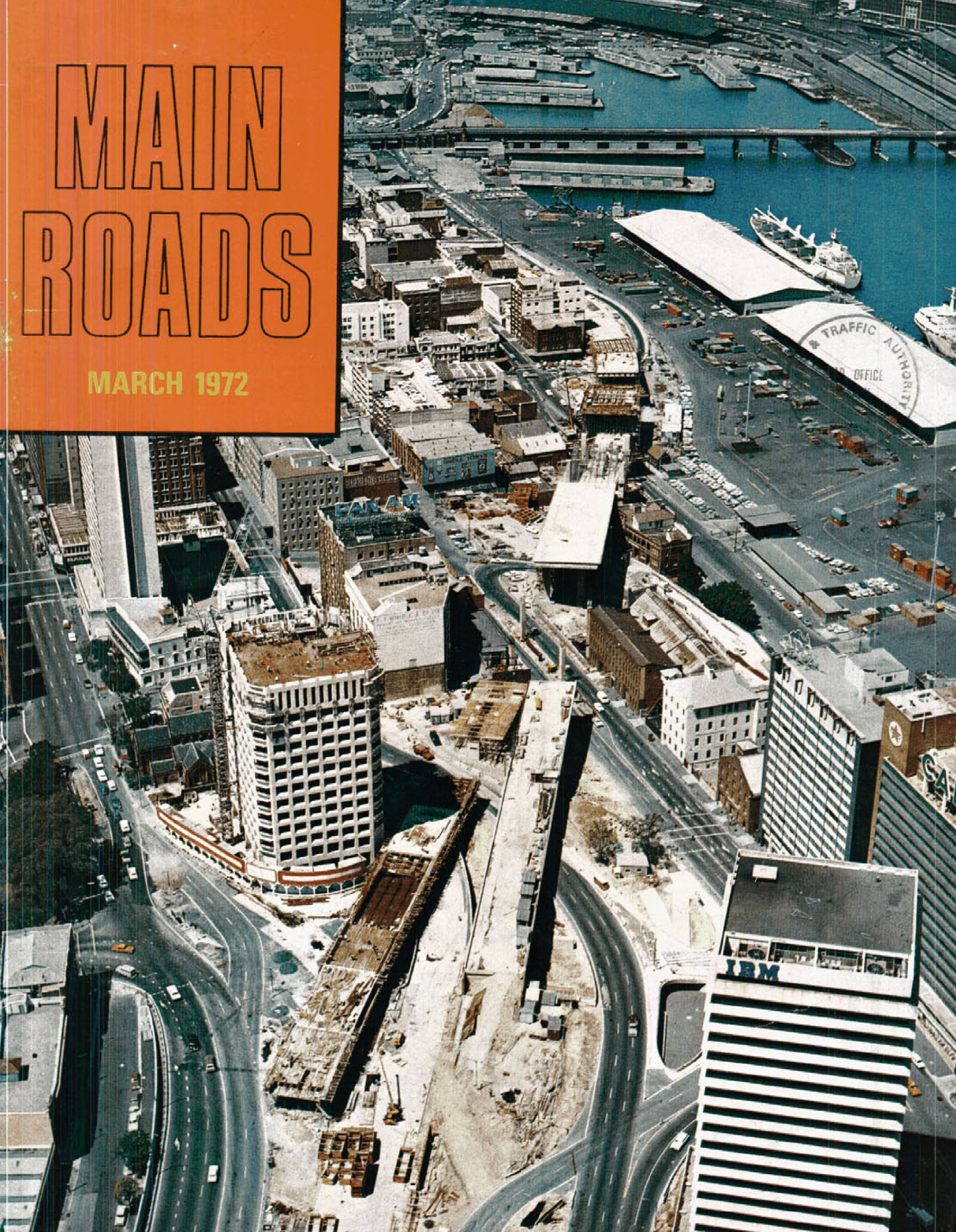
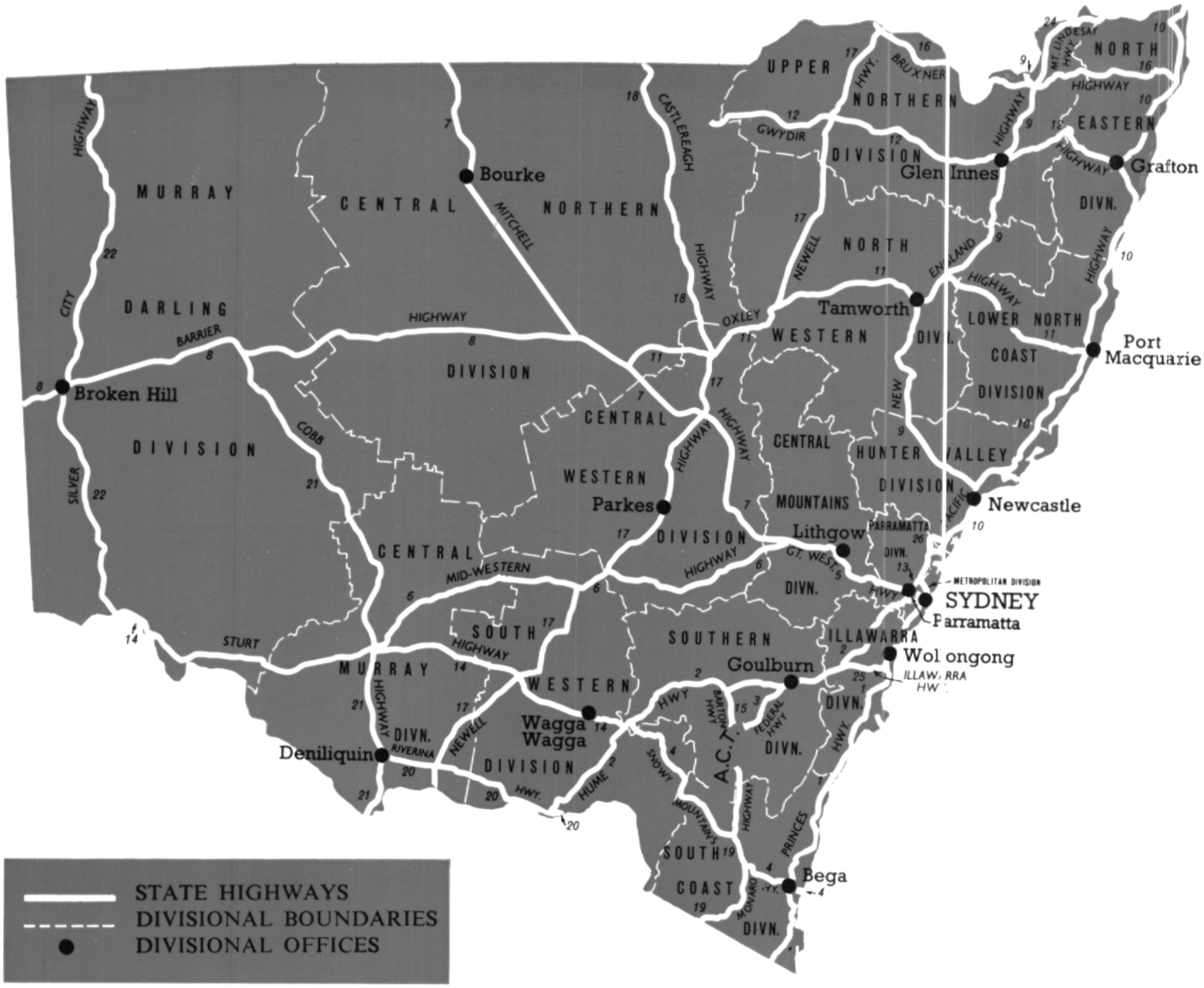
MAIN ROADS

MARCH 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

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MARCH, 1972

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Front Cover: New city expressway link takes shape. View from above southern approach to Sydney Harbour Bridge (looking south) showing construction of first section of the Western Distributor. In the background Pyrmont Bridge can be seen crossing Darling Harbour

Back Cover: A selection of views of Stockton Bridge on opening day, 1st November, 1971 (see article on page 66)

PITCH AND TOSS

"Pitch" is one of those fascinating, yet frustrating, words which are such a delight to etymologists and so confusing to migrants trying to learn the English language. It has a wide range of meanings relating to such subjects as camping, cricket, golf, falconry, music, movement, shape and distance.

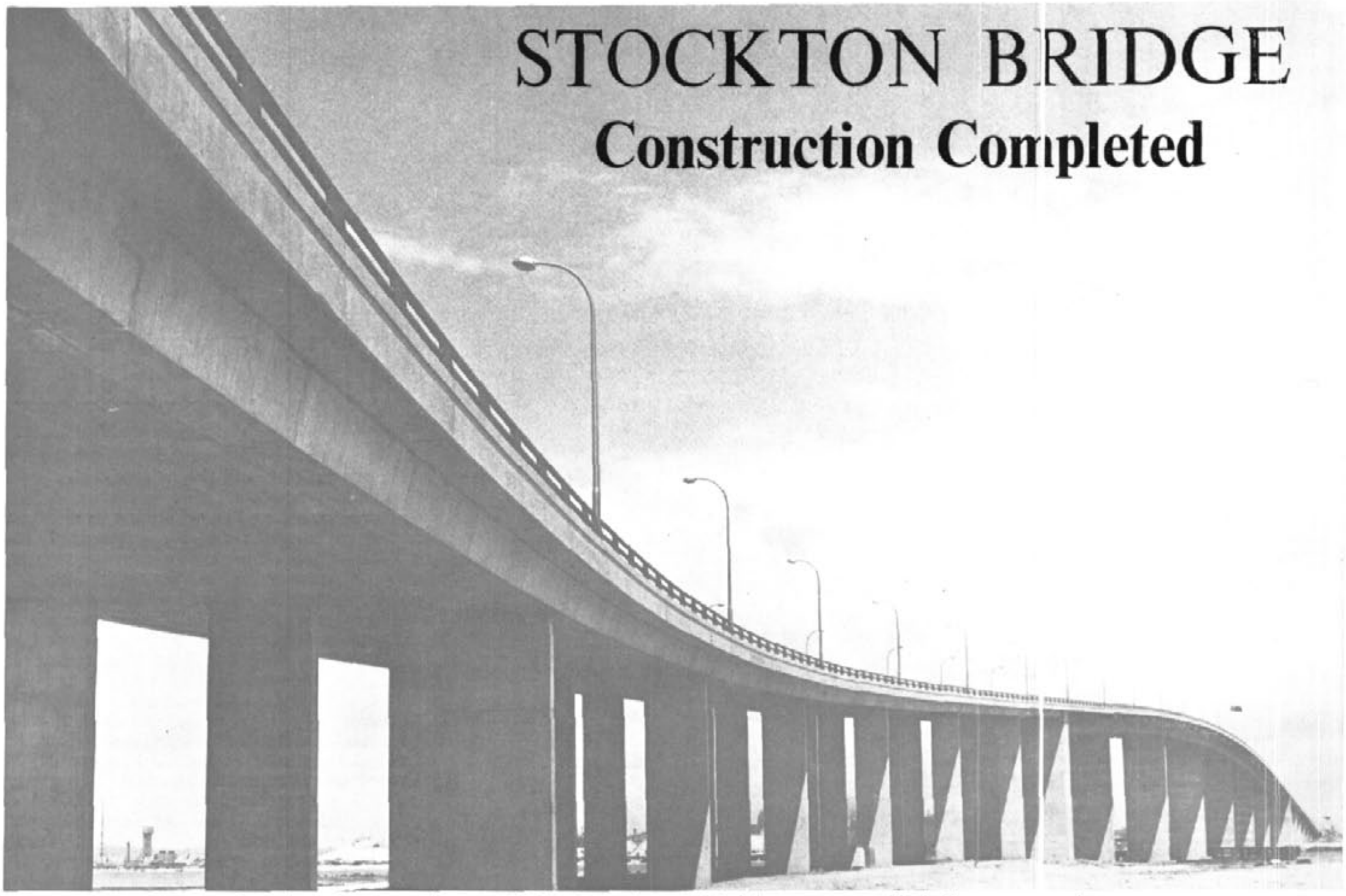
Pitch also refers to a "black, tenacious, resinous substance" which is mentioned as far back as the Old Testament stories of Noah and Moses. Noah's reliable ark was caulked "within and without with pitch" (Genesis 6; 14), while Moses' mother, before setting him adrift amid the bullrushes, daubed his cradle with pitch (Exodus 2; 3). From these notable, nautical beginnings, pitch has progressed through a variety of forms and uses. It is less than 90 years since tar was first introduced to Sydney's rough macadam roads. Thus began, for road-builders, the long task of eliminating the seasonal alternatives of either dusty or boggy conditions.

The phrase "pitch and toss" can refer to a game, to the movements of a ship in rough seas, or those of a restless sleeper. It might also be used to describe the old method of surfacing roads by spreading crushed stone onto hot tar using short-handled shovels and accurate "tossing" actions.

Today, highly mechanised methods are speeding up the Department's bituminous surfacing programme. Sometimes, when looking at particular locations, the sealing of road surfaces may still seem to be a slow process. However, the Department's responsibility covers a total of 27,060 miles throughout the State and, in total, annual achievements add up to an impressive figure. For example, during 1970–71, an average of over 4·7 miles (i.e. over 10 lane miles) of bituminous surfacing was completed each working day by the Department, Councils and contractors (see details on page 91).

Throughout the State, each victory in this "pitched battle" against dusty, muddy and rutty roads brings both personal and commercial benefits to the community. Completion of the sealing of the road between Hillston and Goolgowi (see page 90) has brought improved means of communication to the people of Carrathool Shire. The completion of sealing of the Barrier and Newell Highways in 1972–73 will be of inestimable value, to both local and interstate travellers, in saving time and reducing vehicle wear.

So, in its many bituminous surfacing projects the Department is "pitching in"—and this means "setting to work vigorously"—to provide safer and more comfortable driving conditions. This, in turn, encourages business and promotes tourism by making motoring a pleasure.



STOCKTON BRIDGE
Construction Completed

On 1st November, 1971, Stockton Bridge was officially opened to traffic by the Hon. R. W. (now Sir Robert) Askin, M.L.A., Premier and Treasurer of New South Wales.

Stockton Bridge crosses the North Channel of the Hunter River and links Stockton Peninsula and Kooragang Island, about 2½ miles upstream from the vehicular ferry service which it replaced.

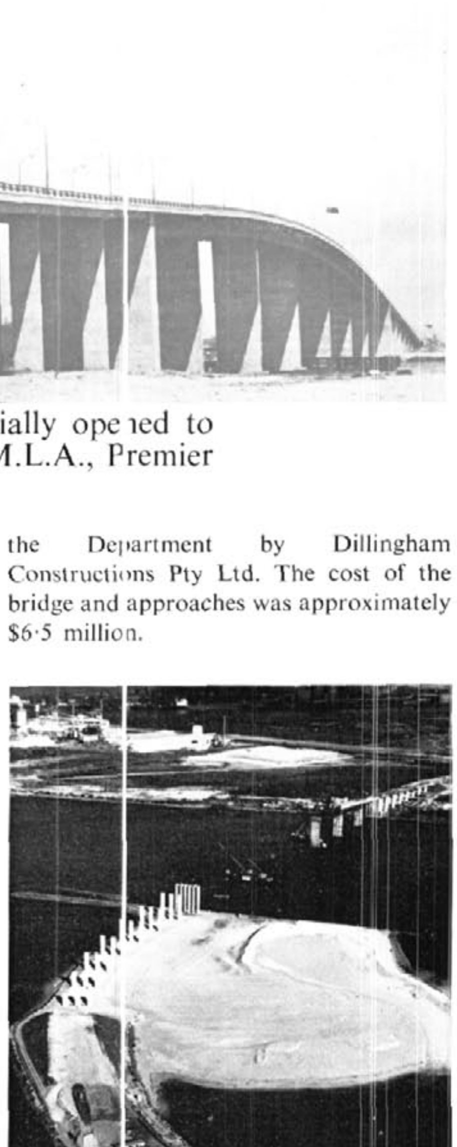
The prestressed and reinforced concrete bridge has 23 spans and an overall length of 3,358 feet. The length over the main river channel is 1,670 feet. Stockton Bridge is the longest bridge to be completed by the Department of Main Roads and is the second longest road bridge in New South Wales. Sydney Harbour Bridge (3,770 feet), which was built under the supervision of the Department of Public Works, is still the longest in the State.

Stockton Bridge is a high-level structure with a navigational clearance of 100 feet vertical and 200 feet horizontal under the centre span. To achieve the required vertical clearance, viaducts have been constructed on each side of the river channel and rise from 20 feet high abutments on a 6 per cent grade. These viaducts, 844 feet in length, consist of 8 spans on each side of the river, and are curved to link with the new road system on Kooragang Island and with the established main road on Stockton Peninsula.

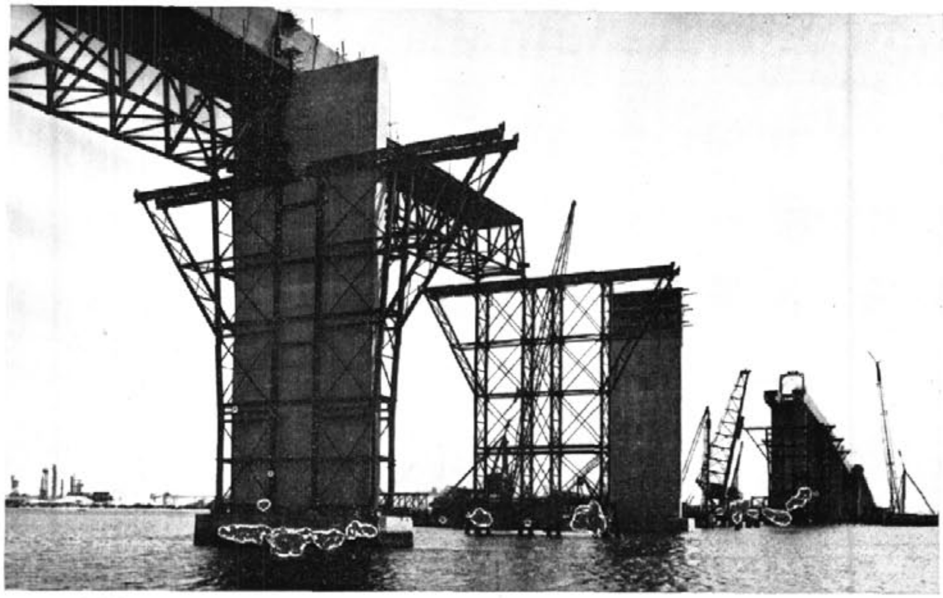
The deck of the bridge consists of two carriageways, each 26 feet wide and each carrying two lanes of traffic. A central footway, 5 feet wide, has been provided between the two carriageways and pedestrian access is available by a stairway through the superstructure near the abutments.

The Department's staff prepared the design for the bridge, with architectural advice being given by Mr D. MacLurcan of Messrs Fowell, Mansfield, Jarvis and MacLurcan.

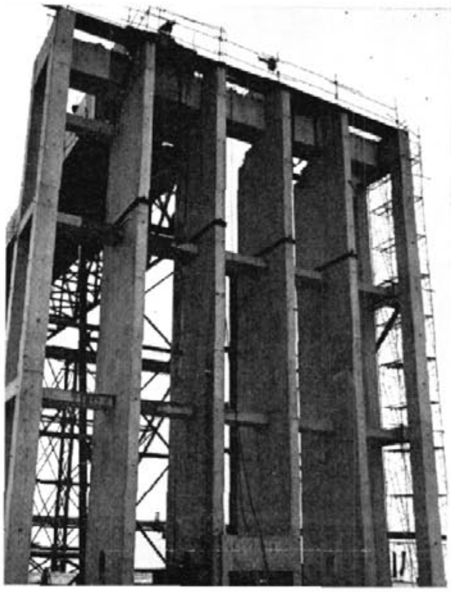
Prior to calling tenders, the Department constructed the piles for the approach spans to ground level, using its own forces. By this means, a saving in the total project time was achieved. The bridge construction, including the piles in the river channel, was carried out for the Department by Dillingham Constructions Pty Ltd. The cost of the bridge and approaches was approximately $6·5 million.



Aerial view looking west from above Stockton Peninsula, showing precast concrete girders (in foreground) awaiting erection. (June 1970)



View of falsework trusses supported by bridge piers and temporary piers, during erection of girders across main river channel. (October, 1970)



Skeleton frame of one of large box piers constructed on each side of river channel. (October, 1970)

Above: Crowds at opening ceremony

Right: The Premier, Sir Robert Askin, cutting the ribbon, with the Minister for Highways, the Hon. P. H. Morton, M.L.A., on the right and the Commissioner for Main Roads, Mr. R. J. S. Thomas, on the left.

Reproduced by courtesy of Newcastle Morning Herald.

THE OFFICIAL OPENING

At 2.30 p.m. on Monday, 1st November, 1971, the ceremony to mark the official opening of the Stockton Bridge commenced in the presence of about 900 guests (including many State and civic dignitaries) and members of the public.

Speaking from a small dais set up on the northwestern approach to the bridge, Ald. D. G. McDougall, C.B.E., Lord Mayor of the City of Newcastle, welcomed the Premier to the district. The Hon. P. H. Morton, M.L.A., Minister for Highways invited the Premier to address the gathering and following his address, Mr W. A. Wade, M.L.A., Member of the State Electorate of Newcastle expressed thanks.

Sir Robert Askin, accompanied by the official party, then left the dais, cut the specially printed blue ribbon and declared the bridge open.

After unveiling a commemorative plaque, Sir Robert Askin was driven over the bridge at the head of a small motorcade.

As soon as the westbound carriageway was cleared for general traffic, more than 100 cars, most of them carrying sightseers, drove over from the Stockton side.

The eastbound lanes were opened approximately 15 minutes later, by which time about 500 cars were lined up for 1½ miles on the Kooragang Island approach to the bridge.

After making its last crossing on the Stockton-Newcastle run, the vehicular ferry "Koondooloo" steamed north to pass underneath the bridge in a symbolic sentimental farewell gesture on its final official voyage.

The New Crossing—Where and Why

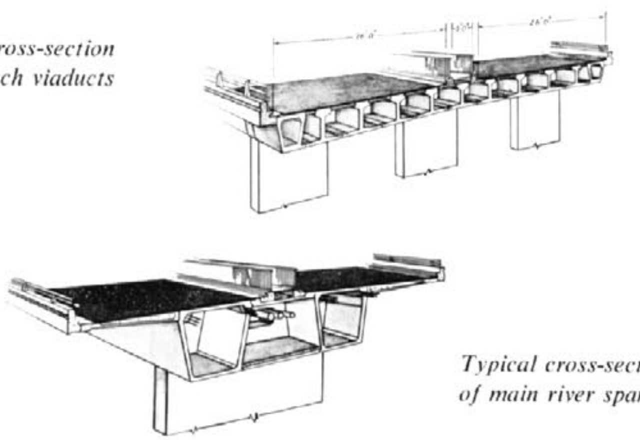
Before the opening of Stockton Bridge, a vehicular ferry service operated across Newcastle Harbour (Port Hunter) between the City of Newcastle and Stockton.

Although three large vessels were used on this service, there were frequent delays during peak periods because of the large volume of traffic. The annual average daily traffic volume at this crossing increased from 3,450 vehicles in 1963 to 4,060 in 1970. Furthermore, siltation of the river bed at the ferry approaches caused occasional stoppages to the service and resulted in serious inconvenience to the travelling public. The growth of the City of Newcastle and the rapid urban, industrial and tourist development in the area continued to make the replacement of the ferries an urgent and necessary undertaking.

The annual cost of maintaining the ferry service, in recent times, has been in the order of $800,000 so that the completion of the new bridge will result in considerable savings as well as vastly improved driving conditions.

For some years the Department of Public Works has been proceeding with a scheme involving the reclamation and consolidation of a number of islands between the North and South Channels of the Hunter River. Channels have been filled to form one land mass which has been named Kooragang Island. In order to provide access and assist industrial development on this island, new crossings of the Hunter River were proposed. Initially, a new bridge over the South Channel at Tourle Street, Mayfield was constructed and opened to traffic on 20th February, 1965. A new road across the island has now been completed to link the bridge at Mayfield with Stockton Bridge.

Stockton Bridge, therefore, not only provides northern access to and from Kooragang Island but also completes a continuous connection by road and bridge between the City of Newcastle and Stockton Peninsula, allowing the vehicular ferries to be withdrawn from service. It will also aid the development of the scenic Port Stephens district to the north by adding an attractive approach and providing improved travelling conditions for holidaymakers. (See map on page 67).



Typical cross-section of approach viaducts

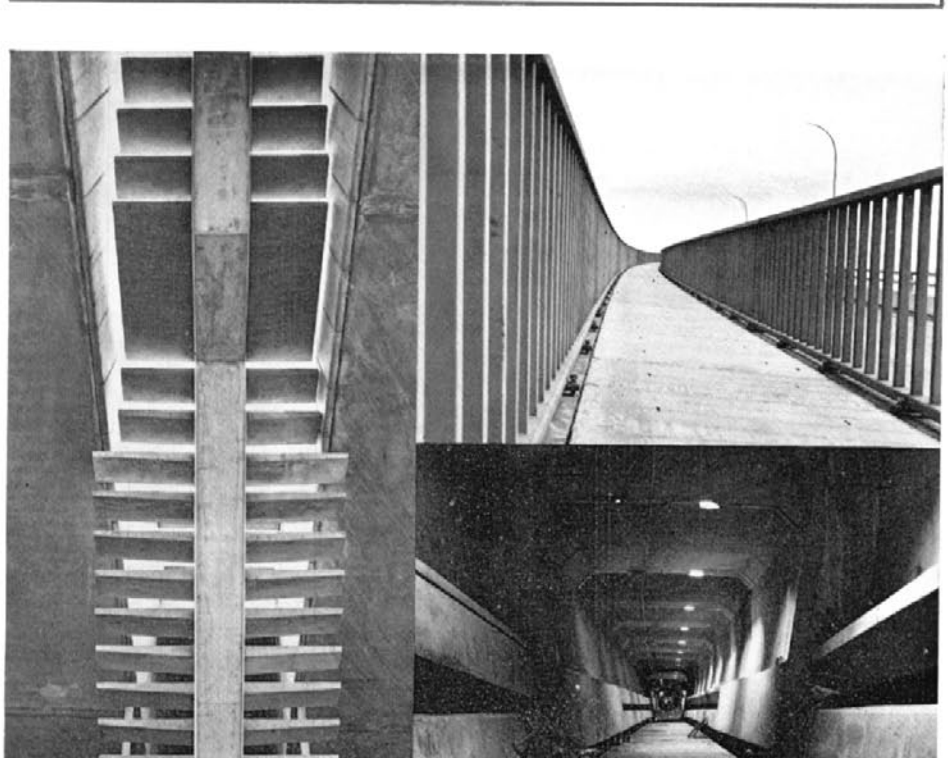
Typical cross-section of main river spans

Construction Details

The bridge site is covered with deep sand and it was necessary for the whole of the bridge to be supported by piles. The piles were designed for a maximum load of 260 tons and consist of hollow 33 inch diameter steel casings, bored into rock at depths of 70 to 140 feet and filled with reinforced concrete. There are six bored piles under each pier of the viaduct spans but in the river channel piers have 14 or 16 piles, depending on the location.

The section of bridge over the main river channel consists of seven spans with lengths varying from 210 feet to 270 feet. Single column reinforced concrete piers, 3 ft 9 in thick and 30 ft wide, support the spans and deck of this section.

These tall single columns are rigidly framed into prestressed concrete box girders from which the deck slab is cantilevered. This type of construction was particularly suited to the site conditions which required construction at great height over a navigable river. The spans were constructed on falsework trusses supported by the bridge piers and other temporary piers.



Patterns and curves
These photographs highlight some of the shapes seen under, inside and on top of the bridge during construction. They show (left) steps leading to the central footway, (top right) grille railing flanking the footway and (bottom right) inside one series of box girders in main river span—see diagram above

The superstructure consists of a box girder (spine beam) made up of two separate girders connected by precast suspended slabs (see diagram). The girders were assembled from precast concrete segments tied together by prestressed steel cables. The jacking force required to prestress the girders was 860,000 lb per cable with twelve cables in some girders and thirteen in others.

After completion of the box spine beam, 12 ft long precast deck slab cantilevers were attached to both sides of it by post-tensioning. The extreme edges of the cantilevers were stiffened by a cast-in-place reinforced concrete fascia beam which incorporates a concrete wall barrier as an active structural part. This was designed to assist in spreading traffic loads over a greater width of the cantilevered deck.

To create a visual separation between the slender approach viaducts and the deeper main spans, the design provided for a large box pier, 59 ft wide and 13 ft thick, to be constructed on each side of the river channel. These piers consist of a reinforced concrete skeleton frame with a cladding of precast concrete slabs.

Each of the two approach viaducts consists of six 110 ft spans between two 90 ft spans. The decks of the viaducts are hollow slabs, constructed by concreting the joints between top and bottom flanges of precast prestressed concrete girders (see diagram). The piers supporting the viaduct spans consist of three 10 ft by 2 ft columns concreted in place.

Pier cross heads have been incorporated in the superstructure system, thus avoiding cross heads appearing below the continuous bridge slab. These cross girders were post-tensioned by six cables using a jacking force of 420,000 lb each.

The girders are 4 ft deep and post-tensioned with 4 or 5 cables, using a jacking force of up to 220,000 lb each.

The reinforced concrete abutments are buried in embankments, approximately 20 ft high, and are stabilised by concrete anchor beams supported on bored piles.

The piers and the superstructure spans are joined together to form continuous concrete units or rigid frames. There are five such frames in the full length of the bridge, separated by "finger plate" expansion gaps to permit variations in length caused by temperature changes.

Concrete wall barriers, topped by steel pipe rails, form the outer sides of the carriageway while vertical bar grille railing separates the carriageways from the footway. Lamp standards, 25 ft high, have been placed in line with the outside barriers.

Steel fenders protect the piers in the main shipping channel. The fenders are designed as rigid frames to absorb the force from any heavy ship collisions by bending and deforming under the impact.

The quantities of the principal materials used in the construction of the bridge are:

Concrete—22,700 cubic yards
High tensile steel—600 tons
Reinforcing steel—2,500 tons●

The Department produced a small 12-page "souvenir" colour brochure on Stockton Bridge for distribution at the opening. Copies of the brochure, which incorporates the information given in this article together with illustrations of the construction and details of the vehicular ferries, are still available on request.

An article on the history and operation of the ferry vessels will be featured in a forthcoming issue of Main Roads.

NEW WARNING SIGNS

Linemarking is a valuable safety feature on roads. Sometimes, due to resurfacing or re-sheeting operations, the lines are obliterated. When this occurs on Main Roads throughout New South Wales, the lines are renewed as a matter of urgency, particularly on sections of road where there are crests or curves and where double lines are used to restrict overtaking.

The first step in linemarking is "spotting" and this is usually undertaken as soon as the new pavement has cooled sufficiently. However, where it is unavoidable to leave a newly surfaced road without lines overnight, warning signs have now been introduced. Three types of signs are available to warn motorists of the absence of traffic lines.

The legends carried by the new signs, which have black letters on a yellow, reflectorised background are:

Sign A	NEW SURFACE NO CENTRELINE FOR NEXT XM
Sign B	DO NOT OVERTAKE ON CRESTS OR CURVES
Sign C	NEW SURFACE NO LANE LINES FOR NEXT XM

● Sign A is a general one and is erected in advance of sections of new two-lane pavement where a centreline has not been marked.

● Sign B is erected usually 150 to 200 ft beyond Sign A, where the unmarked length includes non-overtaking sections.

● Sign C is erected in advance of a section of new, multi-lane pavement where lane lines have not been marked.

* * *

During 1970–71, 14,971 miles of roadway were linemarked. With lane marking of 4,199 miles and edge marking of 2,132 miles, a total of 21,302 miles of linemarking was undertaken.●

REMOVAL OF LITTER FROM ROADS

The Local Government (Further Amendment) Act, 1970 inserted a new division 5A (sections 289A–D) in the Local Government Act, 1919. Under section 289D (1), following conviction of an offender in any prosecution brought by this Department for the deposition of litter, the court may on application to it by the Department, order the person convicted to pay to the Department the expenses incurred by it in removing the litter. This can be additional to any fine the court may impose.

Where litter has been deposited on a road or roadside as a result of an accident, the vehicle driver, owner or agent should have the litter removed at the same time as the vehicle or its salvaged loading is removed. In the event of failure to do so, the Department will remove the litter and may institute court proceedings against the driver both for littering and for the recovery of the cost of such removal.

The new division of the Act in no way affects the Department's powers under the combined operation of section 267A of the Local Government Act, 1919 and section 36 (1) of the Main Roads Act, 1924, to remove any broken-down vehicle, or any matter or thing which has fallen from such vehicle and which is a danger or obstruction to traffic on any Main Road, Development Road, Tourist Road or Toll Work and to recover the cost and expenses incurred●

MODERN AIDS TO ROAD LOCATION

Road location work is the science or art of determining the most feasible route for a road consistent with

- the purpose for which it is intended,
- the possible extent of its future development, and
- the amount of funds that are likely to be available for its construction.

In the consideration of a route, technical studies are made of the following aspects:

- The population distribution along the route and in nearby districts which may also be served by it.
- The benefits which both local and through traffic may derive, in terms of reduced transport costs, from the construction of the proposed road.
- The type of terrain and land-use along the route.
- The geological structure of the area on or adjoining the route, particularly as it effects road construction and maintenance, and the availability of road-making materials.
- The sites where culverts or bridges may be required in order to cross creeks or rivers.
- Possible interference to the livelihood of people living along the route and disturbance of natural fauna and flora.
- The design standards applicable to the location and use of the proposed road.
- The safety features which will need to be incorporated in the design and construction of the road.
- The aesthetic aspect of how the proposed route will look within the landscape.
- The construction methods which will be likely to be available in the area.

Following full consideration of these factors in relation to their importance, the line selected will be the one that provides the greatest benefit to all while adversely affecting as few as possible.

To effectively study and weigh these factors the Road Location Engineer will require the following attributes.

- A deep understanding and proper appreciation of the policies of the road constructing authority for which he works, including a knowledge of the standards of design which it has adopted as well as the proposals it has for future road use in the district concerned.
- The ability to use all sources of information in their proper perspective. This should include the skill necessary to "read" country on the ground, from the air and from maps or photographs, and to determine the best means of collating, classifying, extracting and using relevant available information in the proper context, so that unsuitable alternatives can be quickly discarded and the more suitable alternatives properly assessed in detail.
- The experience which allows him to carry out the investigation in the minimum of time, with a minimum of effort and a maximum of detail.

The Road Location Engineer should not be required to go beyond the determination of a corridor of interest. The exact fixation of a route within that corridor should be a matter for the Road Design Engineer. However, in developing his argument in favour of a particular corridor the Road Location Engineer will adopt a fixed line. This line may be acceptable to the Road Design Engineer but, if not, he should be free to adjust or vary the line within the corridor. However, if the Road Design Engineer considers the line should be moved out of the corridor or, if he comes up with any problem which in effect refutes any of the arguments used by the Road Location Engineer to justify his selection of a route, the problem should be referred back to the Road Location Engineer for re-consideration. Naturally, the narrower the corridor of interest the more economical the location work. Under the worst conditions, this corridor should not have to be more than four times the width of the roadworks (i.e. from edge of clearing to edge of clearing).

On major projects the location work is normally carried out in two stages:

- the reconnaissance survey, and
- the preliminary survey.

The reconnaissance survey should aim at collecting, in detail, the minimum amount of information necessary to enable the elimination of all but the more likely alternatives. The preliminary survey should provide the more detailed information which will allow a factual assessment to be made of the best alternatives and a determination to be made of the one most suitable.

Often when the country is open, accessible and uncomplicated the two surveys may be done as one. However, when the route is through heavily timbered, rugged or normally inaccessible terrain, it is best to make the study in two stages at least. In some of the heaviest types of work, a third stage may be incorporated with the final survey being undertaken after clearing has been carried out.

In past years, the reconnaissance survey was made by a surveyor "equipped" with a good pair of walking legs. If he was lucky and the country was not too rough, he might have a horse, a compass, a clinometer, a barometer, and possibly a plane table. He would need to be provided with all available maps of the area, a couple of staunch assistants armed with axes or scrub hooks, some food and water, a memory for country and a medicine chest for treating snake, tick and insect bites. Lastly, even though his work was thorough, there would remain an appreciation of the fact that no matter how long he spent traversing the area there would remain parts that he has missed seeing—parts that possibly should have been examined and that could possibly have influenced him into making a different recommendation to that which he finally made. For even after spending days, and often weeks, travelling under difficult conditions—probably plagued by flies, mosquitoes, leeches, heat or rain and delayed by cliffs or creeks—time limits could prevent him from looking at the other side of a spur or ridge. Consequently, he might miss a much better saddle to cross than the one which he had selected.

In these days movement and development is too rapid and demands on the limited manpower resources are too great for there to be any practical purpose in applying the old methods. Newer and more effective methods are required. Most of these will be found to be more expensive in terms of cash, but more and more *time* is becoming the measure of the economy of location work. The newer methods are adopted to get results more quickly; however, the extra cost becomes money well spent, because, as a side product, modern techniques allow for *all* possibilities to be considered.

The range of equipment and methods in use in New South Wales to assist in road location now include:

- aerial photography (panchromatic, colour and infra-red),
- photogrammetry,
- orthophotographs,
- terrain evaluation,
- electronic distance measuring equipment,
- rangefinders,
- four-wheel drive motor vehicles,
- two-way radio communication, and
- helicopter.

Aerial Photography and Photogrammetry

An article entitled "Aerial Photography for Road Location and Design" appeared in the September, 1971 issue of *Main Roads* (Vol. 37, No. 1, Page 23). A second article on "Photogrammetry—for Road Engineering Purposes" was published in the December, 1971 issue (Vol. 37, No. 2, Page 42) and a third article, the last in the series, will be featured in the next issue of *Main Roads*.

Left: Aerial survey camera being checked before installation in light aircraft operated by private aerial survey company
Right: Aerial survey photographs being studied by photogrammetrist, using Department's stereo plotting machine (only part of which is shown)

As mentioned in the first two articles, where aerial photography is being obtained for high order photogrammetric work, the Department not only targets the ground control points but also requires that they appear in certain areas on the photographs, where they can be used to greatest advantage in the instrument triangulation. This means that the aeroplane's line of flight, its speed, its height and the starting point of the photography must be within very close tolerances. The Department marks lines of flight and starting points, and insists on dry runs before the photographic run commences. On these dry runs it is common for one of the ground control team to accompany the aircrew and make sure that they see and recognise the various line markers and starting points.

The Department has installed its own photogrammetric plotting instrument and established a small photogrammetric section in order to:

- control the quality of work done for the Department by other authorities or organisations,
- carry out research to develop the use of photogrammetry for road engineering purposes, and
- carry out special types of photogrammetric work not appropriate to contract or about which a specification cannot be satisfactorily prepared.

The quality control checks initially made by this section immediately revealed weaknesses and inaccuracies in work being carried out for the Department. As soon as the Department was able to put "a finger on the trouble", it started getting improvements in the quality of the output. This has continued and work now produced for the Department is reliable and within the tolerances of the specifications. However, to do so, it has been necessary for the Department to carry out certain of the instrument measurements before issuing the work to the contractors, who then undertake only the photogrammetric plotting.

It is in the field of photogrammetry that still greater assistance will be given, in the future, to the Road Location Engineer. The Department is investigating the use of the photogrammetric restitution instrument, the electronic plotting table and the computer as a team. The first-mentioned instrument can produce terrain data in digital form and with greater accuracy than it can produce contours. This digital terrain data is compatible with computer and plotting table use, which in combination can be programmed to interpolate heights, to produce longitudinal and cross sections along any predetermined line and to calculate earthworks to any design along that line. The perfection of such a process will allow for many variations of proposed routes to be examined in less time than it now takes to do one trial. It will also allow more accurate preliminary estimates to be prepared at the investigation stage.

Orthophotographs

The orthophotograph is quite a recent development. It is basically an aerial photograph from which scale distortions due to height variations have been eliminated. It is therefore true to scale and any information plotted at the same scale (e.g. contours) can be overlaid on it.

In densely populated, cultivated or otherwise developed country a great deal of the time of the photogrammetrist is taken in plotting detail. The use of the orthophotograph allows this to be eliminated and the photogrammetrist plots the contours only, thereby greatly increasing the area that can be mapped by one restitution instrument in any given time. The development of this technique is being watched and its use adopted as its need becomes obvious.

Terrain Evaluation

The engineer or surveyor has always found it difficult to interpret geological maps and, in the past, the geologist has produced records which are of little benefit to the engineer. **Terrain evaluation provides a common language for communication between these two specialists. Through it the geologist can be acquainted of the things the engineer wants to know and it allows him to describe country in terms that can be recognised by the engineer.**

Terrain evaluation is the act of classifying country into types and subtypes so that, knowing the engineering characteristics of one area, these can be assumed to exist in any other areas of the same type. It is a form of aerial photograph interpretation and allows for the identification and classification of large tracts of land in very quick time. In fact, four trained men can classify the whole of the area of a 4 mile = 1 inch standard map sheet in 6–8 weeks, including the carrying out of fairly detailed field checking procedures.

The Council for Scientific and Industrial Research in Melbourne has developed the evaluating procedure in Australia along lines suitable for computer storage and retrieval. It has covered wide areas of Central and South Australia and Queensland. This has greatly assisted the work of locating our inland beef roads, in that the most suitable country for road construction can be fixed from the terrain maps and investigation of routes restricted to those areas.

Terrain evaluation is appropriate generally to major jobs spread over hundreds of miles but the idea can be applied to much shorter lengths. In New South Wales it has been used over lengths approximately 20 miles. On one occasion, the Department had to locate a road along a coastal plain comprising sand dunes and swamps (ranging from those with a sound sand bottom to those with 30 or more feet of peat overlying the sand) and crossed by spurs running from the coastal escarpment to the sea. It was considered that a road could be economically built over peat up to 8 ft deep and consequently a geologist was asked to separate the swamp into those areas with a sound sand floor and those with peat in excess of 8 ft. He was asked to comment on the stability of sand dunes, the type of rock in the spurs and any characteristics which would affect road construction. The terrain evaluation by the geologist was based on aerial photograph interpretation of ground cover, knowledge of the geographical formation of the area and a minimum of ground checking. His evaluation gave important information as to the most suitable line of the road. It included warnings concerning probable unstable areas on the ridges, probable batter problems (unless the cuttings were taken normal to the strike of the country) and assurances of stability at other locations in cuttings (even though they might follow the line of strike). This was the type of information which was required by the Road Location Engineer but which was not normally portrayed on geological maps.

Electronic Distance Measuring Equipment

In recent years there have been outstanding developments in the type of equipment which electronically measures distances. The Department has made consistent use of these instruments on ground control work and has had considerable success with them as instanced by the accuracy of the control closes. Major work is connected to the State Triangulation and to State Datum and the monuments erected by the Department accord with State Triangulation practices, so that not only is the work of direct use to the Department but it is eventually incorporated in the State system. Furthermore, the Department connects its control work to cadastral boundaries and so it can quickly ascertain the effect of a proposed road on alienated properties without the need to make a separate property survey at the investigation stage.

Rangefinders

These are a well established item of equipment but have not been used extensively in the past because of the large size of those instruments which have suitable accuracy and the associated problems of transporting them. These factors are not of such importance in many present day circumstances and rangefinders can be of considerable value on ground reconnaissance for determining the distance between suitable bridge abutment sites or for obtaining quick measurements across untraffickable terrain.

Four-wheel drive vehicles are now available to all Departmental survey teams involved in rural road location investigations

Four-wheel Drive Motor Vehicles

Many valuable man hours have been lost in the past, during investigation surveys, by the necessity for two-wheel drive vehicles to negotiate difficult areas at a "snail's pace" (with frequent manual assistance through boggy sections) or to take long detours in attempts to circumvent the roughest parts.

All survey parties engaged on location work should have four-wheel drive vehicles available to them, for quick and reliable transport in all types of terrain and to ensure that they arrive at their job in reasonably fresh condition.

It is essential to provide the best means for getting survey teams onto the job quickly so that:

- they are able to spend the greatest possible part of each day on productive work and
- they have the best equipment available when they are working so that their production per working hour is as high as possible.

There is, of course, the need to keep a sense of proportion to save vehicles being expected to carry teams through difficult terrain when a short trek on foot would be faster or safer.

Two-way Radio Communication

Survey teams engaged on the various phases of road location investigation often become quite widely scattered and sometimes individuals may be working some miles apart. **Surveys can be slowed down by the necessity to stop production and despatch one member to take a message to another member of a team. Such uneconomical delays can be eliminated by the use of two-way radio communication which is now available in simple, cheap, light and robust units.** This equipment is always supplied to Department survey parties for intercommunication purposes at least.

Helicopter

In no aspect of road engineering has this versatile machine proved to be of greater benefit than it has in road location work. It combines the advantages of the aerial photograph and the detailed map and allows the ideal method of investigation to be undertaken.

Using a helicopter the Road Location Engineer can remain as if suspended over the take-off point of the road project. From a helicopter he can see or determine the point of destination of the road and can study an oblique stereo view stretching from horizon to horizon, the cover on the land, the land use, the drainage pattern, the present road system, etc., all at the one time. This enables him to select quickly the most direct corridors and then he can proceed to examine them from the air in greater detail and at closer distance.

The helicopter enables the Road Location Engineer to keep his destination continually in sight so that he does not have to rely on his sense of direction which might lead him astray. After some experience, he can quickly weigh, on the spot advantages and disadvantages of changing the direction of the proposed road against the possibility of having to carry out heavy earthworks.

In the normal course of road location investigation, the helicopter is also used by the Department for the following purposes:

- *To spot height areas of particular importance.* The height of certain features (which may be virtually inaccessible and of which contours are not available) is of vital importance in order to assess the degree of obstruction presented to road construction. The heighting is done by hovering the helicopter for a few seconds on or at a known height above each feature and reading the height shown on the machine's altimeter. The location of the reading is marked on an aerial photograph. A scale factor is determined by landing at two or more points and, using distance measuring equipment, computing the distances from one to the other. The area is then the subject of a quick approximate stereomicrometer compilation which is generally sufficient to decide whether the obstacle is within the limitations of engineering possibility or of sufficient difficulty as to justify discarding any possibility of taking a road through it.

It has been found possible to cover quite a few square miles of country in this manner and produce in a matter of hours what, using conventional equipment, may take as many days or even weeks to accomplish.

- *To fly a grade.* The question repeatedly arises during the course of the aerial examination of a corridor as to whether or not a maximum allowable grade from, say, a bridge site, would allow the road to climb onto the watershed. This can be ascertained by having the pilot fly the line at a fixed ground speed and at a fixed rate of climb and then observing whether the helicopter height gains on the ground height along the line. This is a much more simple and quicker means of resolving such a question when compared with the alternative of walking the length with a clinometer.

● *To guide ground parties.* Often the investigation is through areas of dense timber and, although in such locations a probable line on the top of the forest canopy can be seen from the helicopter, the line has to be checked on the ground. Although this line may be marked on aerial photographs, the man on the ground often cannot accurately locate his own whereabouts on the photographs in order to determine his position relative to the line. However, if he lights a fire and lets the smoke from it rise, the helicopter pilot can give him photo co-ordinates of his position or direct him to move a certain distance to get onto the line. This method requires two-way radio contact between ground and air.

● *As ground control transport.* Triangulation has always involved travelling to the most inaccessible hilltops to set up observation stations. Because of this, progress was slow. Once a target site was cleared for observing, very little work is generally needed to make the site suitable as a helicopter landing pad and the visits by the observing parties are made easy by helicopter transport. Proper programming of the observation work enables the helicopter to move continuously between stations picking up and dropping parties without waste of observation time or of helicopter flying time.

● *For recording flood levels and observing flood patterns.* It is often found that when collecting flood information the sites at which this information should be collected are inaccessible by road and the information has to be obtained after the floods have receded. There can then be some doubt as to the accuracy of such details. A helicopter is ideal for the investigation of flood levels and flood behaviours, provided it is available when the flood is near its peak and provided that ground records are kept of the flooding. These ground records are required in order to accurately deduce the amount by which the highest level reached exceeds the level at the time that the helicopter observations are made.

● *In updating existing photography.* It has repeatedly been found that after obtaining aerial photography for a particular project there has been subsequent development of various kinds over sections of it; this new development could be affected by the selection of the route. Rather than obtain fresh aerial photography at this stage, it has been found possible to take near vertical photos from the helicopter using a hand-held 35mm camera. These photographs are then enlarged or reduced to the scale of the mosaics prepared from the original photography and new prints are overlaid into the appropriate section of the mosaic.

● *For official inspections.* Often the selection by the Department of a particular route draws objections from or through local authorities. Sometimes it has been found to be of great benefit to give the officials concerned an aerial view of the route favoured by the Department and the route being suggested in its stead. This allows the reasons influencing the Department's proposals to be seen and appreciated.

Although a helicopter is a costly machine to purchase and maintain, there is no doubt that, under the conditions existing in New South Wales its use can be fully justified for the purposes of road location alone. As an example, the first job on which the Department's original helicopter was used was to check whether or not a more appropriate route existed than the one previously selected from aerial photo-coverage and ground reconnaissance of a 15-mile section of the Sydney-Newcastle Expressway. In two hours the possibilities of another route were noted. Subsequent confirmation by ground survey, indicated that the Expressway could be constructed to a comparable standard along the latter route at great saving to the Department. In another case, it had been accepted that a new road when constructed would contain seven major bridges, each about 1,100 ft long. An investigation by helicopter led to the survey being continued along a parallel valley and consequently, the new route will require only one major bridge.

* * *

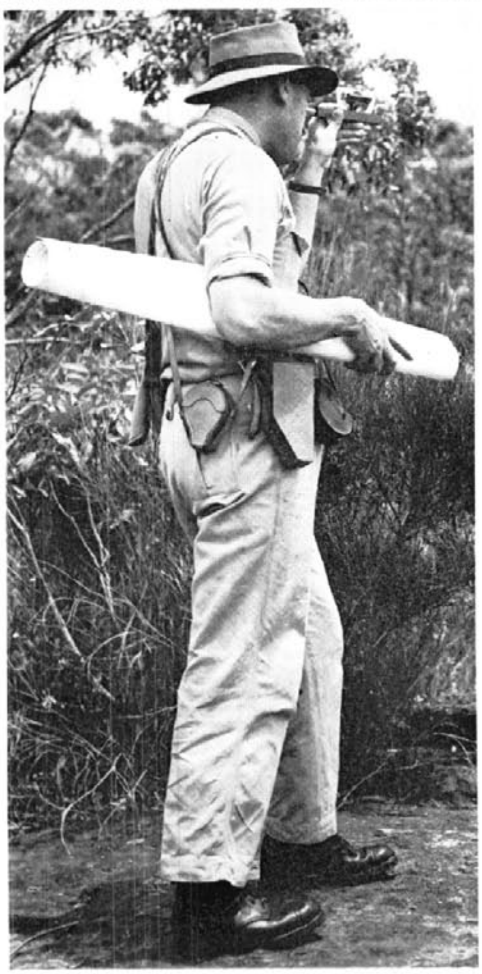
This summary of some of the modern aids used in New South Wales for road location work illustrates not only the latest equipment but also the skills which are being employed and amplified to advantage in this field. It also points to an exciting future in which even more advanced methods and equipment will be introduced and developed by the Department in the interests of faster and more efficient investigation work.●

This article has been adapted from a paper prepared by the late Mr R. E. Playford prior to his retirement in February, 1971 from the position of Rural Investigations Engineer. Mr Playford died in May, 1971.

Opposite, top: A survey team — comprising three men, five horses and one dog (bottom right) — crossing Jacobs River in the Snowy Mountains, in the 1940's.

Opposite, bottom: The horse yard and camp site at "Freebody's Hut", near Ingeegoodbee River, Snowy Mountains.

Above and below: Section of camp site and kitchen where surveyors found refreshment and nourishment during investigations of routes in Guyra—Dorrigo district, 1938.



THE "COMPLEAT" SURVEYOR

CIRCA 1940

His many items of "equipment" and apparel usually included:

- A broad-brimmed hat as a shield against the sun during long hours in open country.
- A strong arm and a steady hand to hold instruments ready for frequent readings — especially in rugged locations where tripods could not be conveniently carried.
- An armful of appropriate plans and maps of the area being surveyed.
- A collection of all the instruments necessary to efficiently carry out the required survey work — all sitting snug in their protective, but heavy, leather cases and strung on straps around the neck or waist — plus a general-purpose bag to hold sundry other items, ranging from food to first-aid kit.
- A sharp bush-knife for hacking the way through thick undergrowth (and sometimes for protection against snakes).
- Heavy drill trousers to protect the legs from blackberry bushes, leeches and mosquitoes.
- A good pair of walking legs with a sturdy pair of boots, suitable and comfortable for rough going over rocks and through streams.

It may look humorous today, but not so long ago this was how road surveys were undertaken in many parts of the State across miles of rugged country which was then virtually inaccessible except on foot or on horseback.

NEW BRIDGE ON BRUXNER HIGHWAY AT TI-TREE CREEK

The new bridge over Ti-Tree Creek on the Bruxner Highway was officially opened on Friday, 26th November, 1971, by Mr J. C. Bruxner, M.L.A., in the presence of the Minister for Highways, the Hon. P. H. Morton, M.L.A.

The bridge is situated on a new deviation of the Highway which has eliminated a winding section of gravel road and an old low-level timber bridge. The opening had a special significance as it marked the completion of bituminous surfacing along the Highway between Ballina, on the coast, and Tenterfield, 118 miles inland.

The Bruxner Highway crosses a region of the State with a rich early history of grazing and timber-getting. Its eastern section commences at the Pacific Highway near the coastal town of Ballina and forms a major connecting link to the New England Highway at Tenterfield. Continuing west, the Bruxner Highway reaches the Queensland border at Goondiwindi and is important in that area as a connection between south-central and southwestern Queensland and the northeastern region of New South Wales.

On 2nd November, 1959, State Highway No. 16 was named the "Bruxner Highway" as a tribute to Mr J. C. Bruxner's father, the late Lieutenant Colonel the Hon. Sir Michael Bruxner, K.B.E., D.S.O. Sir Michael was born at the property "Sandilands" which is situated on the Highway only a few miles from the site of the Ti-Tree Creek Bridge. He had a distinguished career in many fields and, as Minister for Local Government from 1927–1930, was responsible for an amendment to the Main Roads Act which provided for the reclassification of the principal roads of the State according to their importance. Sir Michael Bruxner died on 28th March, 1970, aged 88 years. In his reminiscences, he had written . . .

"*One of my very earliest recollections is that of travelling by buggy over the new road, just completed, through the Richmond Range scrub.*

I have the most vivid memory of us all setting out for Dyraaba early in the morning.

All went well until we started up the first step of the Range over the new formation which consisted of the soil dug out of the side of the mountain and deposited on the logs and brush cut from the first clearing.

Toiling through the sludge, suddenly both horses went right through the bog with only their backs and tails showing. Fortunately a few years before, about 1881, *William Ross selected part of Little Creek and erected a hotel and butcher's shop, where the Mallanganee Hotel stands today.*

My father walked back for help and Mr Ross came along with a big, brown, bald-face draught horse. The addition of this horsepower had the desired effect and we proceeded on our toilsome journey to reach Dyraaba about dark.

This was my first experience of travelling by wheel on the 'Bruxner Highway' ".

An article on the history of the Bruxner Highway appeared in the March, 1968 issue of *Main Roads* (Vol. 33, No. 3, Page 58).

*　*　*

The new bridge is a pleasant change and a valuable improvement compared with the old narrow 4-span timber beam structure (113 feet long and 17 feet wide), which had previously served as a crossing of Ti-Tree Creek since 1896

The Commissioner for Main Roads, Mr R. J. S. Thomas, was chairman at the official opening of the new Ti-Tree Creek Bridge, and the President of the Shire of Tenterfield, Councillor J. H. Hamilton, welcomed the Minister for Highways to the district.

Mr Morton paid tribute to Sir Michael Bruxner and spoke of his 42 years as representative of the Tenterfield Electorate in the New South Wales Legislative Assembly. Mr Morton also spoke of the recent reconstruction and re-alignment of the Bruxner Highway, in particular the 13-mile section of the Highway west of Tabulam. This section includes the Ti-Tree Creek area, where the route has been shortened by 2·2 miles and the cost of roadworks has been $1·9 million. Mr Morton then invited Mr J. Bruxner who, like his father before him, is Member for the State Electorate of Tenterfield, to open the bridge.

After addressing the guests, Mr Bruxner completed the ceremony by cutting the ribbon and unveiling a commemorative plaque. The rain which had been falling steadily throughout the proceedings fortunately abated for these few minutes and the guests, many of whom were local members of the shire, were able to walk over the new structure, after the first official vehicles had crossed it.

* * *

Ti-Tree Creek flows along a heavily timbered gorge situated about 38 miles east of Tenterfield between Drake and Tabulam. The bridge site is deeply incised with fractured rock on the eastern approach.

The new bridge is 224 ft long and measures 28 ft between kerbs. It has three spans (the central one being 100 ft long) and is supported on oval single column piers.

The superstructure of the bridge has been designed to blend with the surroundings, and consists of continuous steel girders with a composite reinforced concrete deck. "Walkways", 2 ft wide, have been provided as part of the raised kerb on each side of the bridge.

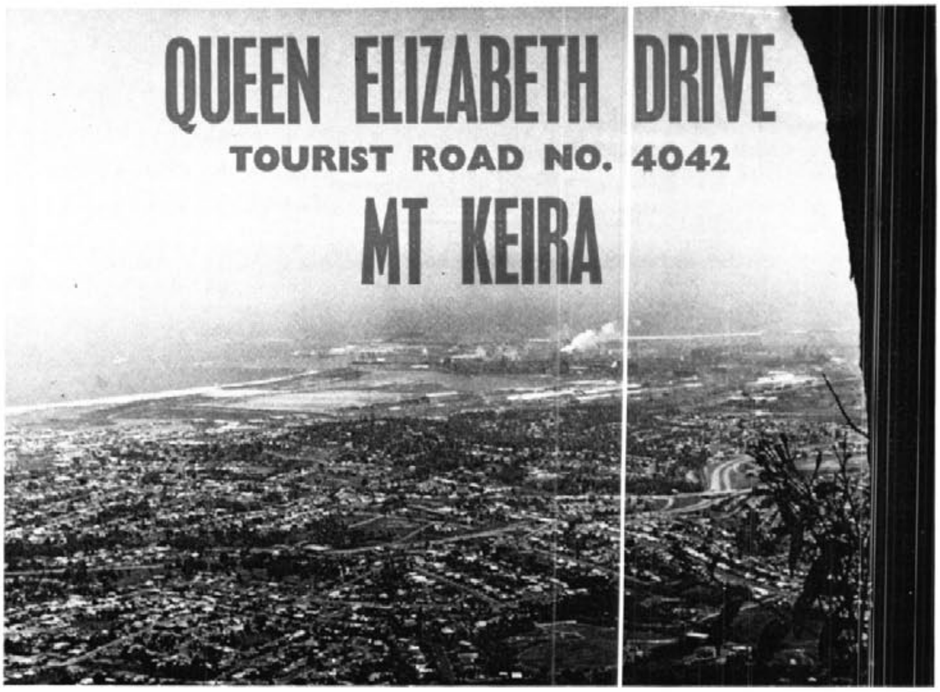
The bridge was designed by the Department's own design engineers and the contractors for the construction were Central Constructions Pty Ltd. The cost of the bridge was approximately $135,800. The bridge approaches and the associated Highway deviation were constructed by the Department.

Bridgeworks at five sites on the deviation have added almost half a million dollars to the cost, making a total of nearly $2·4 million for the 13-mile section (see article in the December, 1969 issue of *Main Roads* Vol. 35, No. 2, Page 35).

Further work has also been undertaken by the Department on the Bruxner Highway, west of Tenterfield, where another 13-mile deviation, 5–18 miles west of Bonshaw, was recently opened to traffic (see article in the December, 1971 issue of *Main Roads*, Vol. 37, No. 2, Page 34).

The Department is currently engaged in reconstruction at a number of other locations along the Bruxner Highway, near Bonshaw and Yetman●

QUEEN ELIZABETH DRIVE
TOURIST ROAD NO. 4042
MT KEIRA



Tourist Road No. 4042—Queen Elizabeth Drive—gives access to two lookouts within the Mt Keira Summit Park, linking the lookouts with Mt Keira Road (Main Road No. 186). The Drive is approximately 0·75 miles in length and lies within the City of Wollongong. It was proclaimed a tourist road on 9th June, 1965 following an application by Wollongong City Council. The Drive was named by Council in 1954 to commemorate the visit of Her Majesty.

Dominating the Wollongong scene are two mountains, Mt Kembla and Mt Keira, which both stand out from the coastal escarpment with impressive grandeur. The panoramic views offered from the Mt Keira lookouts are among the best of the many vantage points which are available from the Illawarra Range. Rising to a height of 1,547 ft, Mt Keira lies directly behind Wollongong and commands a magnificent view of the City and its districts to the south, including the Inner Harbour of Port Kembla with its vast industrial complex.

From the level of the lookouts, the distance to the visible horizon to seaward is 48 miles. Under favourable conditions the Kurnell oil storage installations at Botany Bay, 33 miles to the north, are easily discernible. To the south it is frequently possible to pick out the high headland north of the entrance to Jervis Bay, over 40 miles away.

Mt Keira Summit Park includes the whole of the summit of Mt Keira, an area of approximately 22 acres. Although new homes are being built around the foothills, the upper slopes are owned by Australian Iron and Steel Pty Ltd and have been preserved mainly in their natural state. The drive up Mt Keira Road provides delightful sights of a wide variety of vegetation. Trees, ferns, vines, Illawarra flame trees, cabbage-tree palms, lillypillies, drifts of purple-flowered mint bush, coachwood and sassafras trees, giant figs and a few magnificent red cedar trees bloom in profusion in the rich rainforests of the rising slopes.

* * *

Keira is an aboriginal word said to mean "wild turkey" and this suggests that these birds were once prolific in this locality. However, the aboriginal meaning is also claimed to be "high mountain" and "lagoon".

As early as 1822 Cornelius O'Brien, one of the earliest settlers in the Illawarra district, had a bridle track cleared down the mountain a few miles south of Mt Keira with money subscribed by settlers. In that year, Governor Macquarie himself visited the Illawarra district and travelled up O'Brien's Road.

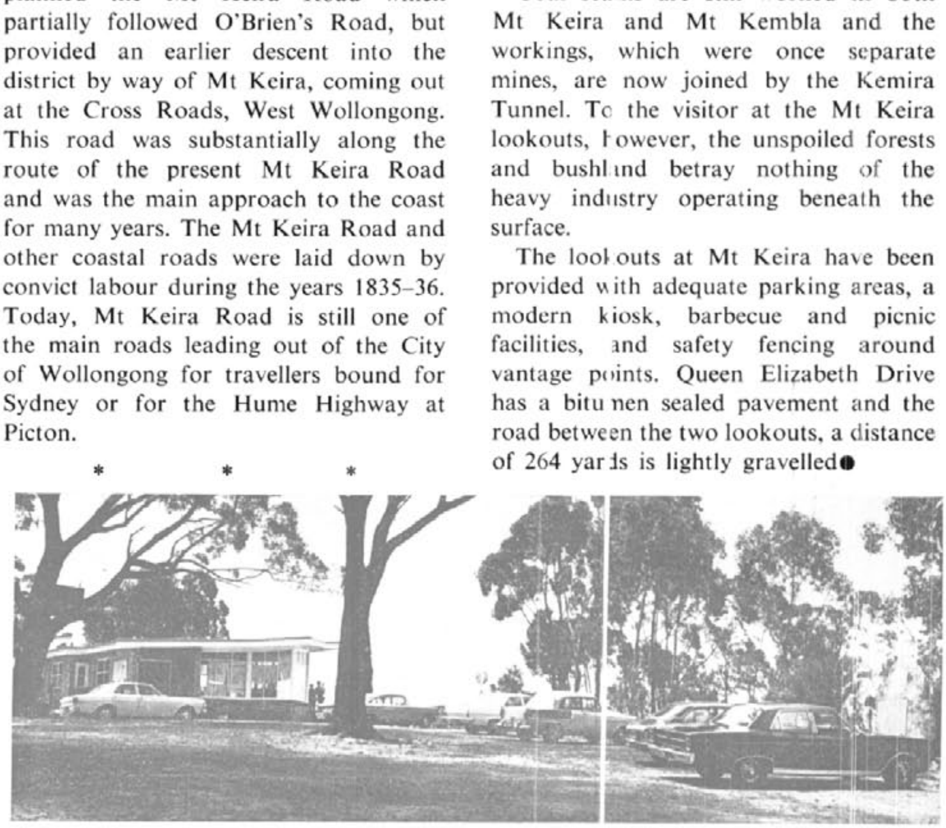
By 1834, following a visit to the area by Governor Bourke and Surveyor-General (later Sir) Thomas Mitchell the surveyance of the township of Wollongong had been completed. Another result of Bourke's visit was that Mitchell planned the Mt Keira Road which partially followed O'Brien's Road, but provided an earlier descent into the district by way of Mt Keira, coming out at the Cross Roads, West Wollongong. This road was substantially along the route of the present Mt Keira Road and was the main approach to the coast for many years. The Mt Keira Road and other coastal roads were laid down by convict labour during the years 1835–36. Today, Mt Keira Road is still one of the main roads leading out of the City of Wollongong for travellers bound for Sydney or for the Hume Highway at Picton.

* * *

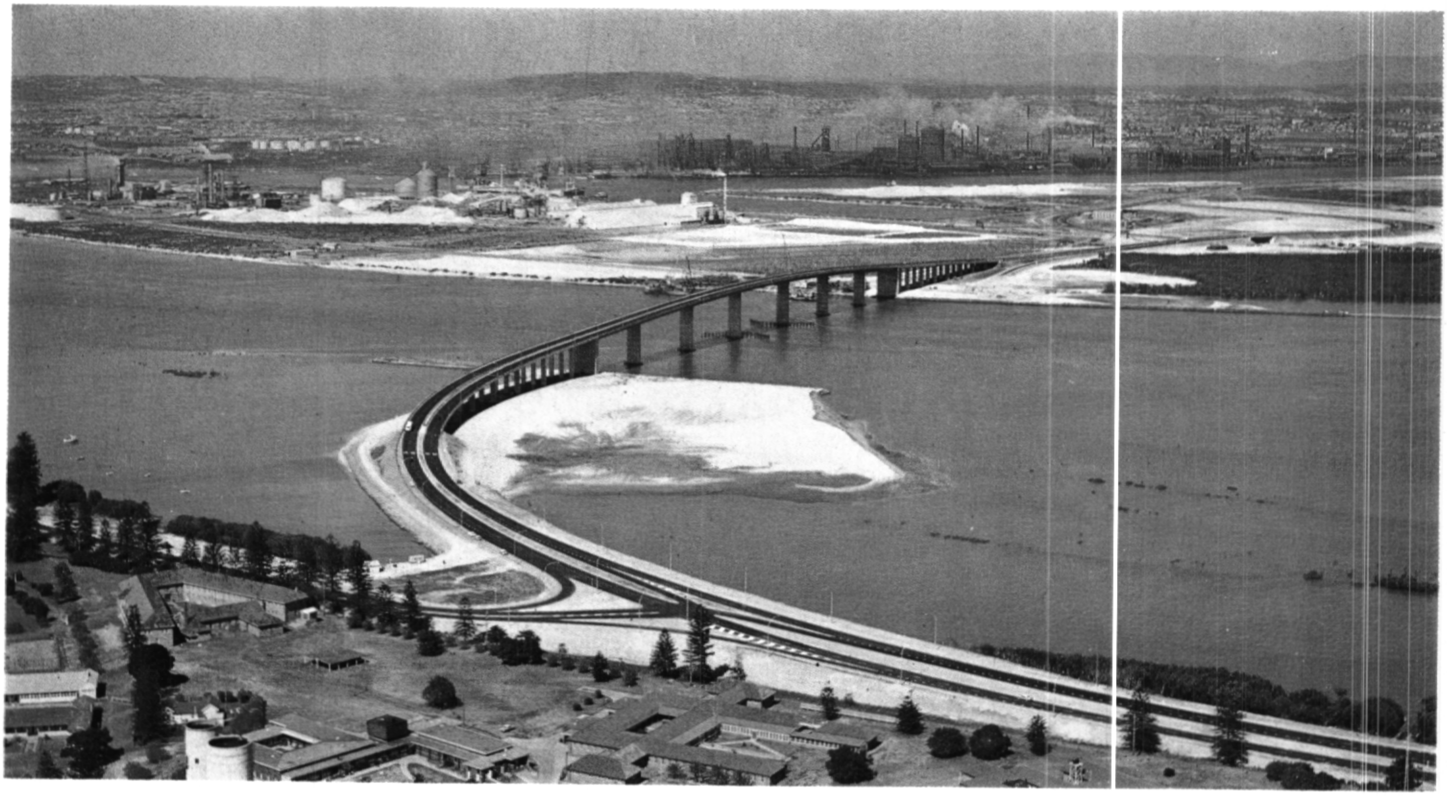
The coal industry, which has been one of the dominant primary industries of the northern Illawarra area and from which has grown the great secondary industries of the district, had its advent at Mt Keira in 1849. It was in that year that James Shoobert, a retired sea captain, opened the first Illawarra coal mine at Mt Keira. The first mine was 100 feet lower than the present Osborne Wallsend Colliery which opened in 1857.

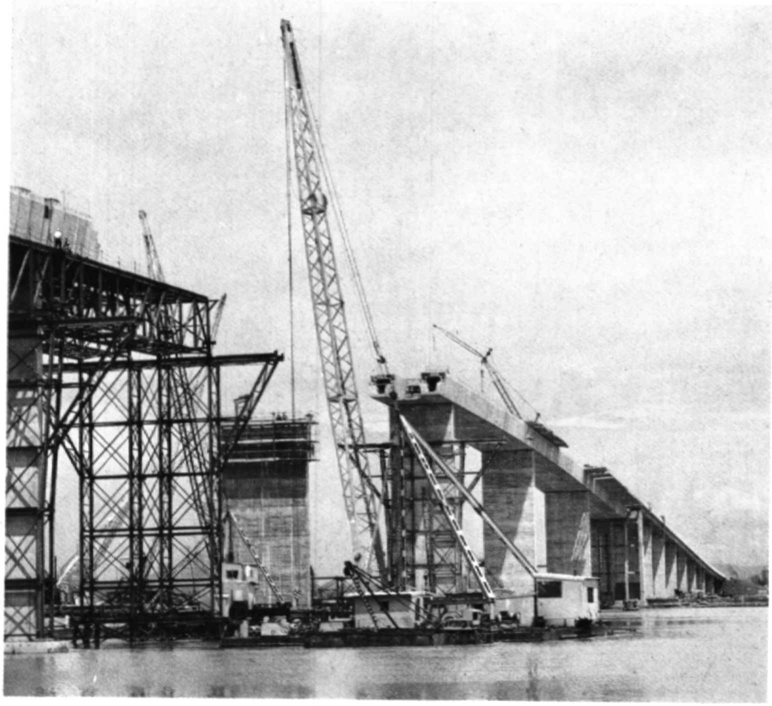
Coal seams are still worked in both Mt Keira and Mt Kembla and the workings, which were once separate mines, are now joined by the Kemira Tunnel. To the visitor at the Mt Keira lookouts, however, the unspoiled forests and bushland betray nothing of the heavy industry operating beneath the surface.

The lookouts at Mt Keira have been provided with adequate parking areas, a modern kiosk, barbecue and picnic facilities, and safety fencing around vantage points. Queen Elizabeth Drive has a bitumen sealed pavement and the road between the two lookouts, a distance of 264 yards is lightly gravelled●



THE SCENIC SOUTH COAST
FROM MOUNT KEIRA LOOKOUT



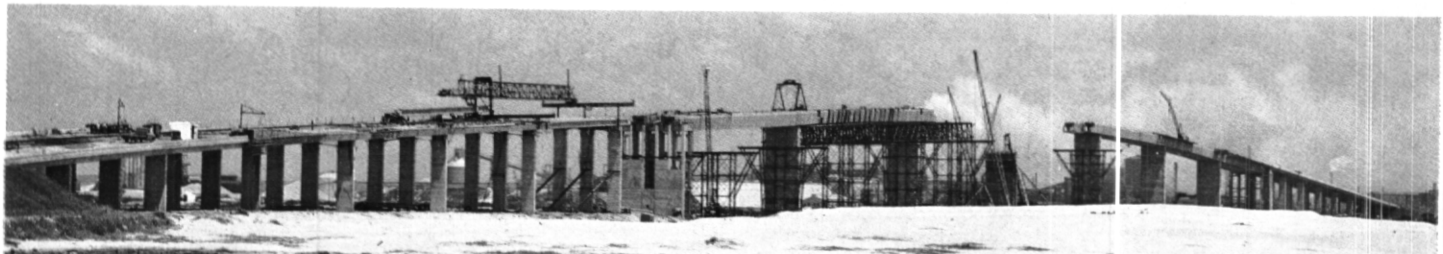


A LONG GRACEFUL LINK

now spans the Hunter River north of Newcastle.

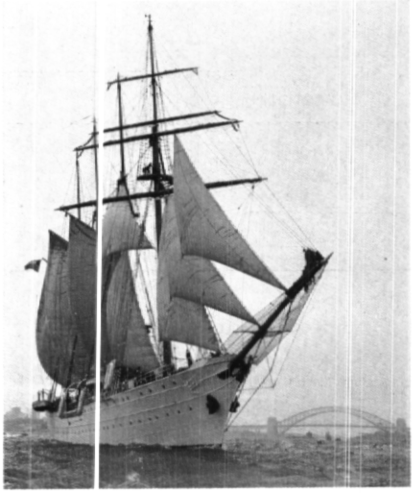
In providing access from the City of Newcastle and the fast-developing industrial sites on Kooragang Island to the expanding suburb of Stockton and the popular Port Stephens resort area, Stockton Bridge introduces a new era for motorists travelling to or through these important commercial, residential and recreational centres.

In superseding the previous Stockton vehicular ferry service with such a spectacularly long leap (3,358 ft), it also brings a new dimension to bridge building in New South Wales.



MODERN AIDS TO ROAD LOCATION

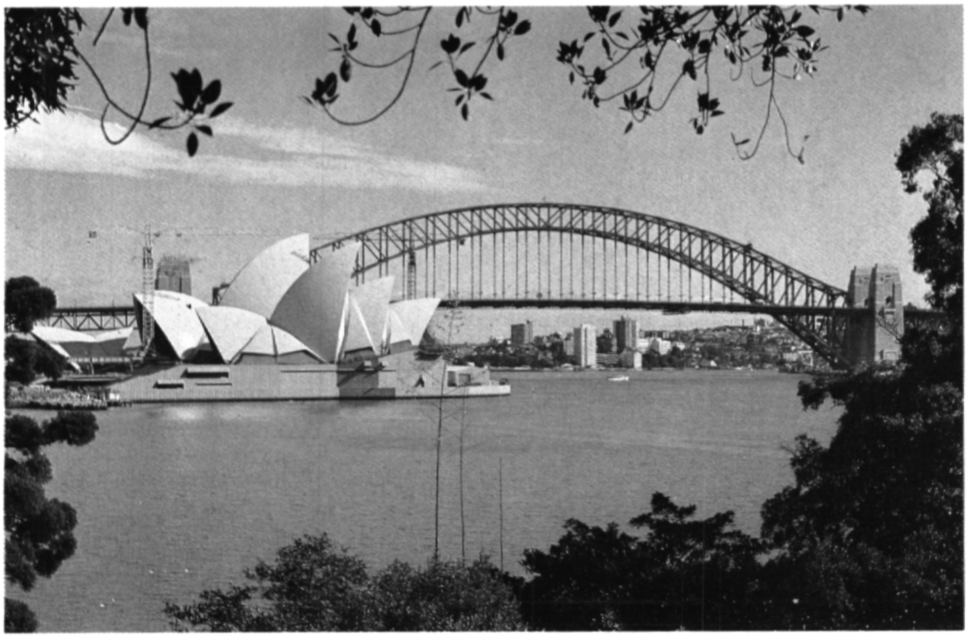
A helicopter, four-wheel drive vehicles and electronic distance measuring devices are among the many items of advanced equipment which are used by the Department to expedite and facilitate road investigation surveys (see article on page 70).



In the years immediately following its completion, Sydney Harbour Bridge, because of its impressive size and attractive design, came to be regarded by residents and visitors alike as the symbol of a modern, mature and progressive city.

Now, forty years later, it is still big and still beautiful – from the air (above left), from the harbour foreshores (below left), from city buildings (top right), from on the water (above right), and from within its own superstructure (below right).

Symbol of a city



In an understandably enthusiastic burst of praise and pride the Sydney Morning Herald of 19th March, 1932, proclaimed . . .

"Across Sydney Harbour has been thrown the greatest arch bridge of the age, a commanding structure with stately towers that stand like the Pillars of Hercules bestriding the tide.

It is an outstanding feat of engineering because, though since rivalled in length, it is the heaviest, the widest and the greatest single span arch yet constructed by man. The size and weight of its members and girders are unequalled; and the smooth progress of its erection involved the solution of problems of engineering, quite unprecedented elsewhere, without a hitch or an error of any kind.

Its magnificence . . . is unsurpassed. Its arch, soaring 440 feet above water-level, is . . . aptly proportioned to the scale of the Harbour and its hills . . . and can hardly be outbalanced even by the greatest skyscrapers that may some day arise. Its vast, sweeping curves, from wherever one may view it, give a sense of rhythm and harmony, of strength combined with lightness and grace. In short, it is one of the finest and most typical products of the Age of Steel."

SYDNEY HARBOUR BRIDGE

The Story of Construction

by

MR LAWRENCE ENNIS, O.B.E.

Director of Construction, Sydney Harbour Bridge, and a Director of Dorman, Long and Co. Ltd.

The following article was initially published in the Sydney Harbour Bridge Souvenir and Programme, which was printed for the opening of the Bridge on 19th March, 1932.

This month marks the 40th Anniversary of the completion of the famous structure and this summary recalls the vision of those men involved in its design and salutes the skill of those responsible for its construction. It was originally described in the introduction as a "graphic and fascinating story" . . . and we hope something of that fascination still filters through to present-day readers.

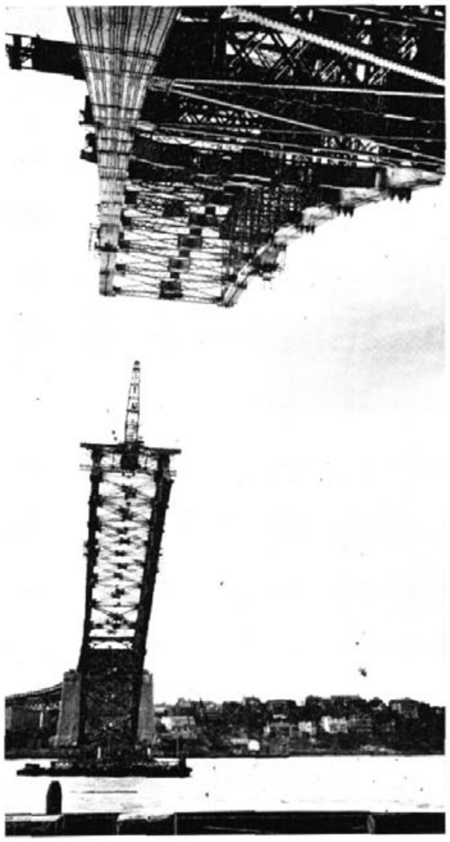
In this re-publication, the article has been interspersed with exerpts—in italics—from a report by Mr Ennis which appeared in the Sydney Morning Herald's special opening day supplement.

The article will be concluded in the June, 1972 issue of "Main Roads", when some details will also be given of the work of Dr J. J. C. Bradfield, who prepared the general design and specifications and supervised construction on behalf of the Government.

ON 24th March, 1924, it was my privilege to sign, on behalf of my company, the document which placed upon us the responsibility of constructing the Sydney Harbour Bridge. Two days later I was on my way back to London to organize the work.

When I left England to submit our tender, I carried with me seven designs, and one of these was accepted by the Government of New South Wales, the contract price being £4,217,721. Our successful design was for the construction of a two-hinged arch bridge of 28 panels, with a clear span of 1,650 ft, with 10 approach spans, and approach piers and main pylons in granite finish.

Immediately on my arrival, early in May, long conferences took place with the company's consulting engineers, Mr Ralph Freeman and Mr G. C. Imbault, in furtherance of our scheme of erection, and to decide upon the equipment necessary for the performance of the contract. The fact that the bridge was to incorporate members greater both in size and weight than any hitherto fabricated and erected meant that much experimental work was necessary before the final details of the fabrication and the scheme of erection could be settled, and before the purchase of plant and machinery and design of the shops could be proceeded with. For example, rivets of a size never before used had to be driven, and experiments were carried out in this connection, not only in regard to the actual driving, but in the heating of the rivets.



30th May, 1930

In order to verify the basis of our calculations, models of typical members of the structure were made to one-eighth actual size and tested to destruction. For this purpose, and also for testing the anchorage cables which I shall refer to later, a special testing machine of 1,250 tons capacity—largest in the world—was made to our order by Messrs Avery's Ltd. At a later date, when these tests were carried out, the results so obtained verified Mr Freeman's calculations. The unusual sizes and weights of the members necessitated consultations with machine makers, so that equipment of the requisite capacity could be designed and manufactured. Orders were then placed in England for such machines as could not be obtained in Australia.

ELABORATE PLANT AND EQUIPMENT

During this period Dr Bradfield visited London, and finally, after consultations with our engineers and architects, the leading details of the bridge and the erection scheme were approved by him.

It was an exceedingly busy 6 months, and almost £1 million was laid out on plant and equipment during that period.

It is interesting to note that the company's first order was a reciprocal one with the New South Wales Government, covering three steamers, each of 400 tons capacity, to be built at the Government Dockyard, Newcastle, N.S.W., for the conveyance of materials from the company's quarry to the bridge site.

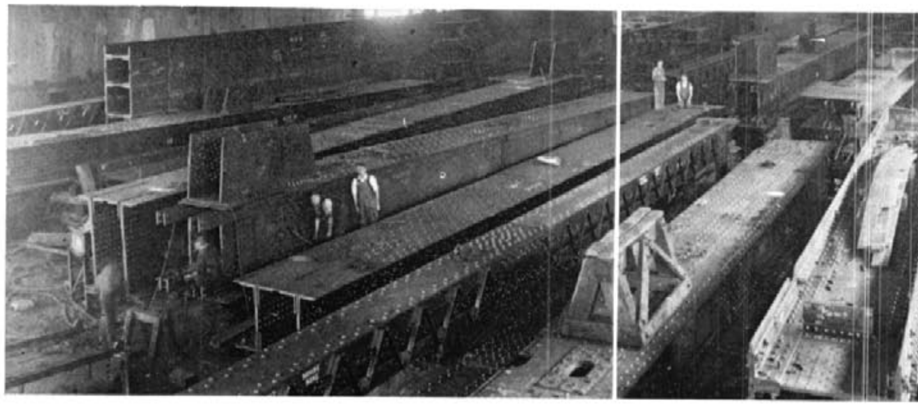
At the end of 1924, I returned to Australia, and on 5th January, 1925, the excavations (*totalling* 137,350 *tons of earth and rock*) for the foundations of the main bearings and approach span piers were commenced.

Whilst this preliminary work was being undertaken at the bridge site, we turned our attention to the opening up and equipping of the granite quarry at Moruya, N.S.W., to supply the 20,000 cubic yards of masonry required for the facing of the piers and pylons of the bridge. Rapid production was essential, and, after having absorbed all available masons in Australia, we found it necessary to bring a large number of men from Scotland. With other workers the total number of men engaged at the quarry reached 250, and for the housing of these workers and their families 72 cottages were erected, as well as a village store, post office, and social hall—a school provided by the education authorities completing a pleasant village settlement, which came to be known as "Granite Town".

Moruya granite is very similar in texture to the well-known Aberdeen granite, and for the dressing the best of equipment was provided—the wastage from the stone dressing sheds was crushed for use as aggregate in the concrete. The power equipment was 2 Crossley 300 h.p. crude oil engines supplied by Crossley Bros Ltd.

For the transportation of the dimensioned stone and aggregate to Sydney the three ships built by the Government Dockyard were used. The vessels were designed for rapid loading and unloading by conveyors and grabs.

For the erection of the bridge fabrication shops, the Government had allotted a site on the northern side of the Harbour on the waterfront adjacent to the bridge, and some 55,000 cubic yards of rock and earth were excavated before the erection of the shops could be commenced. A wharf of a capacity sufficient to receive overseas vessels was built adjacent to the workshops and stockyard, and at the finishing end of it a dock was excavated so that barges could take delivery of completed members from the shop cranes.



Section of heavy fabricating shops at Milson's Point, showing completed truss members for main span. 1*st April*, 1930

POWERFUL MACHINERY

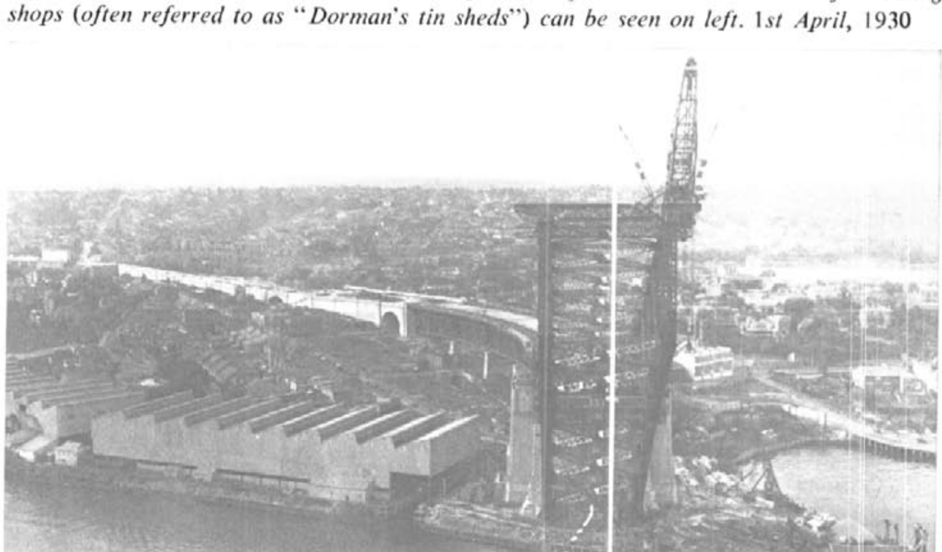
The fabrication shops consisted of three sections—one known as the "light" shop, which had two bays each 65 ft wide and 580 ft long; a "template" shop, 200 feet long by 130 feet wide, erected above and at one end of the light shop, and a "heavy" shop in one bay, 500 ft long by 147 ft wide. In the "light" shop, four cranes, each of 25 tons capacity were installed, while for serving the "heavy" shops two cranes, each of 120 tons lifting capacity, spanning the whole width of the shop, were provided.

In the laying-out and equipping of the shops, it had to be borne in mind that silicon steel plates, up to 2¼ inches in thickness, silicon steel angles 12 inches x 12 inches x 1¼ inches thick, and rivets 5½ inches long by 1 $\frac{7}{16}$ inches diameter were to be used in the building up of the bridge members, and therefore, very heavy machinery was required. The 12 inches x 12 inches x 1¼ inches angles were the heaviest yet rolled, and required the provision of very special equipment at our Middlesbrough works.

Material was unloaded from steamers by our wharf cranes and transferred to the stockyard, there to be sorted and stacked by two semi-goliath travelling cranes. The steel was then dealt with by two straightening machines, the one with a capacity for straightening plates up to 2¼ inches thick and the other capable of straightening angles 12 inches x 12 inches x 1¼ inches.

After being handled by heavy shearing machines and cold saws for cutting to length, and planing machines for planing to width, the larger of which had a travel

View from southern half-arch, showing nine panels in place on north side. The fabricating shops (often referred to as "Dorman's tin sheds") can be seen on left. 1*st April*, 1930



of 66 ft, the material was marked for drilling from the templates which had already been prepared. This process required a high degree of skill and accuracy, for upon it depended the ultimate correctness of the fabrication.

On completion of the drilling, riveting and assembling, the ends of all members were carefully machined before "butting" together for the reamering of the field joints. To ensure a perfect fit, all members connecting together at the main truss joints were assembled in their respective positions on the floor of the shops, prior to their despatch for erection, and lifts of upwards of 200 tons were handled by the two shop-cranes operating in unison. At all stages of the fabrication and erection checks were carefully made by instruments, particularly of the relative positions of the members during the process of "butting together".

Although, on completion, the arch presents to the sight a perfect curve, it is built up of straight members, the effect of a curve in the completed structure being given by bevels machined at the butt joints of bottom and top chord members.

In fabricating bridge members of a size and weight never before attempted we encountered many difficult problems, and at times the fabrication caused me some anxiety. Our difficulties had to be overcome, however, and we got over them one by one.

I have dealt very briefly in the foregoing with the quarry and the bridge fabrication shops, but sufficiently I think to give some idea of the immense preparation that is necessary on a large contract, quite apart from the construction on the site.

My readers will realize this when I say that many of the bridge members for the Sydney Harbour Bridge were more than 100 per cent, heavier than any previously built in the world.

MAKING A START ON THE BRIDGE

Returning now to the work on the bridge site. By September, 1926, piers were built ready for the reception of the approach span steelwork. There are five approach spans on each side of the Harbour, the average weight in each being in the vicinity of 1,200 tons. The trusses in these spans are of the Warren type. Two lines of timber falsework served to support the approach span steelwork during erection from pier to pier—the falsework in advance of the steelwork providing a track for the locomotive cranes used in the building of the falsework and the piers.

The erection of the approach span steelwork was carried out by a 25-ton crane on each side of the Harbour, building the trusses, bracing and deck structure, from the northern and southern terminal abutments respectively towards the Harbour front.

These cranes, after having first been erected on timber towers, travelled forward upon the steelwork which they had placed in position, thus building their own track as they went along.

The spans on the north side approach the main span on a curve of 1,423 ft radius, which was responsible for some delicate engineering problems in the fabrication.

We were subjected to much "armchair" criticism as to our slowness in getting on with the job . . . In addition, many pessimistically inclined engineers in Australia and overseas expressed the opinion that the erection of an arch of such magnitude was a foolhardy attempt to do the impossible, and these criticisms became so definite, that some members of the New South Wales Cabinet at the time expressed alarm, and I was called upon more than once to reassure them.

During the erection of the approach spans the excavations for the base of the main pylons and the "skewback" foundations were completed. The term "skewback" refers to the mass of concrete, to a depth of 40 ft, taking the thrust of the main arch below the main bearings at an angle of 45 degrees. The deposition of the "skewback" concrete was carried out in hexagonal formation, upon advice received from Dr Oscar Faber, of London —a method which was the subject of much interest to visiting engineers. Immediately under the bearing, heavy reinforcement and a special grade of concrete were used.

The setting of the main bearings for the arch, each consisting of an assembly of steel castings and forgings weighing 296 tons (manufactured by the Darlington Forge Co. Ltd, England) was an operation which called for very cautious handling and exact detail. The bearings were first placed in sections upon a steel framework (afterwards removed) and having been very carefully adjusted and secured in position, with the aid of hydraulic jacks operating on the lower edge, they were concreted from the underside.

The arch is quite free to move on a forged steel bearing-pin at the apex of each main bearing, the pin being 14½ inches in diameter by 13 ft 8 in long. The total thrust to be sustained by the four bearings under live-load conditions is no less than 78,800 tons.

During the erection of the approach spans and main bearings the pylons had taken shape. These prominent architectural features of the bridge are constructed in concrete with granite facings.

The pylons present a truly fine sight to-day, and in my opinion are the most classical examples of granite construction in the world. They are the work of our consulting architects, Sir John Burnet and Partners, of London.

The back buttress takes the bearings of the last approach spans. The base dimension of each pylon is 222 ft x 162 ft, and their finished height is 285 ft above the water-level. Fifteen feet below deck-level reinforced concrete floors were built on the outer sections of each pylon, the reinforcing rods used being 2 inches in diameter, and the pylon cross-girders were then erected.

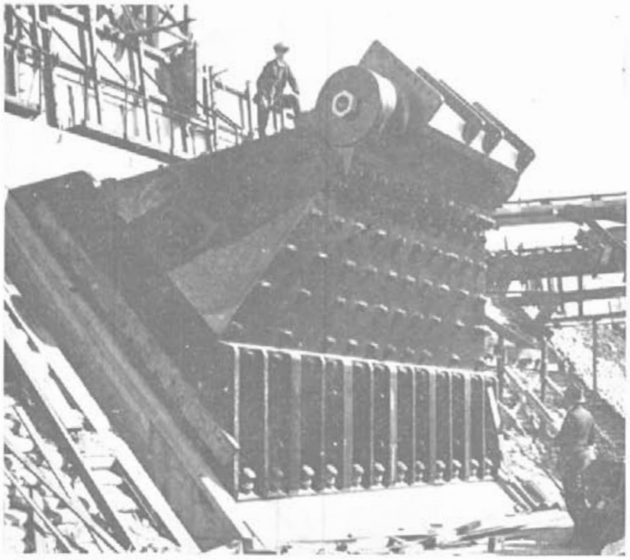
Taking the position of the contract as it appeared to the observer at June, 1928, the five approach spans on each side of the Harbour stood out on the skyline upon their granite piers, the forward ends of the spans adjacent to the main span taking their bearings on the pylons. At the base of the pylons the triangular sectioned main bearings waited to receive the first members of the arch.

GIANT CRANES

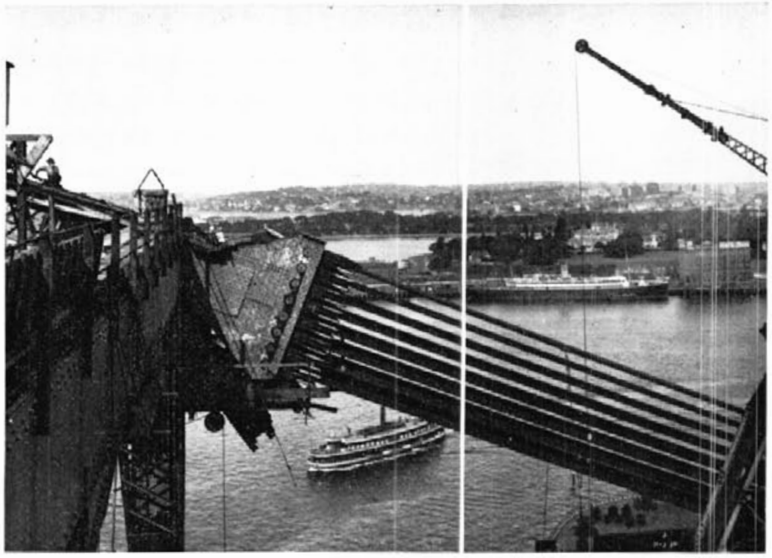
On the concrete floor, just below deck-level, the two pylon cross-girders, each weighing 93 tons, were in position, and on these cross-girders at the south pylon had been erected an inclined steel ramp for the reception of one of the two most important erection units, namely the "creeper cranes". These cranes were designed in collaboration with Messrs Wellman, Smith and Owen, of London. Their purpose was to erect the members of the first panel of the arch from their position on the ramp and thence to "creep" forward from panel to panel as the erection proceeded.

Our next step was the erection of these giant cranes, each weighing 565 tons, and having a lifting capacity of 122 tons with its main hoist.

The carriage of the crane, with its mechanical gear, was erected on the inclined ramp by using the 25-ton cranes which previously carried out the erection of the approach spans. To build

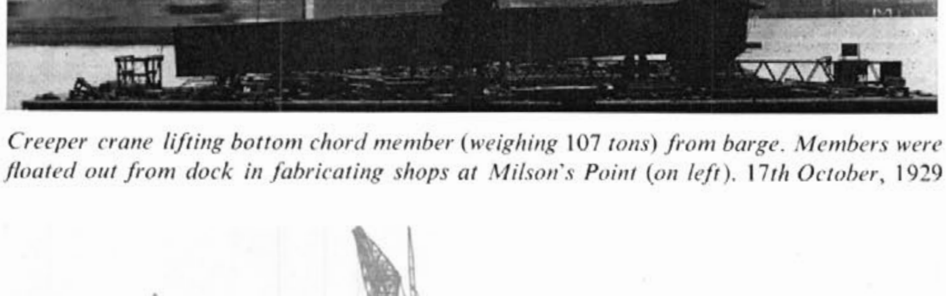


Southeast main span bearing, erected complete with upper saddle, main pin and covers. 26th *May*, 1927



Southeast "fish tail" cable connecting plates. 30th *March*, 1930

Creeper crane lifting bottom chord member (*weighing* 107 *tons*) *from barge. Members were floated out from dock in fabricating shops at Milson's Point* (*on left*). 17*th October*, 1929



View from northeast showing northern approach spans, creeper cranes and cables which anchored each half-arch during construction. 2*nd January*, 1930

the jib, which, at its apex, reached a height of 300 feet above the water, it was necessary to erect a 7-ton crane with 110 ft jib on timber towers, using the creeper-crane carriage as a platform. In addition to the main hoist of 122 tons, each creeper crane was provided with a "jigger" hoist of 20-tons capacity, a 5-ton "walking crane" traversing on the front girder of the creeper crane carriage and two 2½-ton jib cranes on the back of the carriage.

As a passing instance of "where the money goes", it may be of interest to the uninitiated to learn that the cost of placing the two creeper cranes in position was upwards of £30,000, excluding, of course, the cost of the cranes themselves.

The erection of heavy members, such as occur in this and similar bridges, is always an operation which requires considerable thought and careful preparation. Often it is necessary to build a succession of cranes, each one of a heavier lifting capacity than its predecessor, in order to accomplish the final purpose.

ERECTING THE ARCHES

The work up to this point had been comparatively simple, though important. In itself it would have been no mean contract, but we now felt that the real undertaking was upon us. Nevertheless, we approached the task with confidence.

The general scheme for the erection of the main arch was to cantilever out from

LITTLE KNOWN LINK

In the grounds of St Michael's Church of England, near Vaucluse Road, Vaucluse, stands a monument made of Moruya granite and erected to commemorate the association of Mr Ennis and other members of the staff of Dorman, Long and Co. Ltd, with the church.

either side of the water, utilising steel wire cables to "anchor back" the half arches until they met in the centre on a horizontal bearing pin, and became self-supporting. This scheme was made possible by the rocky formation of the land on either side of the Harbour, which provided a safe anchorage to withstand "the pull" exerted by the weight of the half-arch, together with the heavy erection crane upon it. The individual half-arches were anchored back during erection by 128 special steel-wire cables, passing through a horse-shoe-shaped anchorage tunnel, the cables being connected to the upper chords at the top of the end posts. The tunnels were excavated at an angle of 45 degrees in the solid rock to a depth of 132 ft. The anchorages for each half-arch were, of course, entirely separate, one being on the north shore and the other on the south. The steel cables were manufactured by British Ropes Ltd, and Wright's Ropes Ltd, of England, from specially-drawn wire supplied from our own wireworks.

Consisting of 217 wires, the cables were of a diameter of $2\frac{3}{4}$ inches, a length of some 1,200 ft, and an average weight of $8\frac{1}{2}$ tons. When tested they revealed a breaking stress of 460 tons per cable, but in practice were called upon to sustain a strain of only 115 tons.

The tunnels had been constructed simultaneously with the building of the pylons to deck-level, and were ready for reception of the cables when the erection of the main arch commenced, on 26th October, 1928.

The first of the three sections of the lower chord, whilst only some 20-odd ft long, weighed 170 tons, which was beyond the capacity of the creeper crane. The chord was therefore lifted in two halves, split in the direction of its length. All subsequent members of both top and bottom chords were handled in this longitudinally split condition.

Thus the first member erected, which was a section of the bottom chord, direct on to the top saddle of the south-western main bearing, weighed 80 tons, the weight of the complete bottom chords for the first panel on each side of the Harbour being just on 1,000 tons.

For the erection special lifting brackets were provided as an attachment to the member which hinged about a pin in the bracket in such a position that, on being hoisted, the member was horizontal. The jigger hoist of the creeper crane was then attached to the "nose end" of the member to enable it to be tilted to the required inclination. In some cases the lifting-gear weighed up to 5 tons.

The end posts, each in three sections, were then erected. Each end post weighs 201 tons and is 180 ft long. Temporarily, to stay the end posts in position, struts were provided between the pylon and posts. Then followed the erection of the cross-girder and members of the end post bracing, thus completing the end frame. It was at this point we first brought into commission the anchorage cables, and, even now, the connection was only temporary, pending the transfer of the creeper crane to the first panel of the arch.

Before proceeding further with the erection of the arch, I should mention that while we were on with the erection of the first members, the reaving of the 128 anchorage cables around the tunnel was being proceeded with. The connection between the cables and the arch consisted of five fan-shaped link plates attached to the upper chord, immediately above the top of each end post, by means of a 27-inch diameter chromium steel pin. These plates at the "fan" end received eight 11-inch diameter steel pins, and the cables were attached to these pins by means of sockets and cross-heads. The anchorage bolts projected behind the pins to a further cross-head, the space thus provided being a recess for the application of the hydraulic jacks used first in the tensioning, and, later, in the slackening of the cables.

. . . *to be continued.*

* * *

The Department has available a 32-page colour booklet entitled The Story of the Sydney Harbour Bridge—*and, with permission, has reprinted a 12-page article on the construction of the Bridge, written by Dr J. J. C. Bradfield, Chief Engineer, and originally published in the* Commonwealth Engineer, *1st March, 1932.*

Copies of these publications are available from the Public Relations Section, Third Floor and from any of the Department's divisional offices.

Statement of Receipts

FOR YEAR ENDED

RECEIPTS	County of Cumberland Fund $	Country Fund $	Commonwealth Fund $	Total $
Motor vehicle taxation	7,679,104	30,716,415	....	38,395,519
Charges on commercial vehicles under the Road Maintenance (Contribution) Act, 1958	3,368,265	13,473,061	....	16,841,326
Levy upon Councils in accordance with section 11 of the Main Roads Act, 1924	11,407,160	....	....	11,407,160
State Government loans—Repayable	1,700,000	550,000	....	2,250,000
Loan borrowings under section 42A of the Main Roads Act, 1924	4,000,000	5,000,000	....	9,000,000
Contributions by Councils towards maintenance and construction of Main and Secondary Roads	189,807	85,027	....	274,834
Contributions by other departments and bodies towards maintenance and construction of Main and Secondary Roads	505,208	649,433	....	1,154,641
Commonwealth/State Government—Special advance for restoration of flood damage	....	2,400,000	....	2,400,000
Sydney Harbour Bridge Account for expressway approaches ..	69,889	....	....	69,889
Commonwealth Aid Roads Act, 1969—				
Urban arterial roads—Schedule 2	....	....	32,740,000	
Rural arterial roads—Schedule 3	....	....	0,400,000	
Other rural roads—Schedule 4	....	....	3,168,713	
Planning and research—Schedule 5	....	....	970,000	47,278,713
Other	805,662	240,877	....	1,046,539
Total Receipts	29,725,095	53,114,813	47,278,713	130,118,621
Balance brought forward from last year	7,802,676	11,036,729	881,063	19,720,468
	$37,527,771	**$64,151,542**	**$48,159,776**	**$149,839,089**

and Payments

30TH JUNE, 1971

PAYMENTS	County of Cumberland Fund $	Country Fund $	Commonwealth Fund $	Total $
Maintenance and minor improvements of roads and bridges ..	5,192,508	17,468,355	....	22,660,863
Construction and reconstruction of roads and bridges	10,568,458	24,361,817	40,122,912	75,053,187
Maintenance and construction of unclassified roads in the Western Division	....	....	235,995	235,995
Restoration of flood damage	....	1,924,544	....	1,924,544
Land acquisition	7,659,737	994,374	6,285,723	14,939,834
Planning and research	....	....	893,554	893,554
Administrative expenses..	3,073,299	4,299,804	....	7,373,103
Purchase of land and buildings for administration and operation	873,276	874,128	....	1,747,404
State Government loans—				
Sinking Fund payments	14,440	166,261	....	180,701
Interest, exchange, management and flotation expenses	181,530	958,269	....	1,139,799
State Treasury—Repayment of temporary advance	100,000	100,000	....	200,000
Loan borrowings under section 42A of the Main Roads Act, 1924—				
Repayment of principal	202,366	123,136	....	325,502
Interest	639,031	771,189	....	1,410,220
Other	313,849	457,557	....	771,406
Total Payments	28,818,494	52,499,434	47,538,184	128,856,112
Transfers to reserve for loan repayments	134,175	147,076	....	281,251
Net transactions of operating and suspense accounts	1,809,270	1,554,496	....	3,363,766
	30,761,939	54,201,006	47,538,184	132,501,129
Balance carried forward..	6,765,832	9,950,536	621,592	17,337,960
Credit	**$37,527,771**	**$64,151,542**	**$48,159,776**	**$149,839,089**

Trunk Road No. 80: Hillston-Goolgowi Gets . . .

On Friday, 10th December, 1971, the Minister for Highways, the Hon. P. H. Morton, M.L.A., applied the last of the "tar" seal required to complete bituminous surfacing of a 38-mile section of Trunk Road No. 80 between the towns of Goolgowi and Hillston.

As a result of the completion of reconstruction and bituminous surfacing of this section of Trunk Road No. 80, a fully sealed road connection now exists between Hillston and the Mid-Western Highway at Goolgowi and the large centre at Griffith in the Murrumbidgee Irrigation Area.

The plans and estimates for the reconstruction of this section were prepared by the Carrathool Shire Council whose headquarters are at Goolgowi. Most of the work was performed by the Council's day labour organisation, with the remainder carried out by contract under Council supervision. The work was undertaken over a period of eight years.

The new road has been constructed to a 60 m.p.h. standard. The sealed carriageway is 18 feet wide between Hillston and Merriwagga and 20 feet wide between Merriwagga and Goolgowi. Although no bridgeworks were required, it was necessary to construct several lengths of box and pipe culverts.

Total cost of reconstruction of this section was $618,566 and of this the Department contributed about $462,930. Cost per mile of the work was in the order of $16,400.

During the ceremony, which was held just south of Merriwagga, Mr Morton stated:

"*Roadworks are not as spectacular as bridgeworks, but . . . they're certainly no less important. Good roads are a major factor in the economic and social expansion of a region, and the progress of many facets of local government endeavour would be impeded without an adequate local and statewide road communications network.*

The extension of bituminous surfacing on the Main Roads System in the State continues to be one of the most pressing concerns of the Commissioner for Main Roads and Councils.

It is possible that some Councils might think that the sections of newly sealed road within their boundaries are so short as to indicate only slow progress, but . . . from an overall State point of view, much has been achieved in the past year."

Just how much bituminous surfacing has been carried out on Main Roads in New South Wales during 1970–71 is scheduled on the following page.

THE "BLACK STUMP"

Hillston, which claims the original "black stump", is the major centre in the district commonly referred to as "Black Stump Country".

A plaque commemorating the "Black Stump" is to be found within the boundaries of the roadside rest area situated on the section of road near Merriwagga. The rest area also provides picnic facilities such as a gas barbecue, shelter, seats and water. The Department has provided the usual signs indicating the location of the rest area and, because of the historic significance of the site, it has also erected a sign post at the intersection with the Mid Western Highway at Goolgowi.

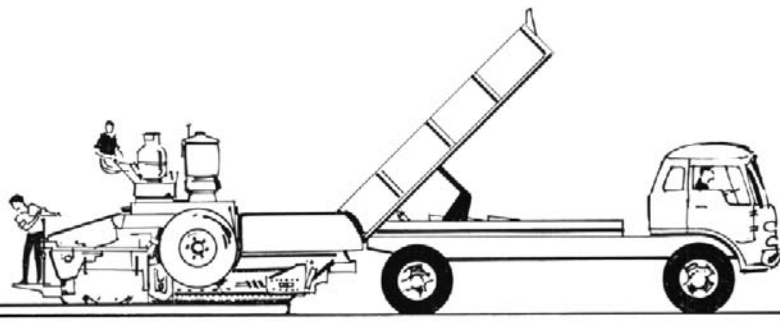
The term "Black Stump" has commonly been used to describe this district since the 1880's, although other towns also claim the original "Black Stump".

The local legend is based on the death of a woman who was burnt to death near the Black Stump tank. The original Black Stump tank was a mile-and-a-half in a southerly direction from the public watering place, now known by the same name and located approximately 10 miles south-east of Merriwagga. The road on which the tank is situated is claimed to be near tracks used by coaches and bullock waggons in the pioneering days of last century.

The woman in question, Mrs Barbara Blaine, was buried in Gunbar Cemetery on 18th March, 1886. Her husband, a teamster, had apparently camped at the tank so that his bullocks could graze on the dry grass nearby. It is said that the bullocky instructed his wife to make a fire while he went off to find fresh food. While he was away the dry grass caught alight and his wife was burnt to death. The teamster is quoted as saying "When I returned to the camp my wife was dead—she looked just like a black stump".

And that is how, it is said, the tank came to be called the "Black Stump"●

ALL IN A YEAR'S WORK



BITUMINOUS SURFACING STATISTICS FOR 1970-71

As at 30th June, 1971 the lengths of the various types of surfaces on the roads for which the Department is responsible throughout New South Wales were:

Cement Concrete	123 miles
Bituminous Plant Mix[(1)] ..	1,059 miles
Slurry Seal[(2)]	4 miles
Sprayed Seal[(3)]	13,026 miles
Primer Seal[(4)]	197 miles
Prime[(5)]	35 miles
Gravel	7,375 miles
Formed only	4,989 miles
Natural surface	252 miles
	27,060 miles

[(1)] *Bituminous Plant Mix—*

involves the mixing, spreading, and compacting of a blend of bituminous binder and aggregate. The mixed material either open graded or dense graded, is usually prepared at a mixing plant, then transported, spread mechanically on the road and compacted.

[(2)] *Slurry Seal—*

involves the application by squeegee or spreading box of a thin layer of a carefully proportioned mixture of bitumen emulsion, water, and fine aggregate to an existing bituminous surface.

[(3)] *Sprayed Seal—*

is the application of a surface layer of bituminous binder into which cover aggregate is incorporated.

The aggregate is spread uniformly upon the sprayed binder, broomed and rolled until it forms a tight mat completely covering the surface.

[(4)] *Primer Seal—*

is the application of a suitable type of bituminous material (primer binder) with fine aggregate cover, intended to carry traffic for a longer period than a normal primer and to provide a temporary protection to the surface, prior to the initial application of a more permanent seal.

[(5)] *Prime—*

is the application of bituminous material to a road pavement, preparatory to the initial application of a seal.

* * *

From the above list, it can be seen that the total length of dustless surface on the State's Main Roads System and on Secondary, Tourist and Developmental Roads (together with some unclassified roads for which the Department is responsible, generally located in the unincorporated western area of the State) is now 14,444 miles. This is an increase of 428 miles during 1970–71.

During the year, bituminous surfacing work was carried out on:

Expressways	2 miles
State Highways	522 miles
Trunk Roads	177 miles
Main Roads	474 miles
Secondary Roads	12 miles
Tourist Roads	8 miles
Developmental Roads ..	9 miles
Unclassified Roads	6 miles

The total length of 1,210 miles involved 2,534 lane miles or the equivalent of 1,267 miles of normal two-lane road.

The Department was the constructing authority for 546 miles (1,167 lane miles) of bituminous surfacing, of which 490 miles (1,055 lane miles) were done by direct control and 56 miles (112 lane miles) by contract.

Councils were the constructing authority on behalf of the Department for 664 miles (1,367 lane miles) of bituminous surfacing, of which 84 miles (180 lane miles) were done by direct control and 580 miles (1,187 lane miles) by contract.

The work comprised:

89 miles of bituminous plant mix surfacing (277 lane miles),

1,012 miles of sprayed seal (2,038 lane miles),

82 miles of primer seal (163 lane miles),

27 miles of prime (56 lane miles).

The bituminous surfacing carried out during 1970–71 was in four categories:

- Initial surfacing of 345 miles (691 lane miles) of road not previously provided with a dustless surface.
- Heavier treatment, either sprayed seals or plant mix surfacing, provided on 69 miles (139 lane miles) of road pavement previously provided with a light treatment such as a prime or primer seal.
- Restoration of bituminous surfaces following reconstruction—
  to widen and/or strengthen the pavement on 57 miles (127 lane miles),
  to provide additional lanes or dual carriageways on 27 miles (87 lane miles), and
  to improve alignment and/or grading on 81 miles (181 lane miles).
- Maintenance resurfacing of 631 miles (1,309 lane miles) of road pavement.

Expressway News

Waterfall-Bulli Pass Tollwork

Construction of Second Stage Commences

Just prior to Christmas, 1971, a tender of $2,934,553.08 was accepted from Citra Constructions Pty Ltd for construction works on the Southern Expressway between Waterfall and the top of Bulli Pass.

The work in this contract consists of earthworks, drainage and fencing and includes two bridges on the 7-mile section from near Darke's Forest Road to the top of Bulli Pass.

Similar work on the first stage of the Tollwork from Waterfall to near Darke's Forest Road was commenced in mid-1970, by G. Abignano Pty Ltd, and is now nearing completion.

At the conclusion of these contracts, the Department will arrange for the completion of the work and this will include pavement construction, asphaltic surfacing, linemarking and signposting. Safety features will include special traffic signals and warning signs to assist motorists when heavy fog prevails in the area north of Bulli Pass.

Initially, the Tollwork will provide dual two-lane carriageways which will later be extended to dual three-lane carriageways when traffic volumes necessitate it.

From the southern end of the Tollwork, motorists will be able to continue on to Wollongong either by the Prince's Highway down Bulli Pass or by the Mt Ousley Road.

The Tollwork is expected to be opened to traffic towards the end of 1973 and will provide the motoring public with $15 million worth of vastly improved inter-city travelling conditions●

South Western Expressway

A tender was accepted in October, 1971, from Citra Constructions Pty Ltd for the construction of a bridge over the South Western Expressway at Minto, approximately 30 miles south of Sydney and 4 miles north of Campbelltown.

The tender of $322,998 is both for construction of a three-span prestressed concrete bridge to carry St Andrews Road over the Expressway and for a large culvert to carry St Andrews Road over Bunbury Curran Creek. The overbridge will be 364 feet long, 28 feet wide, between kerbs, and will have one footway, eight feet wide.

The culvert will be a 3-cell concrete structure, 120 feet long and will take Bunbury Curran Creek through the western approach embankment to the bridge. Both of the new structures were designed for the Department by Messrs G. Maunsell and Partners, Consulting Engineers.

The contract also includes the demolition and removal of the existing reinforced concrete bridge on St Andrews Road at Bunbury Curran Creek. Contract time for the completion of the work is 56 weeks.

The St Andrews Road bridge is one of sixteen structures required on a 9·75 mile section of the expressway which is at present under construction by the Department from Cross Roads, near Liverpool to near Campbelltown. The total length of these bridges would correspond to a two-lane bridge almost 1 mile long.

The Cross Roads - Campbelltown section of the Expressway will cost approximately $14 million. This estimate includes approximately $2·5 million for land acquisitions and about $3·5 million for bridges and major culverts.

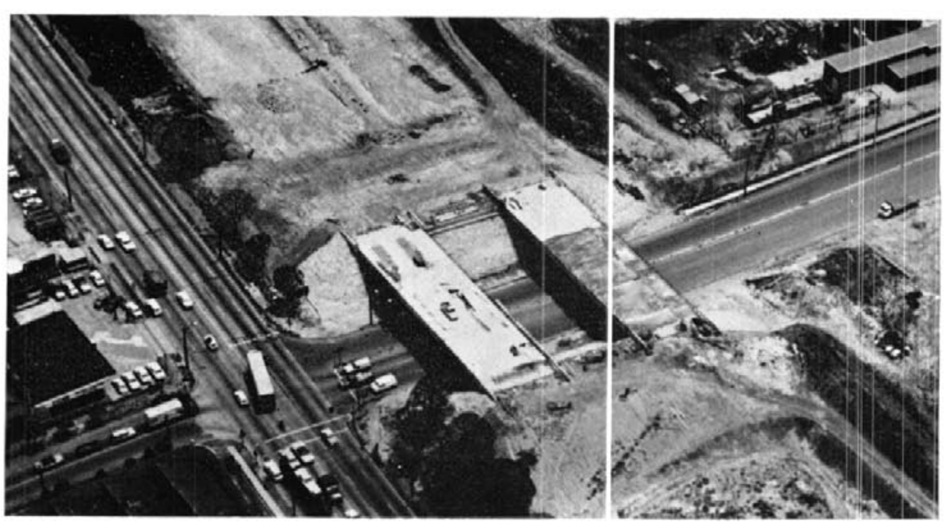
The Expressway will terminate initially at the Campbelltown-Camden Road which will be widened and connected to a deviation of the Hume Highway at its western end. This deviation will in turn, lead to the high level bridge which is already under construction over the Nepean River at Camden.

Future stages of the South Western Expressway will extend to Mittagong. Ultimately, it may continue to Canberra and Melbourne●

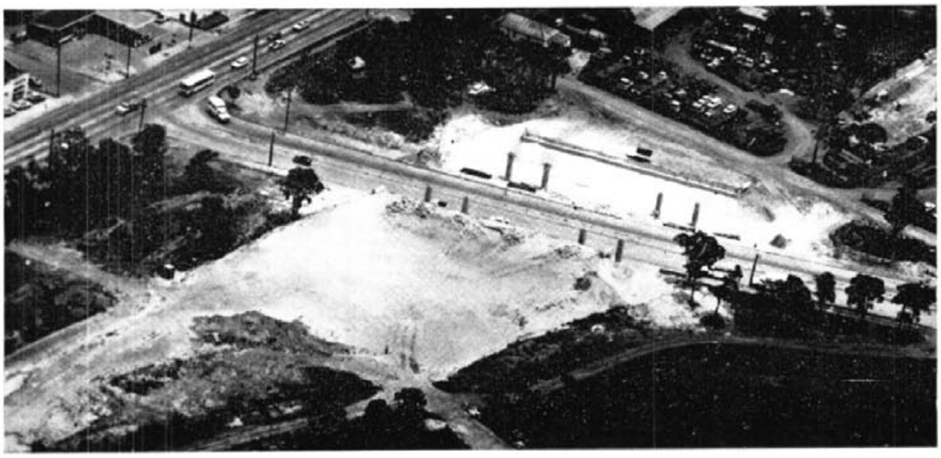
Western Expressway

Work is progressing with the construction of the section of the Western Expressway between Wentworth Road, Homebush and Wentworth Street, Clyde.

There are eleven bridge sites on this four-mile section of the Expressway and at three of these sites, bridgeworks are well in hand●



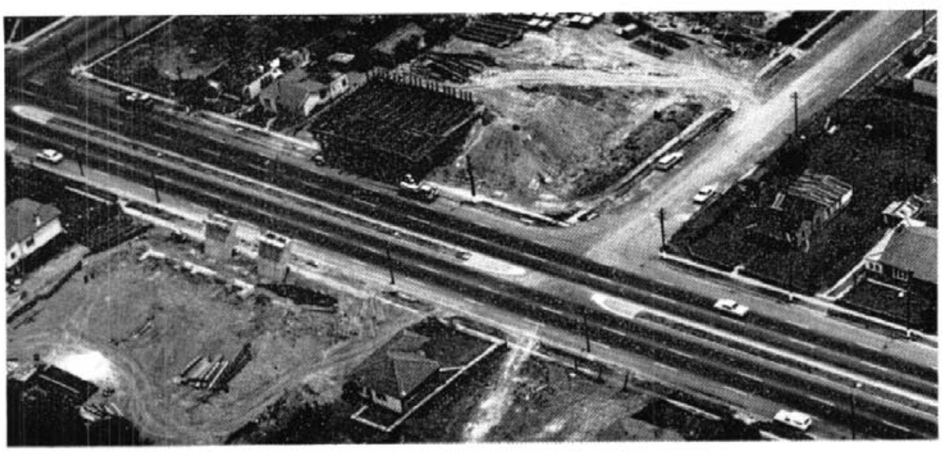
Bridge site at King Avenue, Lidcombe



Bridge site at Hill Road, Lidcombe

The route of the Western Expressway between King Avenue (in foreground) and Hill Road as it parallels Parramatta Road in the industrial area of Lidcombe

Bridge site at Silverwater Road (Main Road No. 532) Silverwater



Cabramatta Crossing Completed

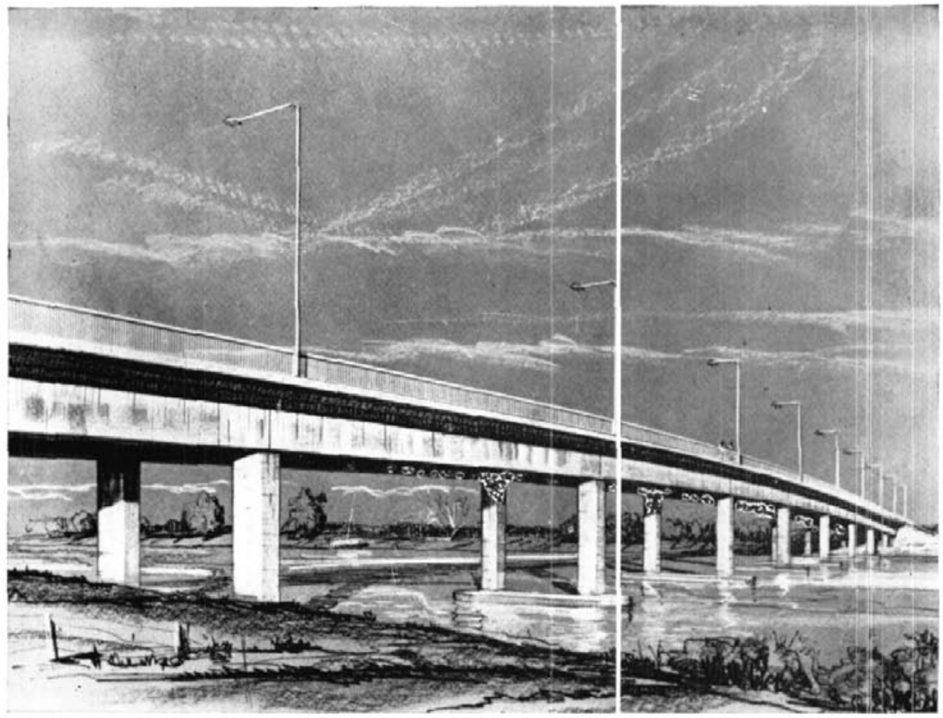
On 22nd November, 1971, a new five-span prestressed concrete bridge was opened, for traffic crossing the railway line adjacent to Cabramatta railway station.

The bridge links Cabramatta Road East and Cabramatta Road West (Main Road No. 534) and extends over Broomfield Street (on the east side) and Railway Parade (on the west side). It has been constructed by the Department of Railways and is located slightly to the south of the previous narrow and poorly aligned structure.

The new bridge is 267 feet long and provides four traffic lanes. A footway has been provided on each side of the bridge.

The Department of Main Roads has contributed five-sixths of the cost of construction of the bridge and has paid the full cost of the approach roadworks. The project cost a total of approximately $750,000●

BRIEFLY . . . ABOUT BRIDGES



NORTH NEAR KEMPSEY

The illustration at right is of the bridge now under construction at Smithtown to replace the vehicular ferry which at present operates across the Macleay River to Gladstone.

Details of this ten-span, 1,125 feet long, bridge were given in the June, 1971 issue of *Main Roads* (Volume 36, No. 4, Page 106). In August, 1971 a tender of $973,993 was accepted from John Holland (Constructions) Pty Ltd for the construction of the bridge and the contract time for completion is 78 weeks.

The artist's impression is by Sir Alexander Gibb and Partners, Australia, Consulting Engineers, who designed the bridge for the Department●

SOUTH NEAR EDEN

Transbridge Pty Ltd has undertaken the construction of a bridge over Whelan's Swamp on a 3-mile deviation of the Prince's Highway, approximately 7 miles south of Eden.

The eight-span steel and concrete bridge was designed by the Department and will have an overall length of 480 feet, with a width between kerbs of 28 feet. The contract time of one year provides for the bridge to be completed by October, 1972.

The bridge will be situated near the southern end of a new flood-free highway deviation which is being constructed by the Department between Boydtown Creek and Kiah.

The new work will eliminate a winding section of the existing Highway and, on completion, vastly improved travelling conditions will exist for motorists using the Prince's Highway between Eden and the Victorian border.●

WEST NEAR WARREN

Construction is in progress by Peter Verheul Pty Ltd of Sydney of a bridge over Sandy Creek on the Oxley Highway, south of Warren.

The contract price for the construction of the 17-span, 595 feet long, prestressed concrete bridge, is $203,145.50. Measuring 28 feet between kerbs, the new structure will carry two lanes of traffic and will replace a narrow timber bridge which was built in 1935.

This new bridge is included in the Department's plans for the reconstruction of part of the Oxley Highway between Nevertire and Warren, a section which is subject to flooding from the Macquarie River●

AT SYDNEY UNIVERSITY

A prestressed and reinforced concrete footbridge over Parramatta Road near the Sydney University Union Building is being built for the Department by Pearson Bridge (N.S.W.) Pty Ltd, at a cost of $86,938.

The bridge will replace the existing pedestrian crossing and traffic lights. A photograph of a model of the footbridge and details of its dimensions were given in the March, 1971 issue of *Main Roads* (Volume 36, No. 3, Page 68).

The cost of the bridge will be shared by the Department of Motor Transport, the Council of the City of Sydney, the Glebe Administration Board of the Church of England, the University of Sydney and this Department●

ON THE CENTRAL COAST

A decisive step in the development of the Central Coast tourist area was taken early in September, 1971 with the acceptance of a tender for the construction of a bridge over the entrance to Brisbane Water at The Rip.

The bridge, the first major cantilever construction in New South Wales, will be constructed for the Department by John Holland (Constructions) Pty Ltd at a cost of $2,173,640. The cost will be shared by the Department and the Gosford Shire Council.

Contract time for completion of the two-lane, 1,082 feet long, arch-shaped, prestressed concrete structure is 140 weeks.

Details of the bridge, together with an artist's impression and a locality sketch, were given in the March, 1971 issue of *Main Roads* (Volume 36, No. 3, Page 72)●

SYDNEY HARBOUR BRIDGE ACCOUNT

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH JUNE, 1971

Income	1970–71	1969–70
	$	$
Road tolls	4,518,708	4,549,136
Railway tolls	299,992	289,630
Omnibus tolls	26,151	26,851
Net rent from properties	170,700	139,347
Total Income	**5,015,551**	**5,004,964**

Expenditure	1970–71	1969–70
	$	$
Maintenance, lighting and cleaning bridge and approaches	564,345	576,936
Provision of traffic facilities	161,124	149,018
Cost of collecting road tolls	516,030	635,340
Improvements and alterations to toll gates and archways	32,143	70,046
Administrative expenses	81,346	71,223
Loan charges—State loans	1,229,660	1,194,310
Loan charges—Borrowings under section 42A of the Main Roads Act	923,576	1,023,335
Total Expenditure	**3,508,224**	**3,730,208**
Excess of income over expenditure transferred to Appropriation Account	1,507,327	1,284,756
	$5,015,551	**$5,004,964**

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 December, 1971.

Council	Road No.	Work or Service	Name of Successful Tenderer	Amount
				$
Armidale	S.H. 9	New England Highway. Alternative route through Armidale. Earthworks in connection with provision of grade separation with Madgwick Drive.	G. W. Chaplin & Co.	18,014.00
Barraba	M.R. 360	Construction of 3 reinforced concrete box cast-in-situ culverts for approaches to new bridge over Noogera Creek 29·8 miles northwest of Barraba.	Enpro Constructions Pty Ltd	37,762.56
Coolah	M.R. 206 M.R. 344	Bituminous surfacing from 10 to 13·5 miles west of Dunedoo. Bituminous surfacing from 5·8 to 10·3 miles north of Mendooran.	Associated Bitumen Spraying Pty Ltd.	18,608.41
Coolah	T.R. 77	Construction of 4-span reinforced and prestressed concrete bridge, 140 ft long, over Merrygoen Creek at Wongoni Crossing, 19·5 miles north of T.R. 55.	M. & E. Firth Civil Constructions (Tamworth) Pty Ltd.	56,361.00
Coolah	Various	Bituminous sealing at various locations.	Shorncliffe Pty Ltd	15,970.81
Coolah	Various	Supply and delivery of cover aggregate to various locations.	T. & E. Concrete and Gravel	10,835.80
Coonabara-bran	Various	Bituminous sealing at various locations	Associated Bitumen Spraying Pty Ltd	20,765.65
Crookwell	Various	Sealing and resealing of various roads at various locations.	Allen Bros (Asphalting Contractors) Pty Ltd	12,391.56
Goulburn	M.R. 248 & M.R. 256	Application of a two coat seal to M.R. 248 and M.R. 256 and reseal of part of M.R. 248.	Allen Bros (Asphalting Contractors) Pty Ltd	21,424.51
Hornsby	M.R. 548	Construction of 3-span reinforced concrete bridge, 105 ft long, over Colah Creek.	Taylor Civil Engineering Pty Ltd	45,921.00
Lachlan	Various	Loading and hauling up to 100,000 cu yd of sand, loam, road gravel, and/or rock to various locations.	Messrs Hughes and Fletcher.	34,000.00
Liverpool Plains	S.H. 11	Oxley Highway. Earthworks in connection with re-construction from 4·3 to 7·3 miles west of Gunnedah.	Hawkins Earthmoving	10,040.00
Mumbulla	M.R. 273	Construction of concrete bridge, 105 ft long, over Spring Creek and concrete bridge, 70 ft long, over Grosses Creek 3·4 and 3·5 miles south of Bega.	N. D. McIntosh	71,212.00
Tamarang	Developmental Work 3210	Construction of 5-span reinforced and prestressed concrete bridge, 200 ft long, and approaches over Quirindi Creek at Wallabadah.	L. G. Rixon	56,581.00
Timbrebongie	Various	Bituminous sealing and resealing of various roads at various locations.	Shorncliffe Pty Ltd	17,401.10
Ulmarra	M.R. 151	Construction of reinforced concrete bridge over Glenreagh Creek, 28·7 miles south of Grafton.	C.I.R. Construction	68,425.06
Urana	M.R. 385 Various	Reconstruction and bituminous surfacing 6·4 to 10·4 miles north of Urana. Bituminous sealing at various locations.	Canberra Asphalters Pty Ltd	22,378.75
Warren	M.R. 333	Bituminous surfacing from 88 to 93 miles north of Warren.	Shorncliffe Pty Ltd	10,603.43
Weddin	Various	Bituminous sealing and resealing of various roads at various locations.	Allen Bros (Asphalting Contractors) Pty Ltd	45,070.87

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 December, 1971.

Road No.	Work or Service	Name of Successful Tenderer	Amount
			$
Western Expressway (X4)	Municipality of Blacktown. Construction of 54 two ft diameter bored cast-in-place piles for bridge over Expressway at Chatsworth Road.	Frankipile Australia Pty Ltd	28,021.00
South Western Expressway (X5)	City of Campbelltown. Construction of 3-span prestressed concrete bridge, 364 ft long, and 38 ft 5 in wide, to carry St Andrews Road over Expressway, 4 miles north of Campbelltown. Construction of 3-cell concrete culvert, 120 ft long, to carry Bunbury Curran Creek through western approach embank-bridge. Contract includes demolition and removal of existing reinforced concrete bridge on St Andrews Road at Bunbury Curran Creek.	Citra Constructions Pty Ltd	322,998.19
South Western Expressway (X5) (and Main Road No. 177)	City of Campbelltown. Construction of 3 reinforced and prestressed concrete bridges, each 77 ft long and 54 ft wide, to carry Expressway and Campbelltown Road over Bunbury Curran Creek (excluding construction of cast-in-place piles).	Central Constructions Pty Ltd	113,506.00
Southern Expressway (X6)	City of Wollongong. Construction of Section 2—Darkes Forest Road to Bulli Pass. Earthworks, drainage and fencing from 33·7 to 40·8 miles and bridgeworks at 35·4 miles and 38·7 miles south of Sydney.	Citra Constructions Pty Ltd	2,934,533.08
State Highway No. 1	Prince's Highway. Shire of Imlay. Construction of 8-span steel and reinforced concrete bridge, 480 ft long, over Whelans Swamp, 7 miles south of Eden.	Transbridge Pty Ltd	194,847.00
State Highway No. 5	Great Western Highway. City of Sydney and Municipality of Leichhardt. Construction of reinforced concrete pedestrian overbridge, 112 ft long, at Sydney University.	Pearson Bridge (N.S.W.) Pty Ltd	86,938.47
State Highway No. 7	Mitchell Highway. Shire of Canobolas. Supply and delivery of 1,000 cu yd of upper course material and 2,000 cu yd of lower course material, from 23·1 to 26·7 miles west of Bathurst.	Canobolas Shire Council	18,100.00
State Highway No. 9	New England Highway. City of Greater Cessnock. Construction of 3-span reinforced concrete bridge, 105 ft long, over Anvil Creek at Branxton.	Western Bridge Constructions Pty Ltd	19,495.85
State Highway No. 10	Pacific Highway. Shire of Port Stephens. Supply and delivery of up to 11,000 tons of ⅜ in gauge asphaltic concrete 1·3 miles north of Hexham Bridge.	Bituminous Pavements Pty Ltd	13,882.00
State Highway No. 10	Pacific Highway. Shire of Wyong. Supply and delivery of up to 4,500 tons of surface course gravel to reconstruction between Wyong Railway Overbridge and North Road, Wyong.	Blue Metal and Gravel Pty Ltd	15,030.00
State Highways Nos 10 and 11	Shires of Hastings, Manning, Nambucca and Macleay. Supply heat and spray R90 bitumen at various locations.	Shorncliffe Pty Ltd	13,628.70
State Highway No. 16	Bruxner Highway. Shire of Kyogle. Construction of 20 cast-in-place foundation piles for bridge over Deep Creek at Piora, 14 miles west of Casino.	Frankipile Australia Pty Ltd	59,768.60
Main Road No. 108	City of Newcastle and Shire of Port Stephens. Supply and delivery of up to 5,000 tons of ⅜ in gauge asphaltic concrete to Stockton Bridge and approaches.	Bituminous Pavements Pty Ltd	69,250.00
Main Road No. 108	City of Newcastle and Shire of Port Stephens. Haulage of up to 18,000 tons of slag products from B.H.P. stockpile to eastern approaches of Stockton Bridge.	W. D. Smith Constructions Pty Ltd	11,340.00
Trunk Road No. 91	Shire of Bibbenluke. Manufacture, supply and protective treatment of steelwork for bridge over Dragon Swamp, at Cathcart.	Transfield Pty Ltd	55,160.37
Various	Supply and delivery of up to 7,000 tons of asphaltic concrete within Parramatta Division.	Emoleum Ltd	81,900.00
	Supply and delivery of up to 4,000 tons of asphaltic concrete within Parramatta Division.	Bituminous Pavements Pty Ltd	46,200.00
	Supply and delivery of up to 4,000 tons of asphaltic concrete within Parramatta Division.	Pioneer Asphalts (N.S.W.) Pty Ltd	46,030.00