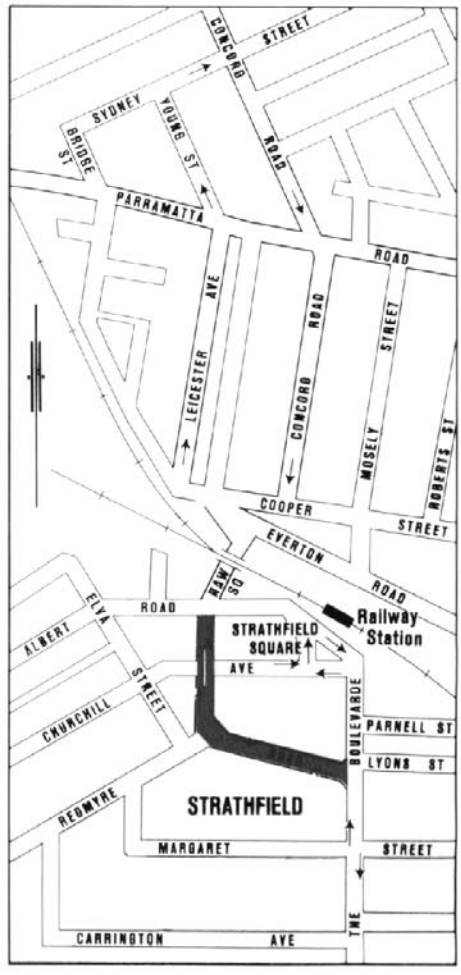
The major portion of the work, in particular excavation and pavement construction, was completed by Road Constructors Pty Ltd under contract to the Strathfield Municipal Council. Council's own forces undertook the remainder of construction. The new road generally provides three lanes for traffic travelling in each direction, although the northbound carriageway reduces to two lanes between Churchill Avenue and Albert Road, at present.

Prior to the completion of this deviation it was necessary for shoppers' vehicles, commercial vehicles, and through traffic to all share Main Road No. 315 where it passes through Strathfield shopping centre. Consequently, peak-hour pedestrian traffic crossing to and from the railway station and cars slowly circling around Strathfield Square waiting to park or to pick up train passengers have always had a detrimental effect on through traffic movements in the area. Furthermore, when vehicles are parked on The Boulevarde only one lane of traffic in each direction is able to use the road.

The completion of the deviation will serve to significantly reduce the congestion that has previously occurred. By separating through traffic from those wishing to stop at the shopping centre or railway station, it will improve the flow of vehicles and thus benefit both groups of motorists.

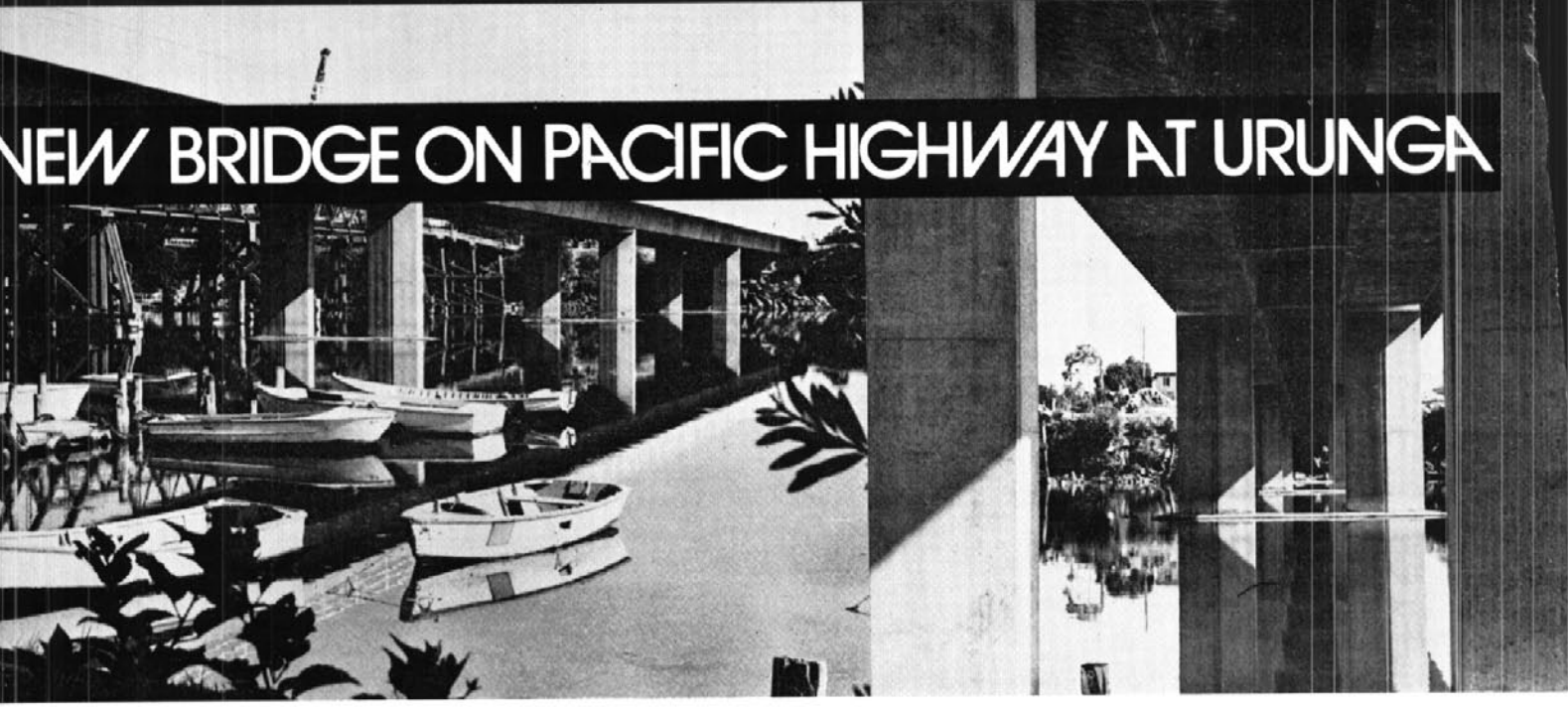
The cost of construction of the new link road and associated improvements has been approximately $110,000, and was paid for by the Department. The proclamation of Main Road No. 315 will be amended in due course to include the new route. Following deproclamation of the section through Strathfield Square and the shopping centre, it will become the full responsibility of Strathfield Municipal Council ●





Aerial view (looking south) showing the new road which links Raw Square (centre foreground) and The Boulevarde (top left), via Redmyre Road (top centre). The new road should ease traffic congestion near Strathfield Square (centre left) on the southern side of the railway station

NEW BRIDGE ON PACIFIC HIGHWAY AT URUNGA



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In a delightful river setting at Urunga, a new bridge was opened to traffic on 13th March, 1972, by the Minister for Highways, the Hon. P. H. Morton, M.L.A.

The new bridge is on the Pacific Highway and crosses the Kalang River, which is still often referred to by many local residents as the South Arm of the Bellinger River. "Kalang" is an aboriginal word meaning "beautiful" and is particularly applicable to this attractive river and its surroundings.

Bellingen Shire is rich in colourful, scenic contrasts, from the mountain greenery of the Dorrigo plateau to the golden beaches along the blue Pacific coast. It is little wonder that it makes up a large part of the tourist area known as Pacific Beautizone. Tourists travelling through the district will be assisted by the unobtrusive benefits of this new bridge whose slim lines leave visitors free to view the surrounding scene without obstruction or distraction.

This article gives details of both the new and old bridges and includes some historical notes about the district.

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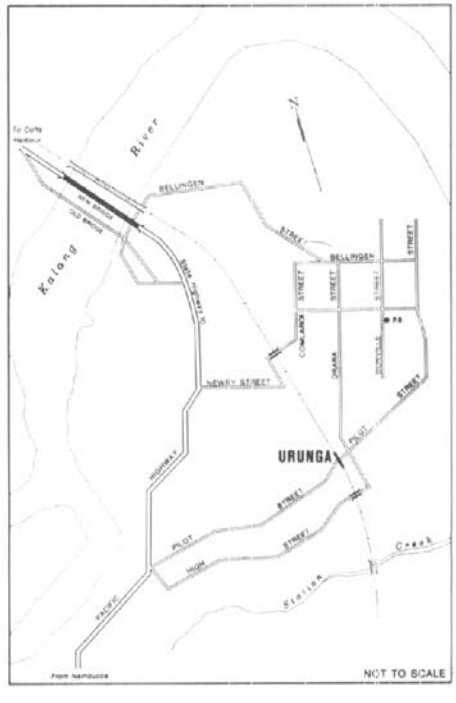
DETAILS OF NEW BRIDGE

Standing so close together (until the old structure was removed) the two bridges were open, for a while, to direct comparison. This made it easy to admire the advances in bridge building techniques over the past forty years. Bridges today are more graceful and blend into, rather than dominate, the landscape while at the same time, they are increasingly functional.

The new bridge, with its virtual "twin" less than 30 miles away near Macksville, are good examples of this trend. (The bridge over Lower Warrell Creek was opened on 21st May, 1971—see details in the June, 1971 issue of "Main Roads".) As is the case with most North Coast bridges, it is rather long—752 feet, spread over six spans—and carries two lanes of traffic and a footway seven feet wide on the downstream side. There is also a stairway to give pedestrians access from the footway down to the river bank, and to Bellingen Street. The bridge provides a minimum clearance of eight feet above the 1950 flood level. The bridge and its approaches cost in the vicinity of $1·13 million.

The new structure was designed by the Department and constructed under contract by Pearson Bridge Pty Ltd. In spite of the long periods of bad weather after construction commenced, the contractors completed their work ahead of time and enabled the bridge to be handed over for use by the public six weeks before expected.



Recent traffic counts indicate that almost 3,000 vehicles a day pass over this crossing, and the volume of traffic is increasing every year. The new bridge will therefore certainly get plenty of use.

ROADWORKS IN BELLINGEN SHIRE

In the current financial year (1971–72), the Department has appropriated almost $900,000 in allocations and grants for maintenance and construction works by

the Department and Council in the Bellingen Shire.

The Council is currently engaged on a programme of reconstruction on the Dorrigo Mountain (Trunk Road No. 76), and this is approximately 60 per cent complete. As a result of last summer's abnormally wet conditions, Trunk Road No. 76, west of Dorrigo, was extensively damaged and restoration of the pavement was necessary. In order to avoid future failure, the existing pavement will need to be strengthened as funds become available, and widening of the pavement and the formation will be carried out in conjunction with the strengthening.

The Department is also arranging for the photogrammetry of Trunk Road No. 76 between Bellingen and Raleigh to establish its best location and so assist Council in preparing plans for its reconstruction.

EARLY HISTORY OF THE DISTRICT

As was the case with most of the mid-north coast, cedar-getting was the genesis of white settlement at Urunga and in the Bellinger Valley. Areas were settled by a simple progress from river to river—as the cedar became less readily available, the gatherers moved on to more abundant stands.

As early as 1820, John Oxley had explored the coast in the "Prince Regent", under instructions from Governor Macquarie, and it is thought the first cedar getters went to the Macleay River area about eight years later.

The actual discovery of the Bellinger River is usually attributed to William Miles, a stockman on Yarrabandinni Station (then owned by Mr Chapman) in about April, 1840. Miles later moved on to Queensland and into a distinguished career as a Cabinet Minister and Member of Parliament.

Surveyor Hodgkinson of Newcastle followed up Oxley's reports of river entrances north of the Macleay in about 1841–42, and travelled about 16 miles up the river. His detailed reports are the first official descriptions of the area.

By 1842, the readily obtainable cedar on the Macleay River had been exhausted and the cedar getters had moved on to the Nambucca and Bellinger Rivers.

The Bellinger Valley was indeed rich in cedar, but the industry declined in the 1850's when aboriginal troubles in the area caused a retreat to the Macleay.

The first permanent settlers came to the area from the Macleay in 1862. They made the arduous trek along the beaches and in makeshift boats over rivers and streams to an area of luxuriant forest and densely wooded scrub, settling between Raleigh and Bellingen. These were real pioneers—coming to an unmapped area, far from the closest outpost of civilization, with no idea of what lay ahead. Within three years their numbers had grown and 33 blocks were occupied. Cedar remained the main industry, although sugar cane and maize were grown and shipped to Sydney. Wine was produced in the late 1800's, and was successful in contests in London and Paris—which clearly shows the versatility of the area. Dairying began its expansion in the area in about 1900.

The township of Urunga itself was formerly known as Bellinger Heads. The river had a particularly difficult entrance, and the first ship to enter was believed to be the "Northumberland", searching for cedar. The first pilot arrived in 1868 and a pilot service operated until 1933.

The entrance deterred many ships from calling at the settlement, and the situation became critical. But the pioneers of the Bellinger Valley were resourceful and

Construction in progress on new bridge in July, 1971

The last trip of Urunga vehicular ferry, prior to opening of bridge on 29th September, 1928

Postcard showing steamroller placed across roadway to prevent access to new bridge before approaches were completed

These two photographs have been reproduced by courtesy of Bellingen and District Historical Society

soon built their own ships, virtually saving the settlement and initiating a new industry on the side.

PACIFIC HIGHWAY DEVELOPMENT

Urunga lies on the Pacific Highway, one of the State's major traffic arteries and a road which is itself steeped in history. Its development took place over many years, following several routes.

In 1895 there was a somewhat inconvenient route open to Brisbane, and, in contrast to the situation to-day, the sea communication was much faster and more reliable. By 1909, however, this early north coast road had been altered to follow the coast. The alteration of the route was carried out in stages to include as many of the North Coast towns as practicable and to fill the greatest need of the time, easy intercommunication.

Since then, it has been, and still is, subject to steady improvement. It is significant to mention that in the three financial years to 30th June, 1971, over $17·5 million has been spent on maintenance and construction works on the Pacific Highway.

PREVIOUS CROSSINGS

Before the old bridge was built at Urunga, there was an old oil-driven punt across the river. This punt carried six cars at a speed of 3 miles per hour, and newspaper reports of 1925 describe it as "very heavily trafficked".

The previous bridge at this site was built in 1928 by the Public Works Department. At the time the local Progress Association opposed its location because it by-passed the town and was thought to have an adverse effect on business. However, the site selected was most suitable to give least expensive construction and to avoid the possibility of flooding. Its approximate cost was £19,000 ($38,000).

Prior to the opening of the bridge, there had been some dissatisfaction with the length of time taken to complete the approaches. At a meeting of the Bellingen Shire Rate-payers Association at the end of August, 1928 (reported in the Coff's Harbour and Dorrigo Advocate), one citizen despaired that if someone didn't get a move on, Santa Claus would once again be using the old punt that year! They claimed that, although not finished, the approaches were in suitable condition to be used in fine weather by light traffic, and should have been opened to avoid the hold-up occasioned by the punt which, even then, constituted a bottleneck.

OPENING OF FIRST BRIDGE

Local residents claim that the night before the official opening, some of the local "young bloods" held an unofficial opening and moved a steamroller, which was being used as a barrier, across the bridge.

The opening ceremony on 29th September, 1928, was well attended and a report in the Coff's Harbour and Dorrigo Advocate of 2nd October, 1928, states:

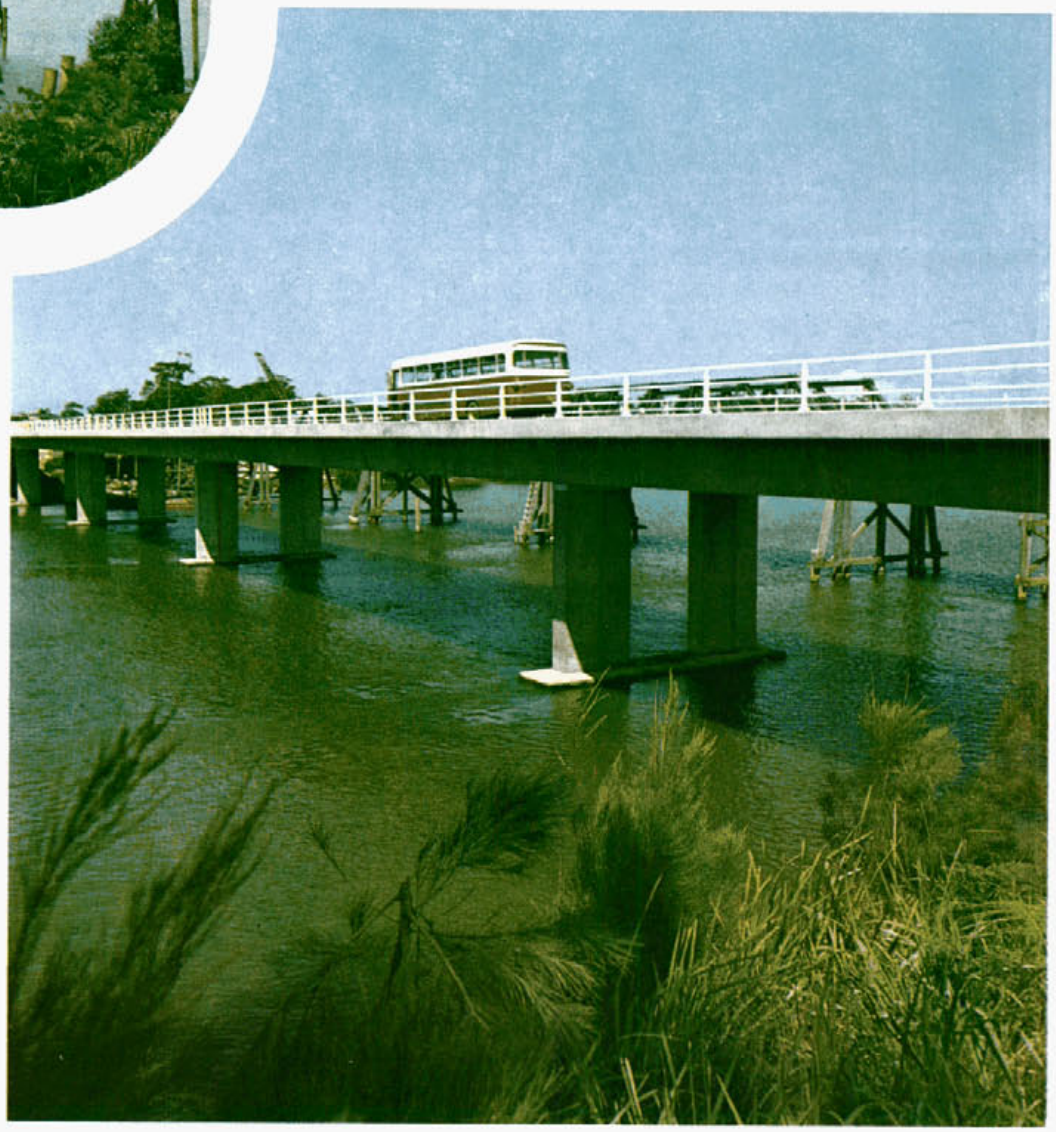
"The Shire Engineer (Mr Baird) drove his car over the bridge and broke the ribbon at the entrance. He had with him Mrs H. Gale (wife of the Bellingen Shire President) and Mesdames Atherton and Bushell, two of the oldest residents of the Bellinger. Mrs Brownlee (mother of Mrs R. J. Smith of Coff's Harbour) was also to have been one of the distinguished party, but was not well enough.

The ceremonies were not elaborate. As the Shire Clerk, Mr Witt, put it, it was a case of 'no champagne–by request' as the council is rather hard up at present. Shire councils are usually hard up but, at the present, Bellingen Shire Council is a little more that way than usual. There was no money to spare for elaborate ceremonies.

There was a basket picnic, the council providing hot water for the picknickers."●

New North Coast bridge blends with delightful setting

and carries the Pacific Highway over the Kalang (an aboriginal word meaning "Beautiful") River at Urunga.



Above:

Early construction scene showing pile driving in February, 1971.

Right:

The finished product needs no "selling". Costing, with its approaches, over $1 million, the completed bridge is good to look at and good to drive on.

Below:

Concrete segment units, precast at the site, and awaiting erection in the superstructure — July, 1971.

Left: *The approaches to the new overbridge for northbound traffic joining the Hume Highway from Canberra.*

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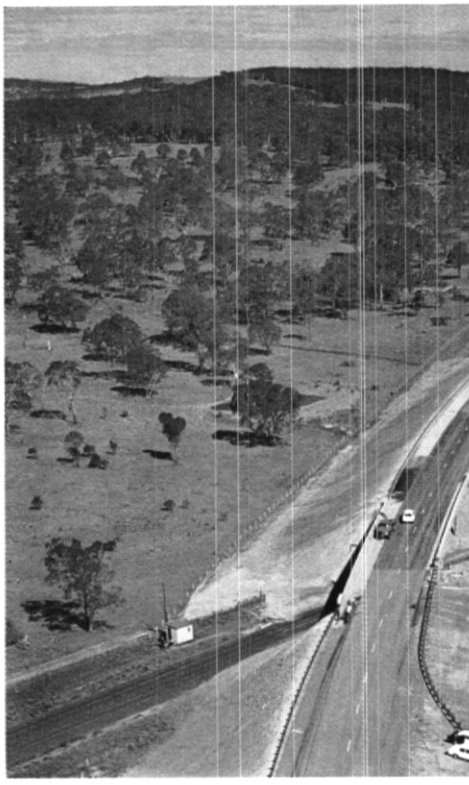
Almost 148 years ago, Hamilton Hu
an overland journey to the southern
Port Phillip is among the classic
era of exploration is over and
scenes show some of the Dep
completed and made av
Sydney to Melbourn



Left: *The grade-separated junction of these two country highways is the first of its kind in the State.*

Right: *An overall view (looking south) of the southern end of the new dual carriageways, approaching the junction with the Federal Highway (top left).*

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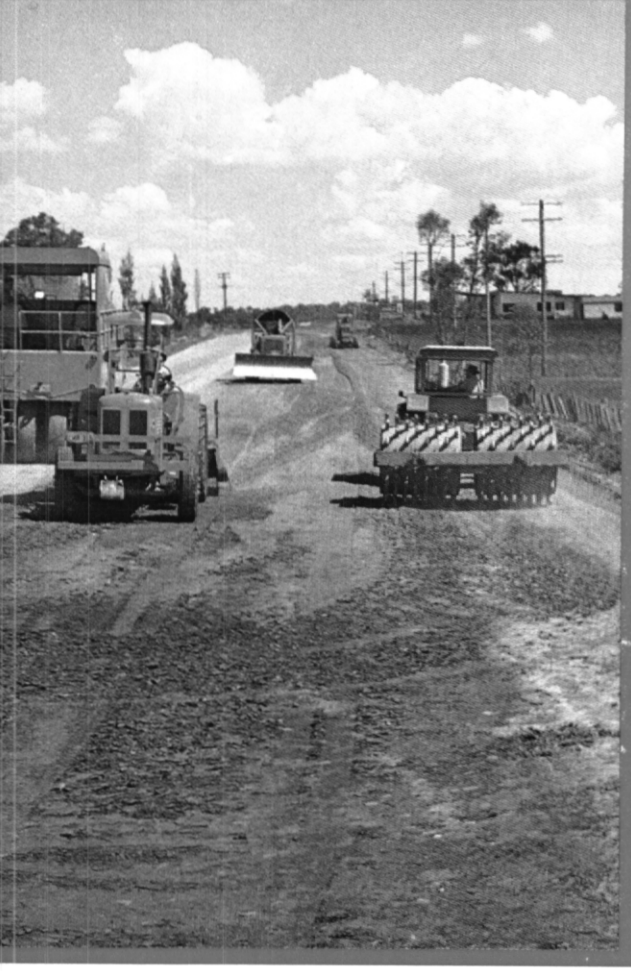
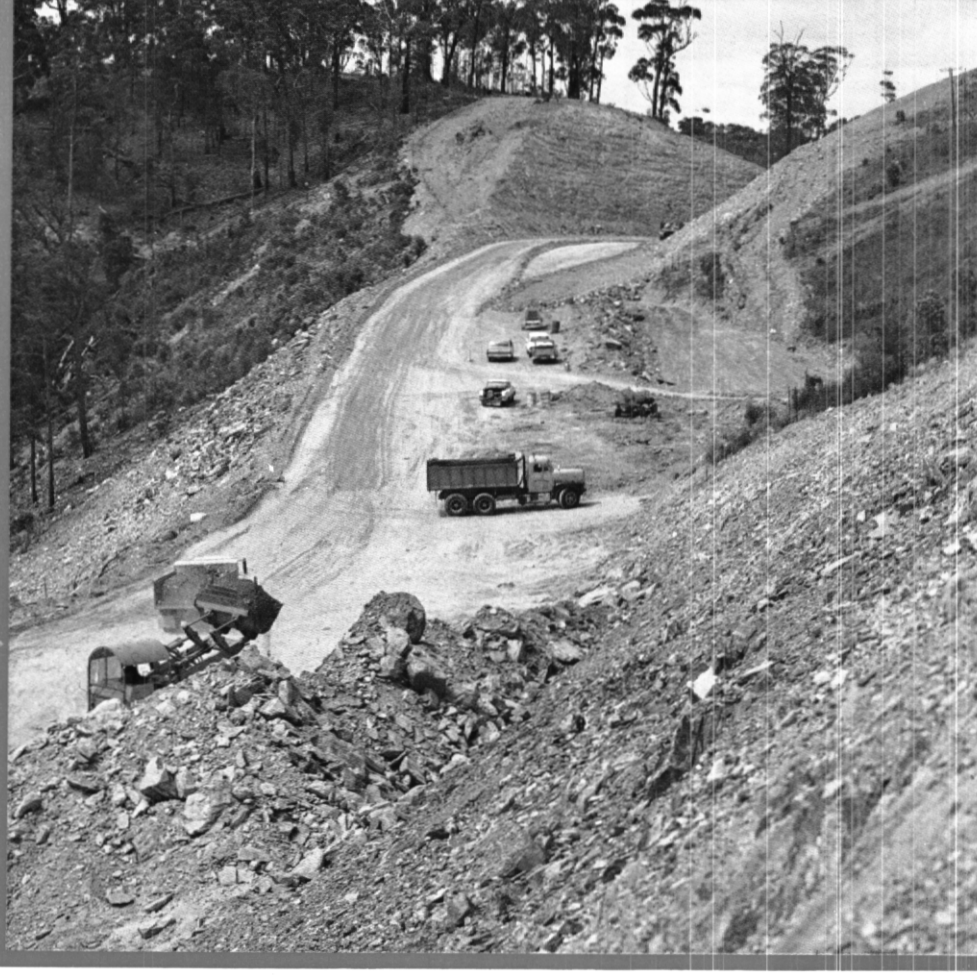
UTH OF GOULBURN

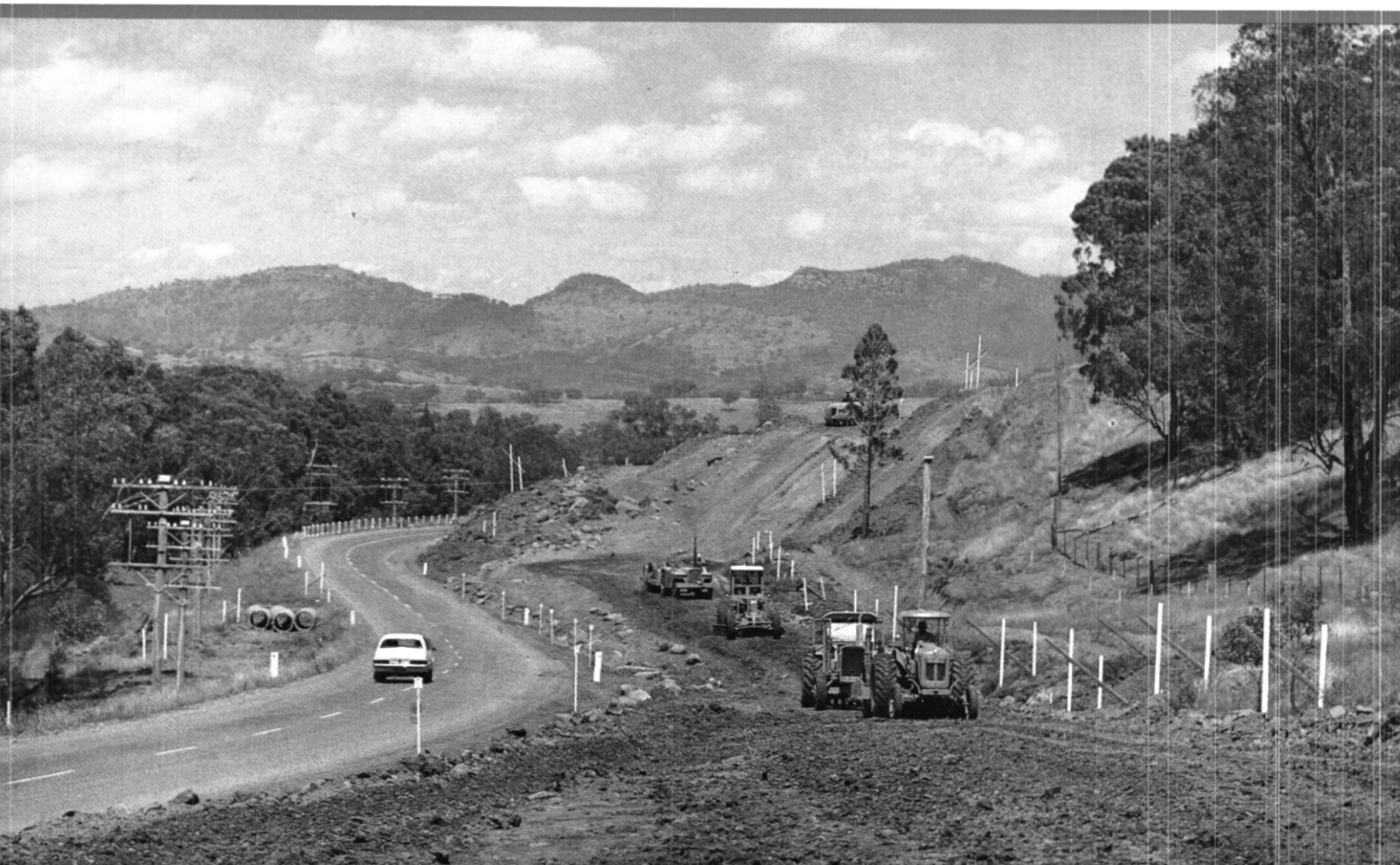
nd William Hovell set out from Appin on st of the continent. Their expedition to early Australian exploration. But the eed is now for development. These ent's "developments," recently le to make the journey from s arduous and far more ying.

Above: *At the northern end, these twin railway overbridges have been completed and the whole $3.26 million project has now been incorporated into the State Highway System.*





Highway reconstruction



NEW ENGLAND HIGHWAY

In pursuance of the Department's policy of continually improving State Highways, a 2-mile section of the New England Highway from Flaggy Gully to the top of Sugarloaf Hill, 30–32 miles north of Murrurundi, is now being reconstructed on an improved alignment.

Pictured on the page opposite (bottom scene) is a section of the work showing the extensive use of batter profile stakes. These stakes are used as guides to operators of earthmoving and road construction equipment, to assist them to form the batters (i.e. slopes) to the required angle.

Another 1·4 mile section of the New England Highway is being reconstructed at approximately 54 miles north of Tamworth on the southern approach to Uralla (see illustration opposite—top left) ●

* * * *

Top right: Prince's Highway —south of Eden

Top left: New England Highway —north of Tamworth

Bottom: New England Highway —north of Murrurundi

Top: Snowy Mountains Highway —northwest of Kiandra

Centre and Bottom: Oxley Highway —east of Walcha

* * * *

OXLEY HIGHWAY

As outlined in the June, 1971 issue of "Main Roads" (pages 114–118), reconstruction of the Oxley Highway between Port Macquarie and the New England Plateau is the major and continuing task of the Department's Lower North Coast Division. As can be seen in the two lower photographs on the right—and on the back cover of this issue—a wide variety of modern plant is being used to carry out this work as fast and as efficiently as possible. The adjacent illustrations show compaction operations of the section 20–22 miles east of Walcha ●

PRINCE'S HIGHWAY

The Prince's Highway between Eden and the Victorian border is also being progressively reconstructed and bitumen surfaced.

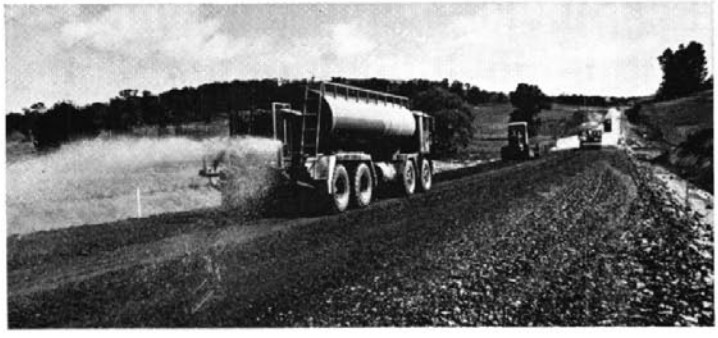
The earthworks pictured on the page opposite (top right) are in the last section which is being reconstructed from Boydtown Creek, approximately 2 miles south of Eden, to the northern approach to the bridge over the Towamba River at Kiah. Kiah is at present nearly 9 miles south of Eden. However, when the new 3-mile deviation is completed, this distance will be reduced to about 7 miles.

Included in this work is the construction by contract of a bridge over Whelan's Swamp (see details in the March, 1972 issue of "Main Roads", page 94) ●

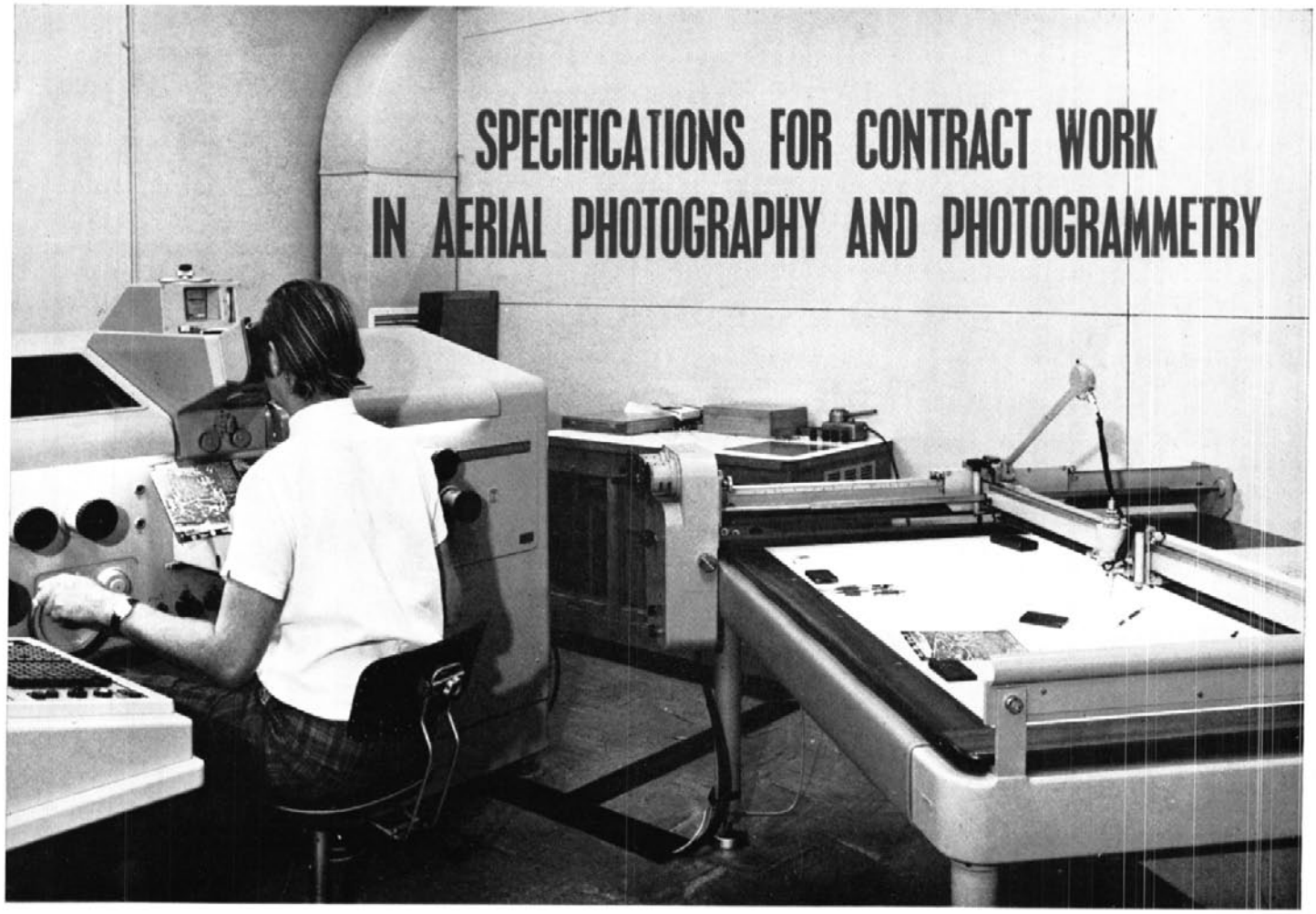
SNOWY MOUNTAINS HIGHWAY

With the completion within the next few years of the reconstruction and bituminous surfacing of the section from Tumut to Kiandra, the whole length of the Snowy Mountains Highway will have been sealed. It will also mean that a direct "all-weather" route will be available to motorists travelling between the southwestern corner of the State at Wentworth and the southeastern coast at Tathra, near Bega (via the Sturt, Snowy Mountains and Monaro Highways).

The photograph below shows the re-alignment and widening of a narrow, winding part of the Snowy Mountains Highway northwest of Kiandra, looking towards Inspiration Point ●



SPECIFICATIONS FOR CONTRACT WORK IN AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRY



This article is the last in a series of three prepared by Mr P. G. Sandwith, the Department's Senior Photogrammetrist. The two previous articles were published in the September, 1971, and December, 1971 issues of "Main Roads" under the titles "Aerial Photography for Road Location and Design" and "Photogrammetry for Road Engineering Purposes".

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This article notes that much of the aerial photography and photogrammetry for engineering surveys in Australia is performed by commercial companies who operate both as consultants and contractors to government departments. The need for careful planning of photography, ground control and photogrammetry is emphasised, with reference to the resources already available. The types of commercial companies are described and the essentials for inclusion in adequate specifications for contract work are outlined for each activity. Checking procedures to ensure that the completed work meets the standards required are also given.

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Project Planning

In the initial stages of a photogrammetric survey the following aspects should be studied:

- Are there any existing maps or aerial photographs covering the area to be surveyed?
- Can these existing maps or photographs be incorporated in the survey or are they too inaccurate, too obsolete or presented at an unsuitable scale?
- What information is required from the survey and for what purpose are the plans to be used?
- How is this information to be obtained and how is it to be portrayed?
- What is the proposed date of completion of the survey?

Existing maps can be used to portray the area to be covered by aerial photography and photogrammetric plotting. Mosaics can be prepared of existing photographs to serve as a basis for planning aerial photography flight lines.

When the extent of the project has been determined, existing ground control must be evaluated to see if it is suitable for the project. Suitability of existing ground control will depend on what accuracy is required for the plans to be produced; whether these ground control points can be readily relocated in the field and identified from the air; and whether they are all interconnected or whether they consist of isolated groups of points unconnected in the field.

Ground control can cost as much as 50 per cent of the whole of the cost of producing plans by photogrammetry, so that careful study of the ground control requirements is necessary before planning aerial photography or photogrammetry. In general, planimetric ground control should be situated around the perimeter of the project, whilst height control should be situated within the area as well as around the perimeter (see Fig. 1, p. 118).

As mentioned in the previous articles, aerial photography should be planned at

an altitude suitable for the proposed contour interval and should extend beyond the perimeter of the project so as to include all selected ground control points. The scale of compilation of plans will also determine the flying height as will the extent of detail to be shown.

It may often be desirable to plan the project in two or more stages. The earlier stages will be an investigation of all possible locations or sites with small scale aerial photography and mapping, and later stages will consist of detailed studies of selected locations or sites by larger scale photography and plans.

Employment of Consultants and Commercial Companies

Most companies engaged in photogrammetry can be employed both as consultants and commercial practitioners, and most of the larger firms own or charter their own aircraft, own their own aerial cameras, employ field surveyors for ground control and have photogrammetric instruments for large scale and small scale plotting.

Several companies specialise in engineering surveys and employ engineers and design draftsmen who can carry forward a project from the initial planning to the design stage preparatory to construction. These companies may have their own photogrammetric departments as a comparatively small section of their entire operations. Other companies specialise in mapping and can be employed on routine mapping of an area at conventional mapping scales as well as on specific engineering projects.

On most photogrammetric contracts, tenders will be called for aerial photography and mapping by the same company, but ground control could be provided by the authority requesting the survey, provided the authority is fully aware of the requirements of ground control for photogrammetry. Many surveyors and engineers are well trained in field surveys for engineering purposes but few have the required experience in ground control surveys for photogrammetry as well.

When dealing with contractors it is advisable to have personnel with some knowledge of photogrammetry available to be able to set specifications for ground control, aerial photography and mapping. Although the theory of photogrammetry is taught at many universities, the practical application which is required for preparing specifications can only be obtained with road authorities and engineering companies which regularly use photogrammetric surveys. Rarely can such experience be obtained with organisations that specialise in mapping only.

Consultants and Commercial Companies

Private practitioners in photogrammetry in Australia can be divided into two categories. There are organisations which specialise in aerial photography and mapping, and organisations which specialise as consultants in the whole field of engineering but which have sections specialising in photogrammetry. The engineering consultant in Australia usually has to obtain aerial photography from a source outside his own company. All the private practitioners in Australia employ surveyors competent to carry out ground control surveys.

Several Australian companies have their own aircraft and survey cameras, and of these, some are competent to carry out aerial photography in colour and to process colour photography. One company will shortly be installing a plotting machine capable of producing orthophotographs. Some of the companies have obtained contracts for small scale mapping from the Commonwealth of Australia, and all companies carry out large scale plotting for various Commonwealth and State Departments including Public Works and Highways Departments. The Department of Main Roads employs its own photogrammetrists who prepare specifications for plotting by private practitioners and who are also engaged on research and checking of work performed by practitioners.

Specifications for Aerial Photography by Contract

There are two types of specification required for aerial photography by contract. The general specification to be used for all contracts should include the following items:

- *Equipment and materials*

The contractor is to be held responsible for the supply of equipment, materials and labour for the whole contract. The equipment used should be available for inspection by authorised persons. A rejection clause covering rejection of any unsuitable material within a specified period must be included. The copyright of any material supplied must be guaranteed.

- *Aircraft and camera operation*

General conditions covering suitable weather and times for photography must be specified. Navigation requirements giving tolerances in flying height, camera tilt, drift and crab, and flight direction should be added.

- *The camera*

The type of aerial camera to be used should be given and the conditions regarding camera calibration and tolerances should be set out. The details of the instrument panel to be recorded on each frame should be included.

- *Negatives*

Some general specifications must be included in respect of the quality of film negatives to be supplied. These specifications need not be too detailed as the rejection clause, mentioned above, guards against the supply of defective materials. However, some knowledge of photography will be needed to check the negatives supplied.

Clauses covering storage and supply of aerial film are required, as well as the technical data to be recorded on each film.

- *Positives*

The supply of check prints for approval should be noted, and the quality of prints and diapositives specified. Colour balances will be required of sample colour prints before general printing is carried out. The information to be recorded on each print should be listed.

Delivery and packing of diapositives must be performed with special care.

* * * *

It has been found from experience that the quality of aerial photography will vary from project to project even when provided by the same company and, therefore, it is necessary to set a minimum standard of acceptance. The clauses covering rejection of materials and copyright are essential.

General specifications can apply to a single contractor engaged for a flying season or two different contractors engaged on separate projects.

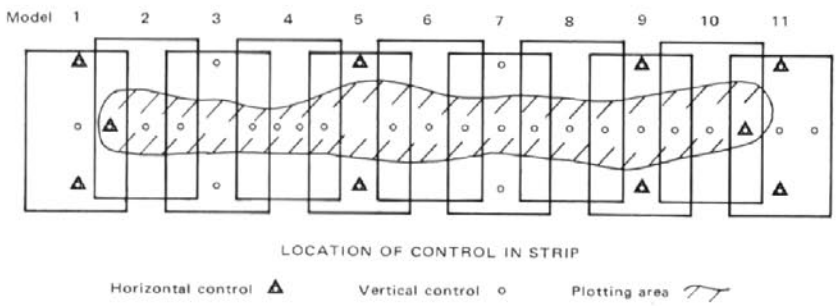
Detailed specifications for a particular project could include a flight diagram to assist the navigator in identifying the flight lines over the terrain.

Ground Control Requirements and Specifications

It will be difficult to set a general specification for ground control and a particular specification should be prepared for each project. The following items should be included in ground control specifications:

- It should be specified whether ground control is to be targetted before photography, or is to be located after

FIGURE 1



photography. The type of target to be used may be specified.

- The general pattern of ground control should be determined and presented to the contractor. This pattern can be specified in general terms such as "Three well distributed position and level control points in the first and last models of each strip, with pairs of position and level control points in every fourth model along the strip. Additional level points to be placed in suitable positions along the axis of the strip".
- Marking of ground control points should be carefully specified. Control points may have to be recovered during setting out surveys and must, therefore, be properly monumented and beaconed.
- Connections to property boundaries should be included in the ground control survey, if required.
- Connections to existing engineering survey marks, bench marks or triangulation stations may be required, and the requirements should be clearly stated.
- The origin of co-ordinates, the azimuth of one line, the level datum, and the map projection on which co-ordinates are to be based, should all be specified.
- The method of survey and the instruments to be used may be left to the discretion of the contractor, but the order of accuracy to be attained in horizontal and vertical control should be laid down. If one contractor is to perform the ground control survey and the photogrammetric plotting, accuracy can be related to the standards of plotting required rather than to the ground control survey itself (unless the ground control survey is to be used for additional purposes, such as control for cadastral surveys or for setting out).

In most cases ground control should be specified to be of such an accuracy as will fulfil the requirements of the particular engineering survey. To quote "third order accuracy" in a specification is insufficient. Accuracies quoted as "one part in five thousand" are also misleading and can lead to unnecessarily high precision over short distances and large discrepancies over long distances. Photogrammetric accuracies are quoted as standard deviations in position and level of points relative to one another and to the ground control, so that a specification for ground control should be formed to allow accuracies to be quoted in terms of standard deviation in position and level. If a standard deviation of "$\pm$ 1 metre" is specified, statistics show that 67 per cent of all points tested should not deviate from their true positions on the ground by more than $\pm$ 1 metre. This will permit, however, 1 per cent of all points tested to be $\pm$ 3 metres in error from their true positions. It is the specifying of the maximum permissible error that causes much difficulty in survey work and makes so many surveys more costly than they need be. A specification that stated that "no point should be in error by more than $\pm$ 1 metre" would probably involve survey costs many times higher than a specification which permitted "a standard deviation of $\pm$ 1 metre".

- All field books, computations, co-ordinate lists, and sketches to identify ground control points, together with a technical report, should be supplied by the contractor on completion of the survey. All or part of the field survey may be rejected if it does not comply with the specifications, and a penalty clause should be included to offset increased costs incurred due to incorrect field survey information.

Photogrammetric Plotting Specifications

Specifications issued to contractors engaged in photogrammetric plotting should cover the following points:

- The scale of compilation. This may be different to the scale of final presentation, but the original compilation sheets should always be supplied by the contractor as well as any fair drawings, or reduced or enlarged plans.
- The base material to be used for plotting should generally be a transparent, stable material such as Cronaflex or Astralon.
- The size of plotting sheets will be controlled by the requirements of the engineer, but may also be influenced by the size of the printing frame used when photographing sheets with a processing camera or by the size of the copying machine used to produce dyeline copies.
- The accurate plotting of a grid and control points should be specified. A grid is particularly useful to relate the positions of points of detail to each other when plotted on different sheets. It may be useful to plot some property corners on plans so that the cadastral information may be related to the detail shown on the plans.
- When aerial triangulation is to be used to provide additional control for plotting by photogrammetry, the result of the strip formation and the strip and block adjustment carried out by the contractor should be submitted for inspection before any plotting is commenced. Such results should include the discrepancies obtained between photogrammetric co-ordinates and field co-ordinates at ground control points.
- A schedule of the "setting-up" of each stereomodel in the plotting machine should be provided by the contractor. The contradictions between the position and level of points observed in the model and the same points plotted on the compilation sheets should be recorded. The size of the contradictions indicates the accuracy of the plotting. Large contradictions may indicate field or photogrammetric errors in position or level, or if the contradictions show a systematic pattern, they could indicate that the stereomodel was not correctly "set up" by the contractor.
- Topographical and relief details required to be plotted should be

specified. Topography includes both natural and artificial features. Natural features of importance to the engineer include the drainage pattern, rock formations, sand dunes, areas subject to flooding, and vegetation. Dense forest will conceal many features on the ground and field survey may be required to supplement the plotting in these areas.

Artificial features to be plotted include existing communications, bridges, buildings, fences and walls that may indicate property boundaries, areas of cultivation (including type of crop) and drainage ditches, canals and dams. All symbols to be used must be specified.

Relief can be portrayed by contour lines at suitable intervals. The contour should be numbered at intervals along each contour line, and major contour lines should be distinguished by a heavier line on the plan to assist interpretation. Spot levels should be plotted at critical points such as bridges, tops of hills, at intervals along existing roads, along streams, and on flat terrain where no contour lines can be plotted, depending on the particular requirements of the plan.

- The title to be shown on the plans must be supplied to the contractor. The contractor should sign a statement on the plans to certify that the specifications have been complied with. An estimate of the plotting accuracy in position and level of the detail shown on the plans will assist other map users.
- Final presentation of plans by the contractor may be in the form of pencil plots direct from the plotting machine, fair drawings in ink of the pencil plots, directly scribed sheets ready for photographing with a process camera, or as printed colour maps. The original pencil plots should always be supplied by the contractor, as fair drawing and map reproduction can introduce more discrepancies into the final plans than the field survey and photogrammetry combined.

There are various disadvantages associated with the different types of presentation of plans. Pencil plots can usually be produced within three months of a project being initiated, but finished maps can take from eighteen months to produce by conventional cartographic methods. Fair drawing can increase costs of pencil plots by 50 per cent and the accuracy is reduced. However, fair drawing could be carried out by the Department's own staff of tracers as required. Direct scribing of plotting sheets is possible from a photogrammetric plotting machine, but it is a slow process at large scales and can be expensive. Pencil plots, although the quickest by-product of photogrammetric plotting, are difficult to reproduce as dyeline copies direct.

Checking of Contractors' Work

On every photogrammetric project there must be some aspects of the contractor's work which will fall short of the client's expectations. The reasons for any deficiencies in the finished work may have been beyond the contractor's control and two questions must then be answered. Firstly, were the specifications set for the project impossible to comply with, and, secondly, can the work be accepted in its present form, or must some of the work be rejected? On many engineering projects a time limit is set for the preparation of plans, and aerial photography may have to be flown under poor conditions in order to comply with the time limit. Experience will show what work can be accepted and what work should be rejected, and thus only experience will show what specifications it is reasonable to set for a project. It will be useless also to set specifications for work which cannot be checked.

The first check to be made of the contractor's work is to request examples of previous aerial photography and photogrammetry performed under similar conditions before engaging the contractor in the first place. It may also be possible to check the contractor's capability to complete a project in the required period of time, by reference to previous work carried out by the contractor elsewhere.

Aerial photography can be checked for the following items:

- Is the required area completely covered by the photographs?
- Are the overlaps and sidelaps within the specified tolerances?
- Is the scale of the photography reasonably correct, and are there large differences in scale between successive photographs?
- Is the image quality of the photographs suitable for the purpose for which they were taken?
- Are there blemishes on the photographs due to inferior processing?
- Is the annotation of the photographs correct?

Ground control surveys can be checked as follows:

- Calculations and co-ordinate lists can be checked for mistakes. This is particularly important when different organisations perform the field surveys and photogrammetric plotting. Experience has shown that most of the mistakes in ground control are made in the office, not in the field.
- The marking and numbering of control on photographs, mosaics, and field sketches, should be carefully checked to guard against misidentification of ground control points by photogrammetrists.
- The ground control pattern should be inspected to see that it complies with the specifications. Some points could be visited in the field to ensure that permanent marks were correctly monumented.

The photogrammetric plot sheets should be checked against the specifications and a checking list can be prepared to include all items that should be inspected.

Checking can consist of three operations:

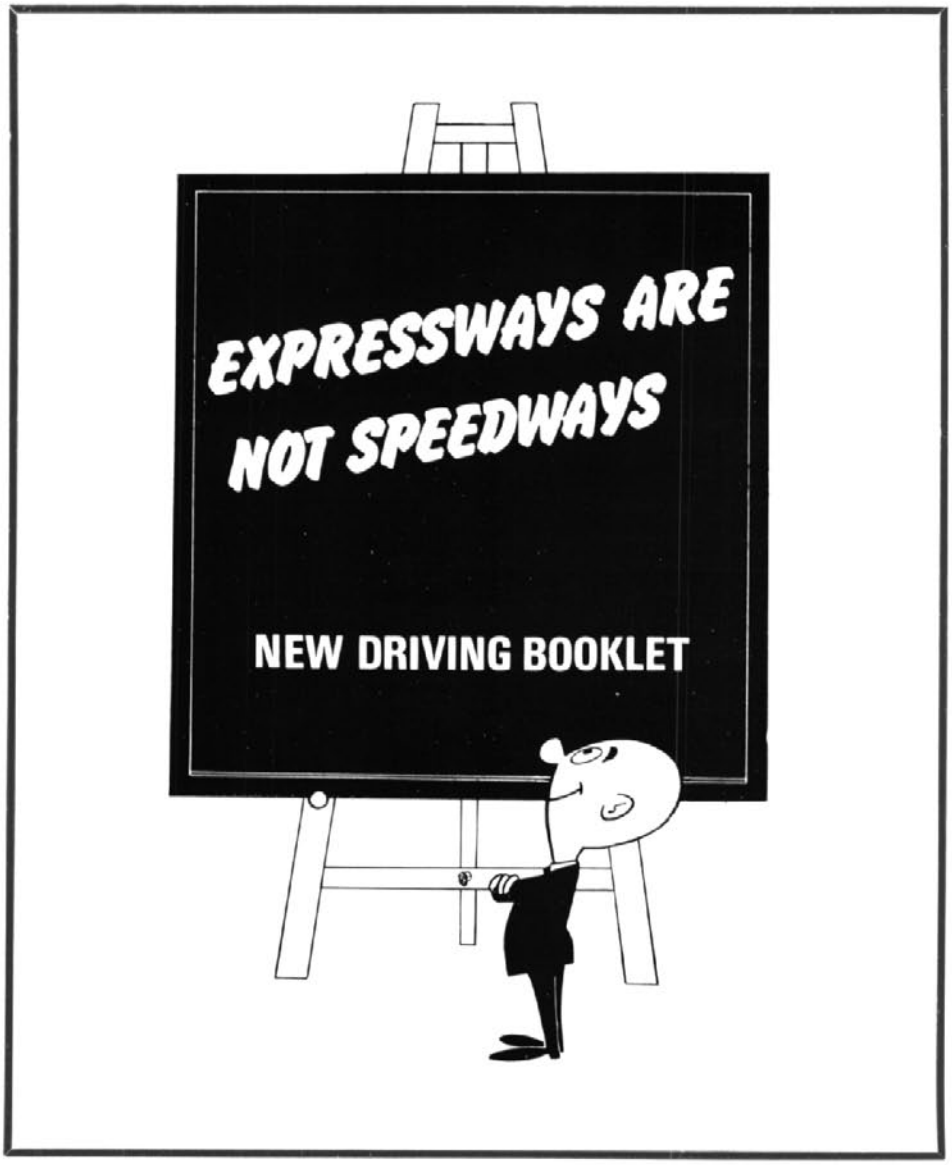
1. Inspection of plotting sheets only.

   This should be a routine operation which can be performed by technicians at the rate of about two to three hours per plot sheet.
2. Setting up photogrammetric models on a plotting machine belonging to another organisation and comparing samples of the work performed on the contractor's machine and the checking machine.

   This can only be performed if a plotting machine is available. Only sample models need to be set up and a complete model can be checked in a few hours.
3. Field Checks.

   This is the most satisfactory form of check on the whole photogrammetric operation and can consist of sample measurements in the field, particularly to test the contours and spot levels shown on plot sheets. If field checks are carried out on a number of projects, an analysis can be made of the comparison between photogrammetric and tacheometric or other types of field survey, particularly with reference to accuracy. The results of the comparisons can be used to reframe specifications for photogrammetric plotting.

In addition to field checks, additonal field survey may be required to fill in detail not visible on the photographs. Such additional survey, known as field completion, may either be performed by the client or by the contractor, according to arrangements made prior to the survey ●



In a new approach to encourage safer driving habits, the Department recently published a booklet entitled "How do *you* drive on expressways?"

A number of new sections on the South Western, Western and Southern Expressways will be opened within the next year or so, and the Department wishes to ensure that the good safety record of the first sections of the Sydney-Newcastle Expressway will also apply to them. It has long realised the need to warn drivers that the special conditions on expressways require their special attention. It has, in fact, printed earlier leaflets on "Safe Driving" and "Expressway Etiquette" for distribution to the public at the time that sections of the Sydney-Newcastle Expressway were made available to traffic.

The latest 12-page booklet was printed in sufficiently large quantities to allow them to be handed out at the Department's exhibit at the 1972 Royal Easter Show. In this way, maximum distribution was achieved in a short space of time and at minimum cost. To give it immediate "eye-appeal" and to encourage young, as well as old, drivers to read it, the booklet incorporated cartoons illustrating the eight major points. It proved to be a popular publication and many Show visitors expressed appreciation of this guidance by the Department towards their own safety.

Some examples of the types of cartoon and associated advice featured in the booklet are given on these pages. Any reader who has not already read the text in full is invited to obtain a copy of the booklet from the Department, post free. Multiple copies are also available to interested organisations on request to the Public Relations Section.

ARE YOU AND YOUR CAR A ROAD HAZARD?

Expressways are especially designed to promote fast and safe motoring. Hazards created by sharp curves, blind intersections, and pedestrian and vehicular crossing movements at road level are eliminated on expressways.

Expressways are crossed by means of bridges or subways which carry the traffic over or under them. Smooth sweeping curves and the provision of easy climbing and descending grades are features of expressways which contribute to the safe movement of vehicles along them. Divided carriageways reduce the chance of head-on collisions.

However, the value of the safety features incorporated in the design of expressways is reduced if the vehicles using them are unroadworthy and if drivers do not practise safe driving techniques.

✳

DO YOU . . . OBSERVE THE SPEED LIMITS?

Expressways are not speedways.

The speed limit on an expressway is related to the safe speed for which the expressway was designed and is therefore imposed for your safety.

Excessive speed is dangerous. Watch for speed limit signs and keep the speedometer reading at a safe level.

✳

DO YOU . . . TAKE NOTICE OF SIGNS?

All signs on expressways have a purpose. They either guide you, advise you, inform you or warn you.

Watch for signs and be prepared to act on their advice—it could save your life!

✳

DO YOU . . . CHANGE LANES CAUTIOUSLY?

Extra care should be exercised when changing lanes on an expressway as vehicles usually travel faster than on other roads. Sudden movement into another lane could lead to a serious accident involving a number of vehicles besides your own.

Give the appropriate signal indicating your intention to change lanes well in advance. Signals aren't enough, however, check your rear vision mirrors as well.●

Are you and your car a road hazard?

Expressways are especially designed to promote fast and safe motoring. Hazards created by sharp curves, blind intersections, and pedestrian and vehicular crossing movements at road level are eliminated on expressways.

Expressways are crossed by means of bridges or subways which carry the traffic over or under them. Smooth sweeping curves and the provision of easy climbing and descending grades are features of expressways which contribute to the safe movement of vehicles along them. Divided carriageways reduce the chance of head-on collisions.

However, the value of the safety features incorporated in the design of expressways is reduced if the vehicles using them are unroadworthy and if drivers do not practise safe-driving techniques.

Do YOU drive safely on the expressways?

Test yourself against the following quiz. If you can honestly answer "yes" to all the questions, you are well on the way to pleasant and accident-free motoring.

do you...
observe the speed limits?

Expressways are not speedways

The speed limit on an expressway is related to the safe speed for which the expressway was designed and is therefore imposed for your safety.

Excessive speed is dangerous. Watch for speed limit signs and keep the speedometer reading at a safe level.

do you...
take notice of signs?

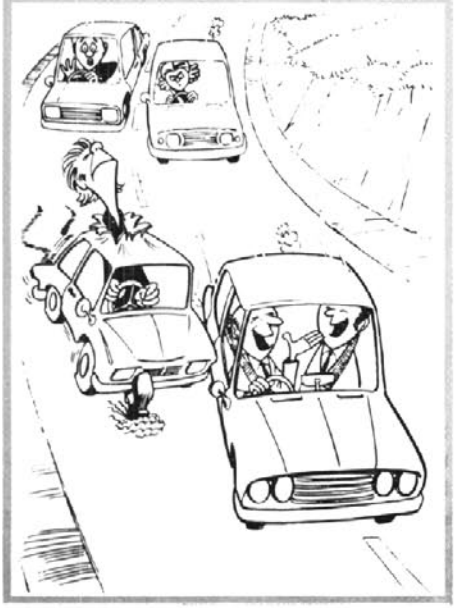
All signs on expressways have a purpose. They either guide you, advise you, inform you or warn you.

Watch for signs and be prepared to act on their advice — it could save your life!

do you...
change lanes cautiously?

Extra care should be exercised when changing lanes on an expressway as vehicles usually travel faster than on other roads. Sudden movement into another lane could lead to a serious accident involving a number of vehicles besides your own.

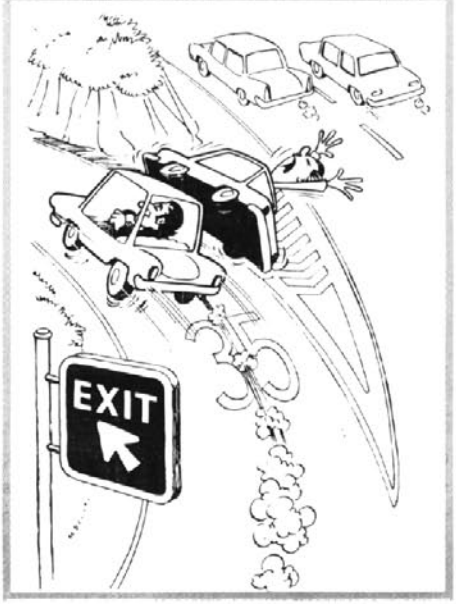
Give the appropriate signal indicating your intention to change lanes well in advance. Signals aren't enough, however, check your rear vision mirrors as well.



do you...
reduce speed when leaving an expressway?

You should reduce speed gradually before leaving an expressway in order to adjust to the slower traffic conditions beyond it.

Signs are displayed to tell you that you are approaching the "end of the expressway" and that you should "reduce speed". Take their advice and rejoin other motorists safely.



do you...
keep a safe distance from the car in front?

Drivers who follow the vehicle ahead too closely restrict their own field of vision which in turn limits the time they have to react to unexpected situations.

Remember the saying "forewarned is forearmed".

Be a defensive driver — keep your distance.

THE STORY OF CONSTRUCTION OF SYDNEY HARBOUR BRIDGE

Part 2

by Mr Lawrence Ennis, O.B.E.,
Director of Construction, Sydney Harbour Bridge, and a Director of
Dorman, Long and Co. Ltd.

This is the concluding part of an article which was initially published in the Sydney Harbour Bridge Souvenir and Programme of the opening of the Bridge on 19th March, 1932. In this re-publication, the article has been interspersed with excerpts—in italics—from a report by Mr Ennis which appeared in the Sydney Morning Herald's special opening day supplement.

The first part of the article appeared in the March, 1972 issue of "Main Roads".

38,000 TONS OF STEEL

Each half-arch to be anchored back weighed approximately 15,000 tons, and consisted of 14 panels, each panel 60 feet long. The total weight of steel in the main span, including deck, is 38,000 tons.

The temporary anchorage of eight cables to the top of the end post having been made, it was now necessary to haul up the creeper crane into a new position which would give it command of the remainder of the first panel. This movement having been carried out to my entire satisfaction, we proceeded with the completion of the bottom chords, diagonals, panel posts, top chords and bracing.

A number of the permanent anchorage cables were attached immediately the crane had moved forward on to the first panel, and this number was further increased as the erection proceeded until the full complement of 128 was connected.

The weight of the first panel of each half-arch was approximately 3,000 tons.

The nose of the arch now projected over the water, and, from this stage, members had to be lifted direct from a barge in midstream, an operation needing great care, in view of the continual passing of ferry-boats and deep-sea liners, for which the fairway was available during the whole period of the erection.

One of the interesting phases of the erection was the control of all crane movements by telephonic communication from the barges to the crane cabs 450 feet above.

As the half-arches proceeded over the Harbour the cables were tensioned to suit the increasing weight of the structure. As each member and panel was erected, the work was under constant check and control by our engineering staff, and on reaching the centre the positions of the half-arches were within 2 inches vertically, horizontally, and laterally of the calculated position.

Our erection scheme of cantilevering the two half-arches, and the method we adopted of attaching the cables to the earth and the arch, were unique. Our cable anchorage scheme gave us perfect and constant control over the structure, not only in the closing stages of the arch, but right through the erection period. As an instance of control, I might mention that on the completion of the eighth panel of the arch on the south side we were within an inch of correct alignment both vertically and horizontally. At however practically the same stage of erection of the northern half arch, it was found that the truss had a tendency to slew westwards. To correct this, the cables were slackened half an inch at the north-west point of attachment. This figure of half an inch was of course only determined after careful investigations had been made, and this sufficed to bring the two half arches practically dead into correct alignment. There was 8,000 *tons erected on the northern half arch at the time, and this was suspended on the cables when the adjustment was made.*

The heaviest lift made during the erection of the half-arches was 110 tons, occurring in the bottom chord of the sixth panel, the reducing section of the bottom chords by this time having reached the stage when each chord could be erected in two complete panel lengths of 60 feet.

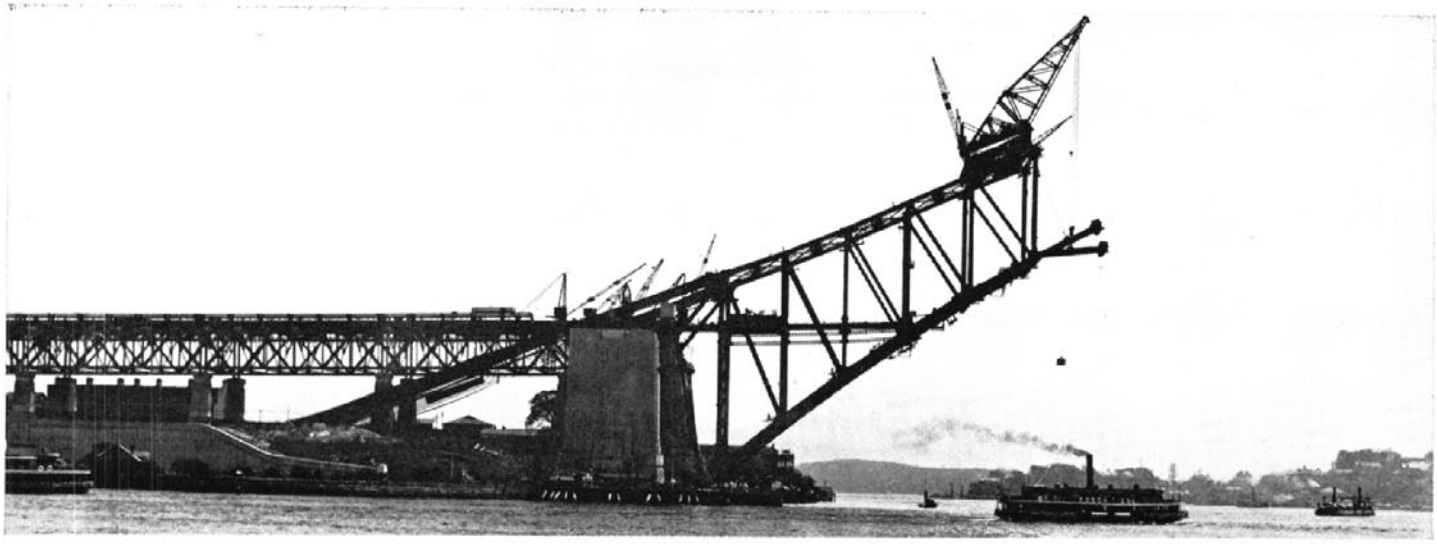
The erection of both half-arches was now proceeding rapidly, and on 26th November, 1929, we had the satisfaction of erecting a record tonnage of 598 tons in one day.

At all stages of the erection the positions of the half-arches were under constant observation by special surveying instruments—fixed on top of the pylons.

To enable the observations to be made, small sighting targets were painted on the bridge members before erection, in a predetermined position. The instruments were then focussed on these targets, in the same way as the marksman at the rifle range focusses his rifle. When heavy lifts were being made, the instruments were focussed on the targets, which were at times 500 *feet and even* 800 *feet away, and as the weight of the lift was being taken by the crane on the end of the half-arch, the deflection of the half-arch could clearly be observed before the lift started to go up. We thus ensured that no undue deflection was being caused over and above that allowed for in the calculations.*

On the completion of the erection of the two half-arches the gap at the centre was 3 feet 6 inches. A severe gale was experienced when the structure was in this condition and it was an impressive sight to stand on the forward end of one 825 foot arm and see the swaying end of the other arm. Indicators, however, registered that the total movement between the two arms was barely 3 inches.

By slackening the anchorage cables the two half-arches were to come together to rest on a central horizontal steel bearing-pin and, for the correction of alignment, pilot-pins had been provided in each truss of the southern half-arch. These pins engaged in square diaphragms



October, 1929

May, 1929

in a similar position in the northern half-arch, the approaching movement and weight of the two half-arches automatically bringing them into correct alignment.

THE ARCH SUCCESSFULLY CLOSED

August 4, 1930, saw the completion of the bottom triangle of the 14th panel on the south arm; the northern arm reached a corresponding position three days later, and the two arms were then ready for lowering, the gap, as previously mentioned, being 3 feet 6 inches.

The slackening of the cables was carried on day and night, the weight handled from each shore being over 15,000 tons.

The first closure was effected at 4.15 p.m. in the afternoon of 19th August, 1930, but there was a subsequent slight opening with the contraction in the cool of the evening. Slackening of the cables was continued without intermission, and the final closure was made at 10 p.m. the same day.

There were only five men up there in the darkness when the actual closure took place—our Chief Erector, Mr Hipwell, my assistant, Mr Alfred Martin, Mr Freeman, Dr Bradfield, and myself. When we realised what had just taken place we were so overawed with the mightiness of it all that we did not speak —I for one could not—and I think each was conscious of the feeling of the other. The silence to me was most impressive, and when I could trust myself to speak I broke the silence by saying; "Well, boys, that's that, and thank God she is home". We shook hands with each other, stepped into the cage, and were lowered down to our little launch in the middle of the harbour, and went home, but so far as I was concerned, not to get much sleep.

Next morning the Union Jack was flown from the jib of one creeper crane, and the Australian Ensign from the other, to signify to the City that the arch had been successfully closed.

Intense interest had been manifested by the citizens of Sydney right through the closing operations, and the breaking of the flags was the signal for an outburst of enthusiasm. Harbour ferries and other vessels sounded their sirens, and people cheered as they passed on their way to business.

We had all felt the strain of recent months, and were inspired and heartened by this spontaneous tribute to the result of our efforts.

We felt that the arch had become not only a link between the two shores of a beautiful Harbour, but a further bond of Empire.

It was a memorable day—all the leading hands and all the men engaged on the releasing of the cables (who did yeoman service) received a golden sovereign from the company as a souvenir of the event, and every man and boy on the job (over 1,400) received as a personal gift from Mr Freeman a new two-shilling piece, with an invitation from him to drink a toast of prosperity and long life to the bridge. A half-holiday with pay for all was declared, and Mr and Mrs Freeman, my wife and myself spent our half-holiday at the Taronga Park Zoo, and so finished our little celebration.

With the closure of the arch the cables were removed and coiled, and preparations made for the closure of the top chord, which, although less spectacular, was equally as important as that of the bottom chord.

When the joining of the two half-arches at the centre was accomplished, the arch became a three-hinged structure—the main bearing-pins at the bases being two of the hinges and the bearing-pin at the centre the third.

The erection of the remaining members to complete the two centre panels of the arch was completed so as to leave a gap between the top chords of 24 inches, into which was inserted four hydraulic jacks in each chord. These eight jacks were capable of exerting a combined force of nearly 8,000 tons, at an operating pressure of 4 tons per square inch. The two top chords were forced apart to a predetermined extent, and in the space so made carefully machined steel slabs were inserted as packing pieces.

. . . in other words the "keystone" was placed in position.

By forcing the two central top-chord members apart, the crown of the arch was converted into a rigid structure, and thus into its final two-hinged condition, the main bearings alone acting as hinges.

Under full live load of traffic conditions the four main bearings will sustain a thrust of 78,800 *tons. The dead weight of the main span is* 42,000 *tons.*

EFFECT OF TEMPERATURE

Throughout the erection the temperature of the steel was an important matter to be considered, as, due to the relative positions of the sun, the temperature variations of the east and west trusses were considerable.

In calculating the pressure to be exerted in the stressing of the top chord, the question of temperature was a vital one. It would have been impossible to estimate accurately the effect of varying temperatures in different parts of the steel, but, fortunately, on 8th September, 1930, a condition of equable temperature, as registered by twenty-four thermometers distributed throughout the top and bottom chords, removed this source of possible error.

Any error in calculations, manufacture, and assumption would have been revealed in the magnitude of the opening produced when the two chords were forced apart. The actual divergence—it was not an error because it was within the limits of unavoidable divergence—was about half an inch.

Our Consulting Engineer, Mr Freeman, was entirely responsible for the calculations and design of the structure, and during the above important operations his presence in Sydney was necessary. He made a special journey from London to witness the two closures, and the operations in this connection were carried out under his direct advice.

THE HANGERS—THEN THE DECK

The erection of the hangers to support the deck was our next problem and for some considerable time this matter had been given my closest attention. The problem was complicated by the fact that the final position of the hangers was directly underneath the 11-feet wide bottom chords, and to clear the chords with crane ropes meant that the line of lift would be 10 feet out. After some difficulty, I worked out a satisfactory scheme, embodying the use of a specially designed cradle to which the hanger was attached at one end by means of a pin connection. The cradle, together with the attached hanger, was lifted into a horizontal position from the barge, and in its journey to the under-side of the chord was swung into a vertical position.

The longest hangers were 193 feet, weighing the comparatively small tonnage of 38. The lightness in weight, together with the extreme length of the hanger, made it liable to twist and bend if erected singly, and the cradle thus not only served to place it in position under the bottom chord but also acted as a stiffening whilst the lift was being carried out.

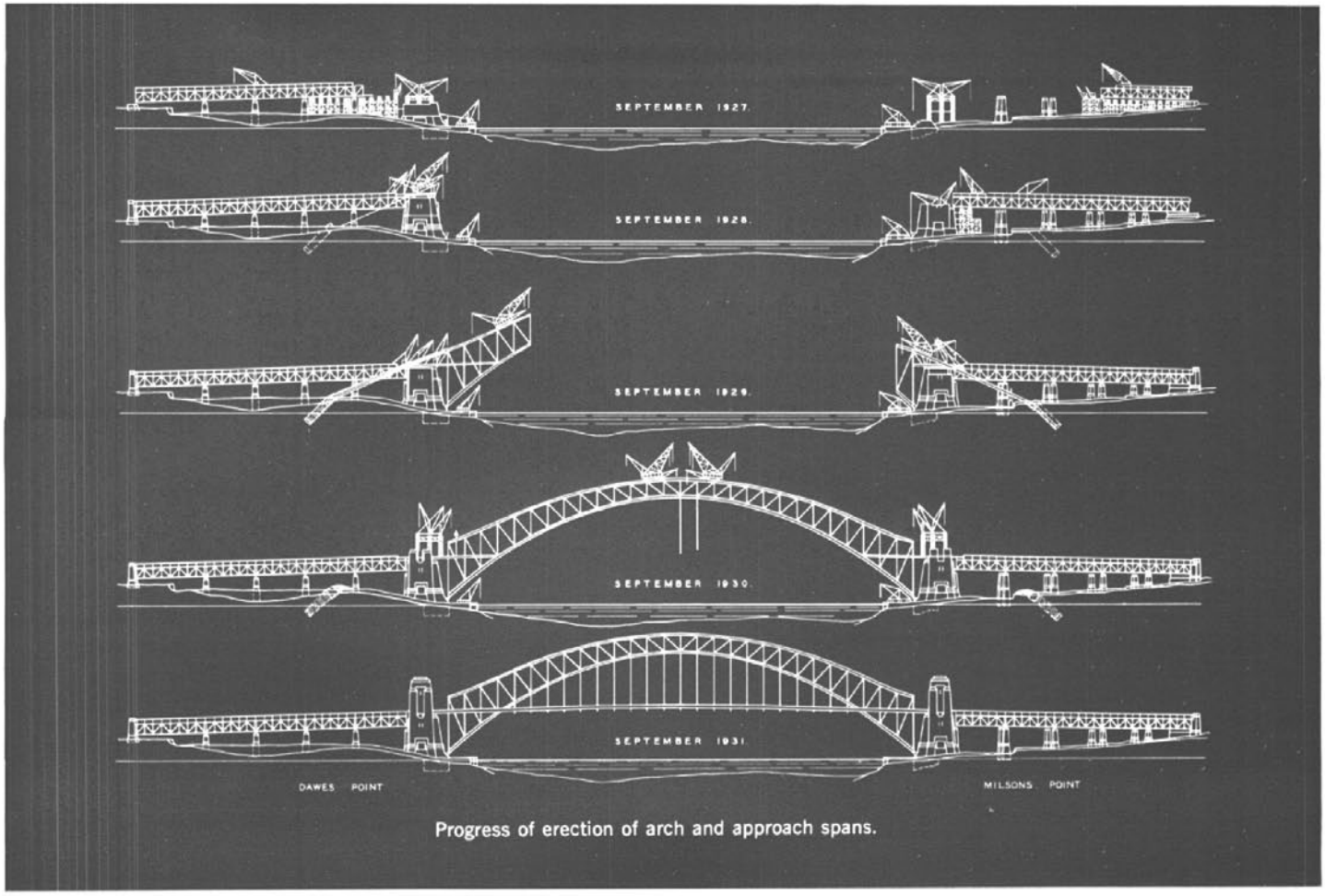
This scheme of hanger erection enabled rapid progress to be made . . .

I shall always remember the speedy erection of this dangerous and complicated portion of the work—nearly 12,000 *tons being erected in six months.*

. . . and within nine months of the closing of the arch, the steel-work erection of the deck of the main span was completed, including all hangers, cross-girders, bracing, railway and roadway stringers and pressed plates for the deck. The cross-girders, which are connected by 14-inch pins to the hangers, were erected in one piece, the heaviest lift in this connection being 114 tons.

Upon the completion of the erection of the steel for the main span, we concreted the roadway. The asphalt finish of the roadway and footways was applied by the Neuchatel Company of Sydney.

July, 1930



Progress of erection of arch and approach spans.

The railway overhead wiring supports were erected; ironbark sleepers and planking for the railway tracks then laid, followed by the rails themselves.

Simultaneously with the completion of the deck the pylon towers were concreted and granite faced to the finished height of 285 feet, and the bridge was then ready for testing.

I think it is unique for the one Company not only to have manufactured the greater portion of the steel but also to have carried out the complete fabrication and construction of a bridge of this magnitude, involving also the quarrying and dressing of stone for the sub-structure.

I cannot pay too high a tribute to our Consulting Engineer, Mr Ralph Freeman, from whose drawings and calculations we have worked throughout. Dr Bradfield, the Chief Engineer for the Government of New South Wales in connection with the Bridge Contract, has received from us many hundreds of drawings and calculations during the past eight years, and I am very pleased to say that I do not know of one major detail where his approval has been withheld.

We are very grateful also to Dr Bradfield for the many valuable proposals we have received from him, arising from his independent inspection and verification of all that has been done.

APPRECIATION FOR AUSTRALIANS

The Electricity Department of the Government Railways supplied us with the main power for our equipment throughout the contract, without interruption. This continuity of service, I have highly appreciated.

Of the 54,000 tons of steel and rivets for the bridge, 10,500 were supplied by the Broken Hill Proprietary Company Ltd, of Newcastle, New South Wales, and 3,500 by the Australian Iron and Steel Company Ltd.

In the fabrication and erection we used over 5,000,000 *rivets, and of the* 54,000 *tons of steel required in connection with the erection of the bridge,* 40,000 *tons were manufactured by Dorman, Long, and Co. Ltd.*

Messrs Macpherson's Proprietary Ltd, of Melbourne, Victoria, supplied us with the five million odd rivets in the contract, varying in size up to $1\frac{7}{16}$-inch diameter.

Cement was obtained from the Kandos Cement Company Ltd, sand from the Nepean Sand and Gravel Company Ltd, and paint from Lewis Berger (Australia) Ltd.

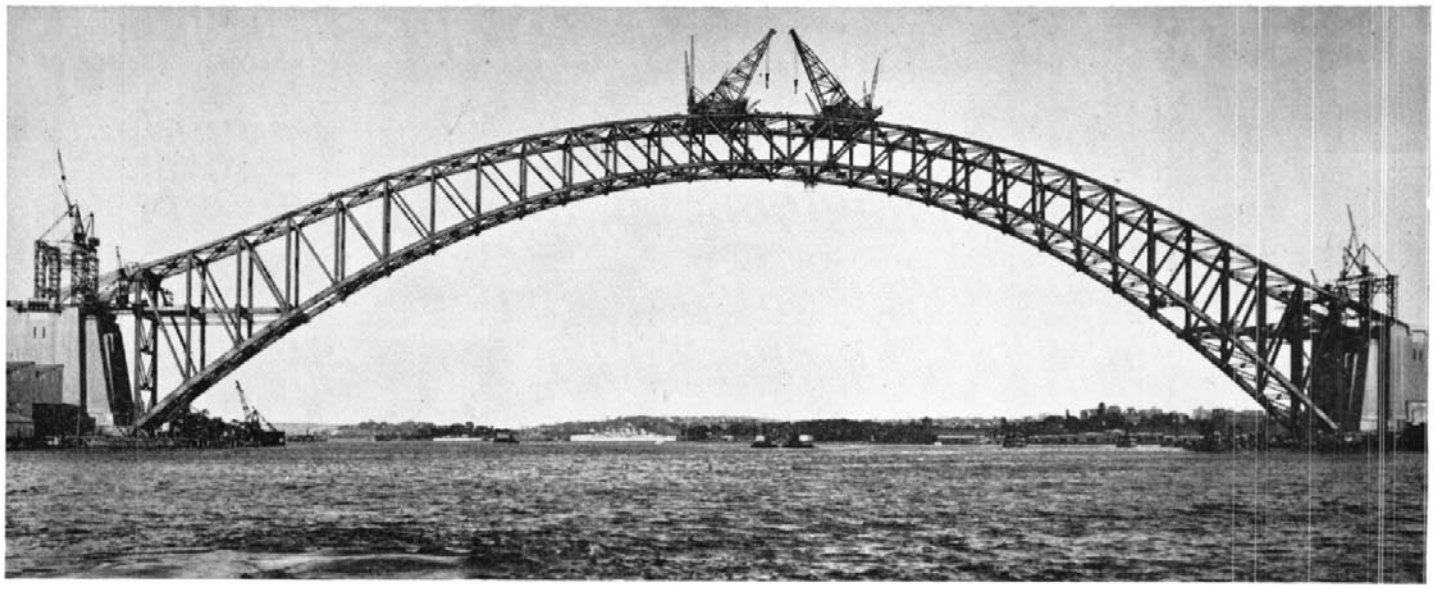
Our disbursements in Australia for the contract totalled over £3,000,000, the greater portion being in salaries and wages.

Our Australian suppliers and transport organizations gave us the very best of service, and their co-operation has been invaluable.

I wish to pay a tribute to the men we had engaged on the work. I must admit that when I first came to Australia I had doubts as to whether we could obtain men with sufficient experience to carry out the work with the high standard of accuracy that was required. My doubts were soon dispelled.

The Australian workmen proved to be as good tradesmen as any that I have had experience with in Britain or America. They gave us of their very best, and the successful completion of the work could never have been attained without their whole-hearted co-operation.

It is naturally a source of gratification to me that the tangible result of the work of Mr Freeman and myself and our



September, 1930

respective staffs now crosses Sydney Harbour.

This article would not be complete, however, without acknowledgement of the part played by the managers and staffs of our several works in England in the supply of the special steel plates and sections used in the construction. The transportation of this material, in addition to many thousands of tons of plant and equipment, without loss of a single item, was in the hands of the England-Australia shipping lines. Their valuable co-operation has enabled our programme at all stages to be carried out to schedule ●

This account has been, of necessity, only a brief outline of the full "Story of construction of Sydney Harbour Bridge". A detailed record of all aspects of the design and construction would require volumes rather than pages. Limited space has unfortunately prevented the inclusion, at this stage, of additional information (e.g. concerning the work of Dr Bradfield, the opening ceremony, etc.) and publication of this material has therefore been postponed to a later date.

An interesting historical article entitled "Bridges and Vehicular Ferries across Sydney Harbour—The Story of their Development" was published in the December, 1954 issue of "Main Roads" (Vol. 20, No. 2, Pages 35–40).

Among the many other records of this magnificent work is a special issue of the Australiasian Engineer, dated 7th March, 1932 (Vol. 32, No. 189), which also includes details of some preliminary designs by Dr Bradfield and some of the unsuccessful designs submitted when tenders were called in 1922.

In its 16 mm film library, the Department holds copies of two black-and-white movie films on Sydney Harbour Bridge, both produced by the Commonwealth Government. One film is a 90-minute silent version, giving detailed coverage of construction between 1925 and 1931. The other is a 10-minute film, with commentary, briefly showing the construction and completion of the structure.

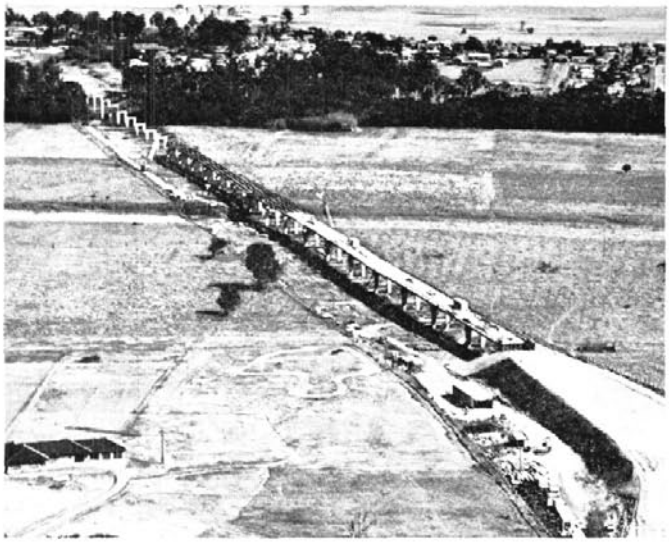
Both films are available for loan or screening to appropriate organisations and bookings can be made through the Public Relations Section.

NEW BROCHURE ON "PLANNED EXPRESSWAYS FOR SYDNEY, NEWCASTLE AND WOLLONGONG"

A new 32-page brochure has been produced to introduce to the public the Department's expressway proposals.

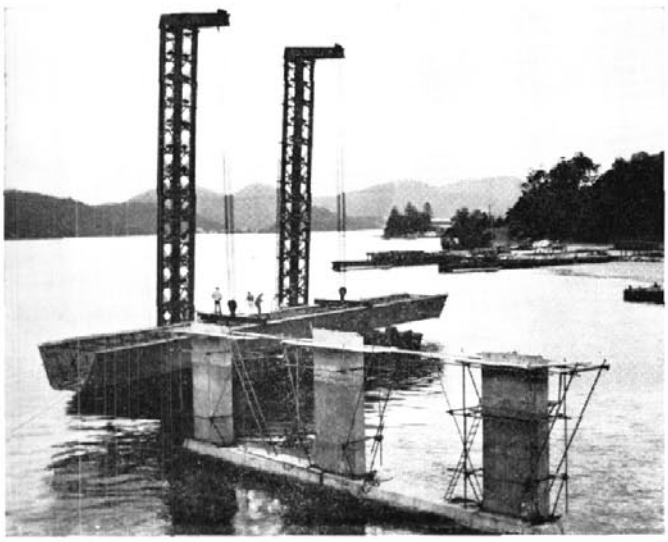
This brochure is of the same page size as "Main Roads" and provides, in general terms, a brief description of the routes and the purposes of the various arms of the Department's planned expressway system. It is illustrated with photographs of completed sections, as well as of scale models and artist's impressions of future proposals.

Planning urban expressways is planning for people—so that they and their goods can move quickly, cheaply and safely through increasingly crowded areas. Used in conjunction with Departmental maps, this new brochure gives a good overall picture of proposals for the Sydney, Newcastle and Wollongong area. It can be obtained, free of charge, from any of the Department's principal offices and should be read by all who want to know how expressways will help them in the future ●



Camden Bridge *May*, 1972

Western Distributor *February*, 1972



Hawkesbury River Bridge *December*, 1971
First girder being placed in position

REPRINTS AVAILABLE

A number of articles, which were published in recent issues of "Main Roads", have been reprinted and are now available on request.

These articles, which give detailed information about some of the Departments current major works, are:

- Design of New Bridge over Nepean River at Camden.
  This is a 6-page feature about the longest bridge (3,380 feet) to be constructed by the Department. It is illustrated with locality sketch, diagram of abutment, typical cross-section, perspective view of pier and superstructure and artist's impression of completed structure.
- Oxley Highway—Reconstruction between New England Plateau and Port Macquarie, and
- Oxley Highway—Notes for Tourists.
  This 8-page composite reprint is also from the June, 1971 issue and provides details of current reconstruction work—as well as historical information about points of interest along the route (such as at Walcha, Apsley Falls and Wauchope).
- Western Distributor.
  The 5-page article in the September, 1970 issue has been up-dated by the addition of some more recent construction photographs. As construction of the first section approaches completion, details of this important project will be sought by many of the thousands of city motorists who daily see it progressing from plan to reality.
- North Western Expressway—City to Glebe.
  With the addition of a map showing the route of this section of expressway, this reprint from the September, 1971 issue gives 4 pages of text and illustrations. The 6-year project is already under way with pile-boring operations in Darling Harbour Railway Goods Yard being undertaken by the Department.
- New Expressway Bridge over Hawkesbury River.
  This 8-page reprint is a composite of two articles, both illustrated with photographs and diagrams. Firstly, one on foundations for the new structure (which rank among the deepest piled bridge foundations in the world) . . . which appeared in the March, 1970 issue . . . and, secondly, one on construction methods . . . initially published in the December, 1971 issue.

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Interested persons or organisations are invited to obtain copies of these reprints from the Public Relations Section, Head Office, or from any of the Department's Divisional Offices.

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TENDERS ACCEPTED BY COUNCILS

The following tenders (in excess of $10,000) for road and bridge works were accepted by the respective Councils during the three months ended 31st March, 1972.

Councils	Road No.	Work or Service	Name of Successful Tenderer	Amount
				$
Bibbenluke	State Highway No. 19	Monaro Highway. Reconstruction to subgrade level, 10·1 to 10·9 miles south of Bombala, including construction of 2 cell 7 ft x 6 ft reinforced concrete box culvert.	W. J. Hayden	45,615.00
Canobolas	Various	Bituminous sealing and resealing at various locations	Shorncliffe Pty Ltd	10,883.60
Concord	M.R. 200	Reconstruction of intersection of Concord Road and Killoola Street, Rhodes.	R. Stillone Pty Ltd	28,330.89
Coonamble	M.R. 202	Bituminous surfacing, 0 to 5 miles south of Quambone	Emoleum (Aust.) Pty Ltd	13,306.13
Goobang	M.R. 390	Bituminous sealing, 5 to 10 miles north of Trundle	Allen Bros Pty Ltd	13,302.83
Goodradigbee	T.R. 56	Construction of 2-span steel and concrete bridge, 80 feet long, over Boorowa River, 14·4 miles north of Yass.	L. J. Ward	40,672.00
Lyndhurst	Various	Bituminous sealing and resealing at various locations	Emoleum (Aust.) Pty Ltd	12,551.70
Peel	State Highway No. 11	Oxley Highway. Construction of 4 cell 10 feet x 5 feet reinforced box culvert at 18·3 miles west of Tamworth.	Concast Pty Ltd	10,978.00
Tomki	T.R. 83	Manufacture, supply, delivery, and stacking of 60 prestressed concrete bridge units at site of new bridge over Deep Creek, 5·75 miles south of Casino.	Dowsett Products (Aust.) Pty Ltd.	30,360.00
Waugoola	Various	Bituminous sealing and resealing at various locations	Boral Road Services Pty Ltd.	60,570.59

TENDERS ACCEPTED BY THE DEPARTMENT OF MAIN ROADS

The following tenders (in excess of $10,000) for road and bridge works were accepted by the Department during the three months ended 31st March, 1972.

Road Number	Work or Service	Name of Successful Tenderer	Amount
			$
Western Expressway	Municipality of Blacktown. Manufacture, delivery and erection of 20 precast, pretensioned concrete girders for bridge over Western Expressway at Chatsworth Road, Colyton.	E.P.M. Concrete Pty Ltd	63,767.00
Southern Expressway	City of Wollongong. Construction of 2-span prestressed concrete hollow box-girder bridge, 370 feet 4 inches long, to carry Prince's Highway over Southern Expressway.	Pearson Bridge (N.S.W.) Pty Ltd	149,850.00
Southern Expressway	City of Wollongong. Construction of single span, 40 feet 3 inches long, prestressed, reinforced concrete bridge over Main South Coast Railway line at Figtree.	Enpro Constructions Pty Ltd	138,138.20
Southern Expressway	City of Wollongong. Construction of 12 feet x 12 feet reinforced box culvert underpass, 167 feet 6 inches long, 27·3 miles south of Sydney.	Concast Pty Ltd	38,989.00
State Highway No. 2	Hume Highway. Municipality of Camden. Construction of reinforced concrete cast-in-place piles for bridge over Macarthur Road, Camden.	Vibropile (N.S.W.) Pty Ltd	24,838.90
State Highway No. 10	Pacific Highway. Shire of Wyong. Supply and delivery of up to 850 tons of ¾ inch gauge asphaltic concrete between Wyong overbridge and North Road, Wyong.	Bituminous Pavements Pty Ltd	10,829.00
State Highway Nos 10 and 11	Pacific and Oxley Highways. Shires of Hastings, Manning, Nambucca and Macleay. Supply, heat and spray of R90 bitumen and incorporation of cutter oil at various works.	Shorncliffe Pty Ltd	25,470.10