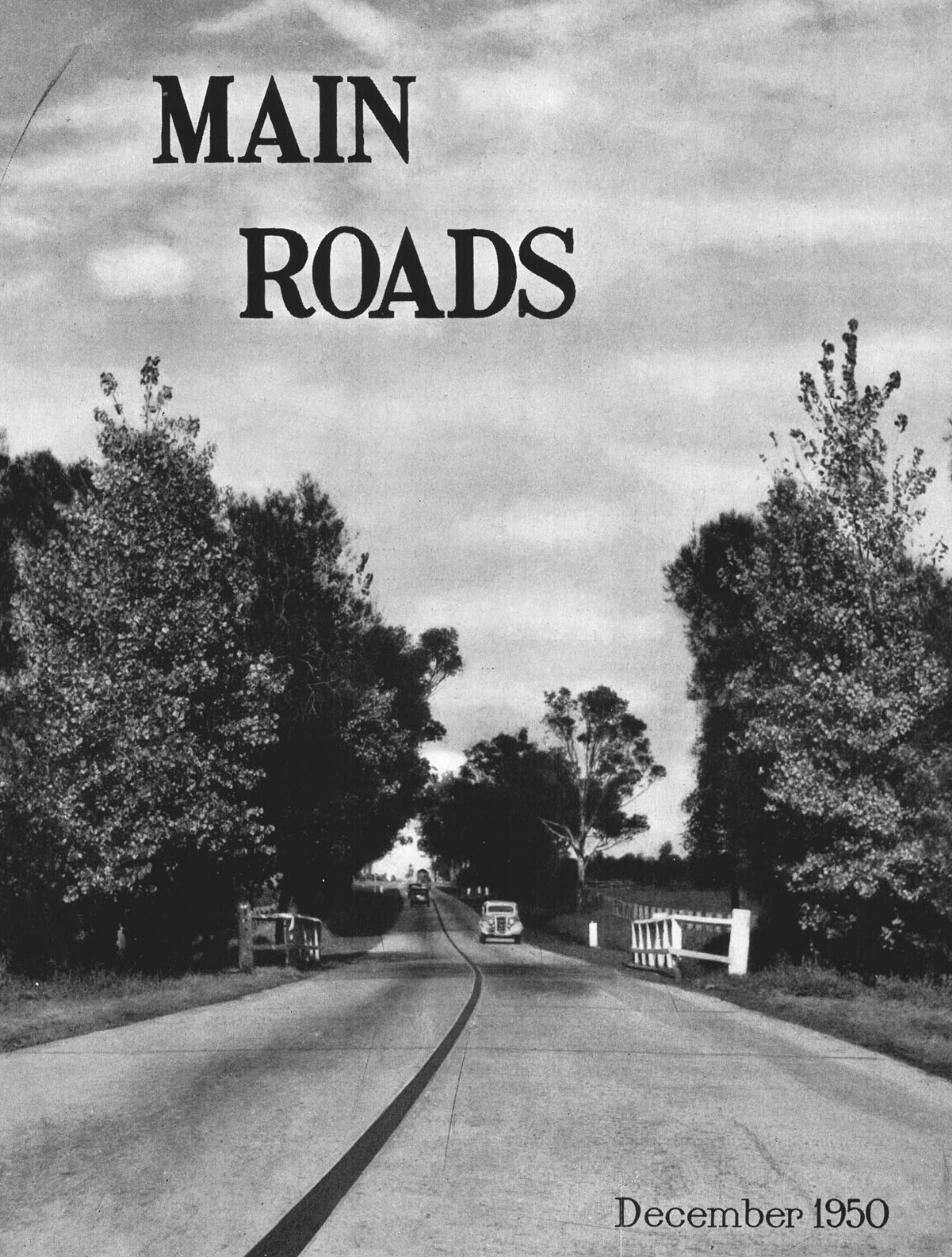
MAIN ROADS



December 1950

MAIN ROADS.

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Cover Page.

Poplars and Native Casuarinas on the Hume Highway 3 miles on the Sydney side of Narellan.

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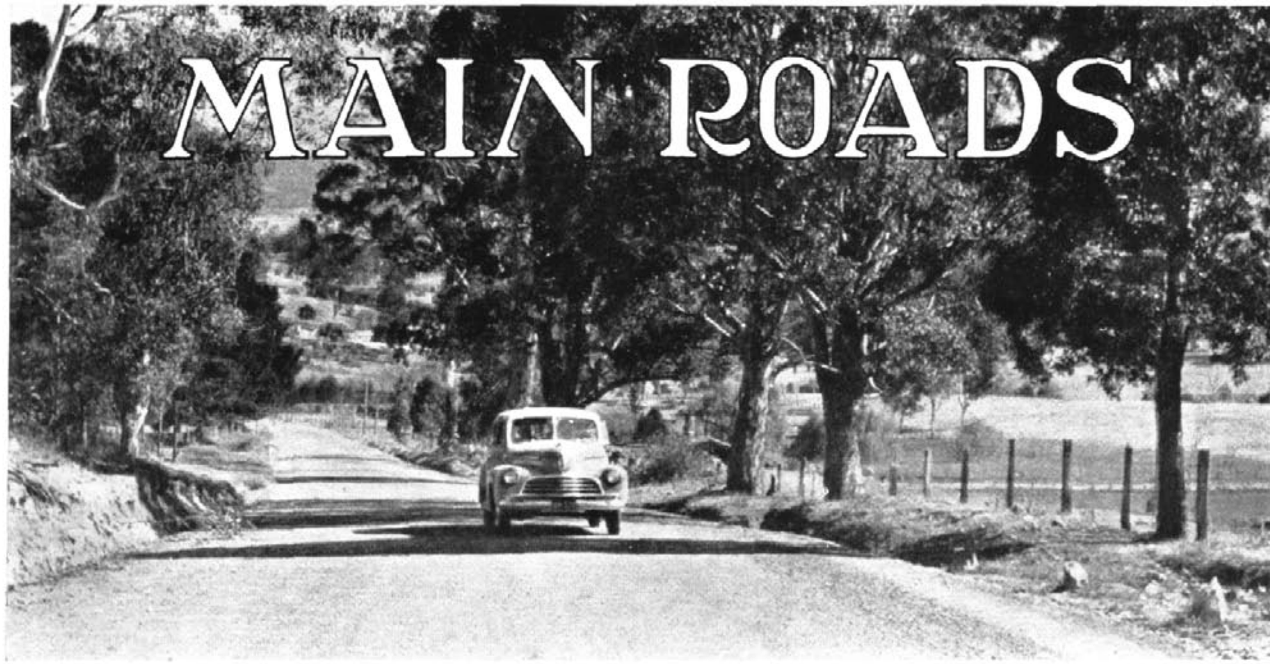

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Survey of State Highway Pavements.

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The more lightly constructed bitumen surfaced pavements on the State Highways have suffered severe damage during recent years, and a comprehensive survey of the situation is now being carried out in order to assess the nature, extent, priority, and cost of the work necessary to strengthen the roads to meet present day requirements. The map on page 35 shows the bitumen surfaced sections of the State Highways.

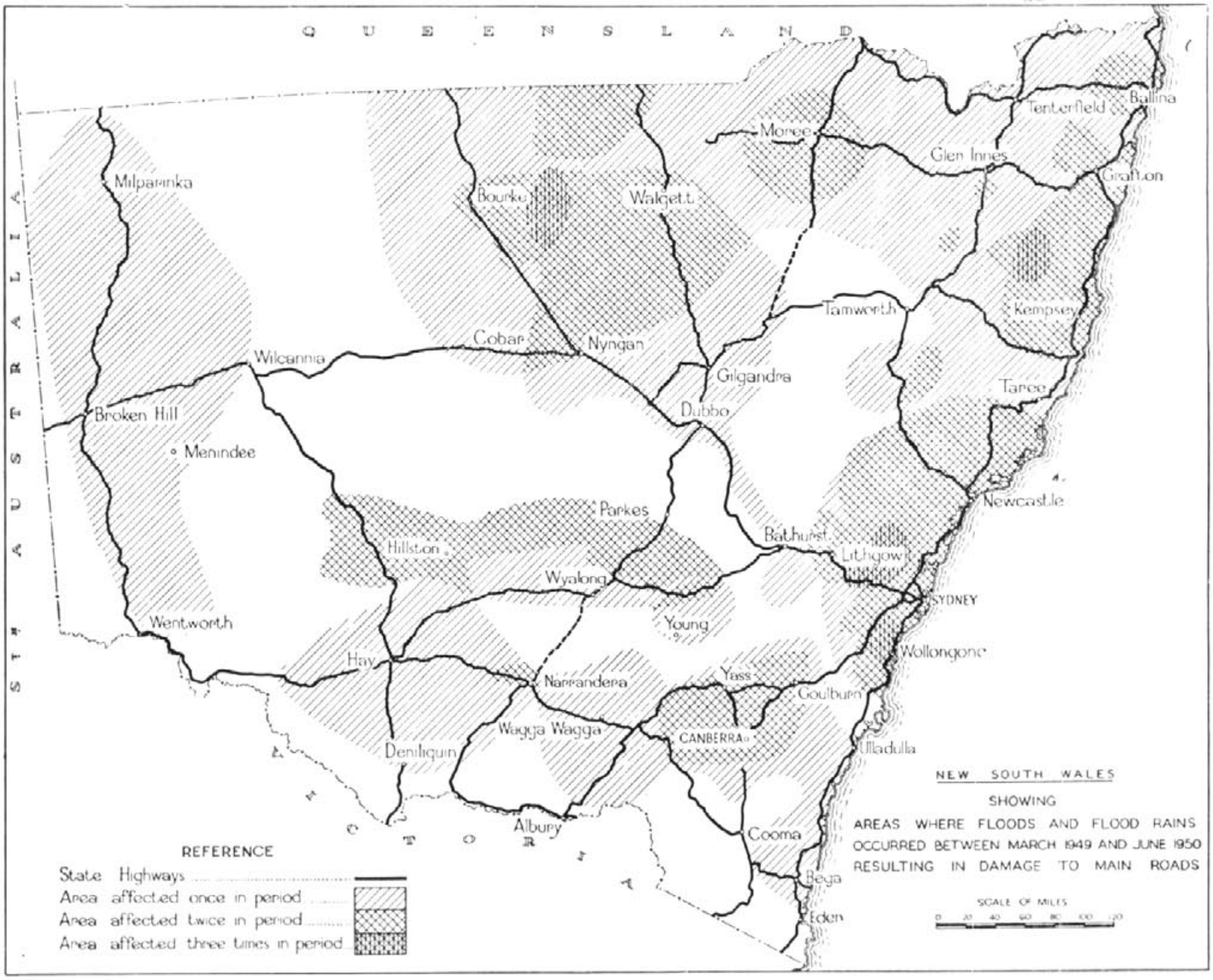
Most of the roads affected were originally constructed in gravel, and later provided with a surface treatment of bitumen or tar covered with stone or slag screenings. In the great majority of cases, these lightly constructed pavements have given fifteen to twenty years service, and proved entirely satisfactory for the traffic using them in pre-war years. Further, they successfully carried a substantial volume of heavy traffic during the war years, although damage was done in some cases.

After the war, business and production gradually increased in volume with the discharge of men from the armed forces, and the change-over from war-time to peace-time production. A new situation developed when the railways temporarily could not handle all the freight offering, and this was partly diverted to road haulage.

As a result, a very large increase occurred in heavily laden vehicles carrying both primary produce and manufactured or partly manufactured goods proceeding over considerable distances, and the bulk of this traffic has travelled, and continues to travel, on the principal State Highways, particularly on the Interstate routes.

As well as a sudden growth in the number of commercial vehicles travelling long distances, the nature of the vehicles also had changed in comparison with prewar conditions. It was just about the time the war broke out that large semi-trailer vehicles first appeared in significant numbers in New South Wales. Since that time, this type of vehicle has found widespread use, particularly for long distance freight haulage. Another type of vehicle new to this State which came into use in large numbers during the war years, and to some extent since, is the exceptionally large lorry of a type, which, when fully loaded, is likely to impose wheel loads and total loads much greater than those normally experienced in the past. While this type of vehicle appears to find its greatest use in relatively short hauls of bulk materials, such as broken stone and coal, it is also used on long hauls, frequently with a trailer.

Under the new traffic conditions, with heavier vehicles than in the past in large numbers, long distance roads constructed to meet pre-war conditions inevitably suffered considerable distress, and it became



apparent that considerable expenditure would be required to strengthen the roads if this traffic was to continue for long. While this position was serious enough, it was rendered more acute by two further factors—namely overloading of vehicles, and years of exceptional rainfall in 1949 and 1950.

The loaded weights of vehicles on main roads are controlled through Ordinance 30C under the Local Government Act. The original Ordinance was drawn up many years ago before modern types of long distance road transport vehicles had been introduced, and many of these were not adequately provided for in the Ordinance. As a result, a measure of overloading occurred which was reflected in road damage. The Ordinance has now been brought up to date, and is being actively policed.

The exceptional rains during 1949 and 1950, especially the latter, have in many localities considerably reduced the supporting power of the road foundation. (See map of areas affected by flood and flood rains.) Some localities have become so charged with water that the ground has been practically waterlogged. The constant hammering of heavy traffic in such circumstances, day and night and in wet weather and fine, has increased the magnitude and extent of the destruction of road pavements. Subsequent light rains, falling on ground charged with moisture, have had further adverse effects out of proportion to their magnitude.

Floods that occurred in 1949 and 1950 caused temporary suspension of railway services in some cases. Where this occurred traffic was largely diverted to the roads and placed a severe load on pavements at a time when they were particularly susceptible to damage on account of the softening of foundations by protracted rains. Stoppages or reduction of railway services in this or an adjoining State due to causes other than floods, have also at times thrown an extra load on the State Highways.

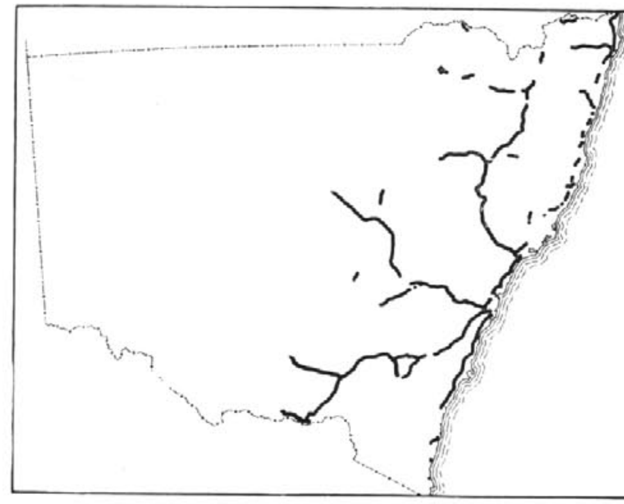
The road first adversely affected by heavy truck loading was the Hume Highway, between Berrima and Tarcutta, where the deteriorating condition became apparent in 1946-47. Extensive heavy strengthening work was at once put in hand, and has been continued year by year subsequently, but it has not proved possible with available resources to restore, as yet, the road to its normal condition.

Subsequent to the Hume Highway, the Pacific Highway between the Hawkesbury River and Newcastle, much of the New England Highway, and that part of the Great Western Highway beyond the Blue Mountains showed distress, and soon had many sections as seriously damaged as the Hume Highway. Later other lengths of State Highways suffered.

It is significant that those sections of the State Highways which before the war carried the heaviest traffic, and which had therefore been provided with substantial bituminous macadam pavements, have hitherto withstood the battering of the heavy long distance lorry traffic. Examples of this are the Great Western Highway from Sydney to Mt. Victoria; the Hume Highway from Sydney to Mittagong; and the Prince's Highway from Sydney to Tomerong.

From the survey of State Highways now in progress, it will be possible to determine the needs of the situation that has so rapidly developed. It is already apparent, however, that much stronger road surfaces are essential under present conditions on those parts of the principal State Highways which were previously constructed of light type. Even if it were possible for much of the present heavy transport on the State Highways to be diverted to rail, it appears likely that heavy long distance transport by road will exist in future to a degree greater than before the war, in view of the continued development of motor vehicles and having regard to the trend in overseas countries.

Whether long distance heavy road haulage continues indefinitely or otherwise, and on a large or small scale, a considerable expenditure will be involved in the strengthening and re-establishment of the country State Highways. Considerable additional plant, material and labour will be required, and the work will necessarily need to spread over several years. Until this work is completed, lengths of the more lightly constructed bitumen surfaced pavements on State Highways may have temporarily to revert to gravel surfaces. Thin bituminous mats cannot be satisfactorily maintained on gravel pavements which are insufficiently strong to carry the loadings imposed on them, but the pavements can be reasonably maintained as gravel surfaces while being strengthened by the addition of more gravel until they are strong enough to again carry a new bituminous mat without distortion.



Map of New South Wales showing bitumen surfaced sections of the State Highways.

The old pavements satisfactorily met pre-war traffic needs, and gave many years of good service, including the war period. Strengthened by increasing their thickness, with material selected and controlled to meet Department's standard requirements, and provided with a new bitumen surface, they can continue to give service under the new conditions of heavier loading. In the meanwhile Councils and the Department are continuing to maintain the Highways and to strengthen those sections most in need of attention, to the maximum extent that resources permit.

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for Period 1st July, 1950, to 30th September, 1950.

Income.	£
Road Tolls	119,503
Contributions—	
Railway Passengers	33,730
Tramway Passengers	2,525
Omnibus Passengers	2,220
Rent from Properties	3,390
Miscellaneous	59
	£161,427

Expenditure.	£	£
Cost of collecting road tolls		8,973
Maintenance and Minor Improvements		14,877
Alterations to Archways		244
Construction of new Toll Barrier and Office		773
Administrative Expenses		650
Loan Charges—		
Interest	58,250	
Exchange	6,150	
Sinking Fund	16,875	
Management Expenses	500	
		81,775
Miscellaneous		280
		£107,572

Bridge Building in New South Wales

PART 1. The Early Stone Bridges

"History—social, economic, and military—clusters more thickly about bridges than about towns and citadels."
—John Buchan (Lord Tweedsmuir)
Introduction to British Bridges (1933).

The *Sydney Gazette* for the 26th February, 1804, after urging the able-bodied among its readers to lend a hand in the building of a new stone bridge over the Tank Stream, went on to say:—"If, on the other hand, the work should be left to be finished by the labour of a few feeble women, the length of time likely to intervene will be attended with a portion of inconvenience that must continue to be severely felt by the owners of carriages and horses." The *Gazette's* astute appeal to the self-interest of their readers had its effect; within a month the bridge was complete.

This and other unusual sidelights—the payment of an early bridge contractor in spirits instead of coin, and the stealing of the coins and inscription plate from Lansdowne Bridge—make the story of bridge building in New South Wales interesting and readable. To see the story in proper perspective, however, we should first take a quick glance at the older story of bridge building, a story which began in Europe and Asia many centuries before the landing at Sydney Cove in 1788.

Man built bridges even before he learned to write; but for thousands of years, his methods were for the most part unscientific, being guided only by experiment and precedent. Probably his first productions in this direction were crude imitations of nature; simple beams on the model of storm-felled trees bridging streams and chasms; suspension bridges of vines and creepers; and, where the flow of water was slow and shallow, mere stepping-stones.

Before the invention of tools there were no means of fashioning bridges; in fact, at the time, there was little need for them; for it was not until the rise of civilisations and the introduction of transport that bridges other than those gratuitously provided by nature came to be urgent practical necessities. This began the age of bridge building as an art, the spirit of which was perhaps happily voiced by Palladio, the Renaissance architect, who said:—"Bridges ought to have the self-same qualifications we judge necessary in all other buildings, which are that they should be commodious, beautiful and lasting."

It is only during the last 150 years that bridge building has become a science. This is not to say that earlier builders had no scientific knowledge. As early as 1638 Galileo formulated the laws governing the transverse strength of rectangular beams, but these and other scientific discoveries were not collected into a systematised body of scientific bridge building knowledge much before the beginning of the nineteenth century.

Ancient Bridges.—For many centuries the chief materials in bridge construction were timber and stone; one of the earliest bridges about which we have reliable information—that built over the Euphrates at Babylon in 606 B.C.—combined both materials, the piers being of stone and the beams of timber.

Undoubtedly the greatest bridge builders of ancient times were the Romans. The Pons Sublicius—celebrated by Macaulay's account of its heroic (and probably legendary) defence by Horatius—was built about 620 B.C., and rested on piles. Equally famous was Julius Caesar's pile trestle built over the Rhine in ten days in 55 B.C., which became a widely imitated model.

Like their modern successors, armies of the ancient world made extensive use of pontoon bridges. Herodotus, describing the pontoon built over the Hellespont by the Persian general, Xerxes, for the invasion of Greece in 480 B.C., records that it consisted of a double line of boats, each line containing more than 300. Homer, five centuries before, had written of similar types.

Although no date can be assigned for the erection of the first suspension bridge, it is fairly certain that these had been built in China long before the dawn of the Christian era. But it was not until the invention in more recent times of stiffening trusses of wrought-iron and steel that there was much development of this type.

The corbeled arch (more strictly termed a form of cantilever) was known to the Egyptians five or six thousand years ago. An example of true cantilever construction of ancient date is the "Shogun's Bridge" in the sacred city of Nikko, Japan, built in the sixth century, A.D.

New Discoveries.—Passing over the centuries to the Renaissance, we find that the provision of suitable tools, training in their use and the development of the truss as a structural principle were the most significant contributions to bridge building knowledge. While rudimentary forms of the truss had been devised in earlier times, it remained for the Renaissance builder to work out systems of truss design which were practical and structurally sound. The importance of these discoveries was that they made possible the spanning of gaps much beyond the range of single timber beams.

So far, progress in the art of bridge building had been slow, and it continued to be slow until a greater knowledge was obtained of physics, chemistry and mathematics, and until the manufacture of iron, and later steel, became practicable on a large scale.

Assisted by her world leadership in industrial development in the eighteenth and nineteenth centuries, England was among the first to apply the lessons of the new discoveries. The first cast-iron bridge was built over the Severn River at Coalbrookdale in 1776, with a central arched span of 100 feet.

Later in the same year a much larger iron bridge over the Wear near Sunderland was completed. The bridge, designed by the political reformer, Thomas Paine, was described by Robert Stephenson as one of the boldest examples of arch construction in existence. In 1790 Paine had planned cast-iron arches of framed open panels in the form of voussoirs; next, he tested the theory by making an experimental arch of 88½ feet span, which was exhibited with great success at Paddington. When the ferry at Wearmouth was to be discontinued in 1790, it was decided that a bridge of castiron should be built; the ideas of Paine were adopted in the design and part of the ironwork of his experimental arch was used in its construction. The span of this bridge, which was in one segmental arch, was 236 feet.

However, cast-iron had defects as a bridging material, and several failures occurred, mainly due to its extreme variability of composition. Experiments in the early part of the nineteenth century proved the superiority of wrought-iron which thereupon became of major importance. A celebrated example of a wrought-iron bridge is the suspension bridge built (1819-1826) across Menai Straits, Wales, by Thomas Telford.

The spread of railway systems brought about the need for bigger and stronger bridges. Steel of mild and medium quality which had been developed and found more suitable for the purpose gradually replaced wrought-iron. In the construction of the massive Forth Bridge in Scotland in 1890, steel only was used. At this time, also, further developments in bridge construction were becoming possible by the use of reinforced concrete.

Since the beginning of this century the practcial application of knowledge won only after centuries of painstaking research and experiment, has resulted in the construction of still more wonderful examples of bridge engineering, such as the Sydney Harbour Bridge.

Early Bridges in New South Wales.—When the first settlement occurred in Australia in 1788, bridge building in Europe was still mainly on the basis of stone or timber construction, and there was no alternative but to use these same natural materials in the new land.

The first bridge in Australia was built of logs over the Tank Stream in 1788, near the present site of Bridge-street, Sydney, which was named after it. This was the predecessor of the stone bridge over the Tank Stream already mentioned.

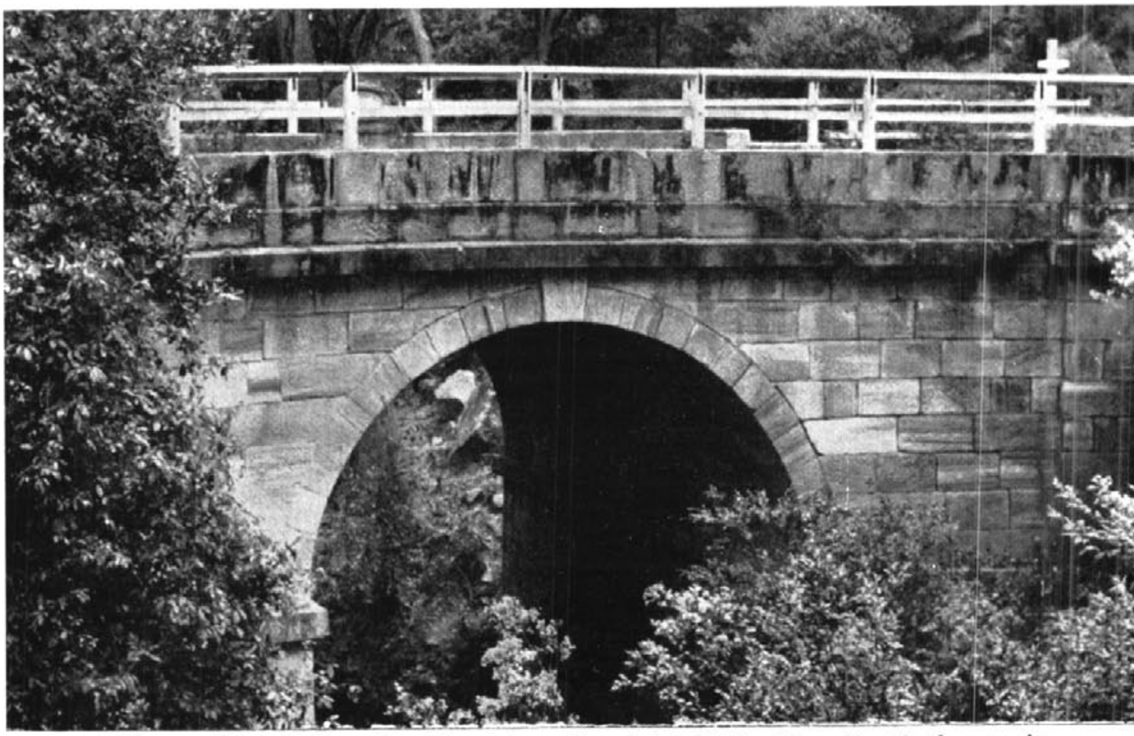
The stone bridge, erected in 1804, had an arch spanning 24 feet. Three years later it collapsed, and after the passage of a further five years, was re-erected in improved form. The contractor who undertook its re-erection received payment of 660 gallons of spirits, this being an alternative currency in the Colony at the time. Upon the bridge's completion his payment was supplemented by a bonus of 15 gallons for good work!

The historic Tank Stream, although still existing, can no longer be seen by users of Bridge-street, for it has long since been covered over.

Meanwhile a pontoon bridge had been built over South Creek at Windsor in 1802. The builder, Andrew Thompson, was given official approval to collect tolls for the following fourteen years, provided he kept the bridge in repair. This arrangement did not run its full term, however, for within 12 years the bridge had been replaced by a new one, built 24 feet above water level, and at that time the largest in the Colony. Since then there have been several bridges successively built at or near this site.

Before 1832 New South Wales was without scientifically designed bridges. In that year, however, a new chapter in the Colony's bridge-building history was begun with the discovery by Surveyor-General Mitchell of David Lennox, lately arrived from England. Lennox brought with him a fund of technical experience gained while in the employ of the famous bridge engineer, Telford, on the construction of the famous Menai Suspension Bridge and on the Gloucester Bridge over the Severn; but at the time of his meeting with Mitchell he was cutting the coping stone of the wall in front of the Legislative Council Chambers. During the conversation which ensued Mitchell

David Lennox.



Bridge on Mitchell Pass, Blue Mountains. Completed 1833. The oldest bridge on the Australian mainland.

decided that Lennox was the man to supervise the extensive programme of bridgeworks necessary to meet the requirements of the expanding Colony. On Mitchell's recommendation, therefore, he was appointed Sub-Inspector of Roads on 1st October, 1832, at "£120 per annum but without any forage for a horse", and later on 26th June, 1833, he was appointed Superintendent of Bridges.

From 1813 onwards, when the Blue Mountains were crossed for the first time, the achievements of explorers had revealed the natural wealth of the country that lay beyond the limits of early settlement. Adventurous spirits among the colonists were pushing outwards, and by the 1830's the Colony's economic and geographic development required improved communications. At this time Mitchell was undertaking a survey of the Colony's main roads and planning improvements and extensions which would require the assistance of a competent bridge engineer. He therefore set Lennox to work at once on the construction of a series of stone bridges, some of which still stand as monuments to the skill and ingenuity of their designer.

Bridge on Mitchell Pass.—The first of these was begun late in 1832. Earlier that year Mitchell had begun to construct a deviation in the Main Western Road, the object being to avoid the ascent of Lapstone Hill. The work was well advanced, but there remained a rather formidable gully to bridge. Within six weeks of his appointment as Superintendent of Bridges, Lennox had begun to bridge the gully with a stone arch, the labour being supplied by a gang of twenty men, who quarried the stone five hundred yards away. In July of the following year (1833) Lennox reported the bridge finished; and shortly afterwards Mitchell described it as "a somewhat experimental work, which Mr. Lennox executed extremely well." By direction of the Governor the bridge was named "Lennox Bridge", the words "David Lennox" were inscribed on the keystone of the upstream side of the bridge and on the opposite side "A.D. 1833."

It has survived the hazards of 116 years and is to-day the oldest bridge on the Australian mainland. Until the construction of a new deviation in 1926, it carried all the traffic from Sydney to the west. The single arch spans 20 feet; the roadway is 30 feet wide at the crown of the arch, and the same height above the bed of the gully. Shortly after the bridge's completion, the Colonial Architect, with whom Lennox subsequently had several differences, reported that it was showing signs of instability, and advised remedial measures. Lennox, after inspection, reported that though a small crack had appeared in one of the walls, it was of no serious consequence; but that if the Colonial Architect's recommendations were followed, the effects might prove disastrous. Lennox's advice was taken; and time has vindicated his judgment.

Three Legs o'Man Creek Bridge.—Within six months of completing the bridge at Lapstone, Lennox reported that he had laid out a site for a bridge over the Medway Rivulet on what is now known as the Hume Highway (then the Main Southern Road) three miles south of Berrima. Part of this watercourse is now known as "Three Legs o'Man Creek," and this has given the name to Lennox's bridge, a wooden structure supported by three masonry piers 20 feet apart. The "Three Legs o'Man" Bridge was destroyed by flood about 1860 and later replaced.

Lansdowne Bridge.—Lennox's next bridge was more pretentious than the two already described; its construction was spoken of at the time as "a work of more than ordinary importance", and Mitchell made a special request for the services of Lennox. The site of the new bridge was Prospect Creek on the Hume Highway about 16 miles from Sydney. Construction here presented serious difficulties to contemporary bridge builders, as the creek was subject to heavy floods and had a flat bedrock bottom at the point of crossing. Previous bridges at the site had been swept away, and the then existing bridge was in a ruinous condition.

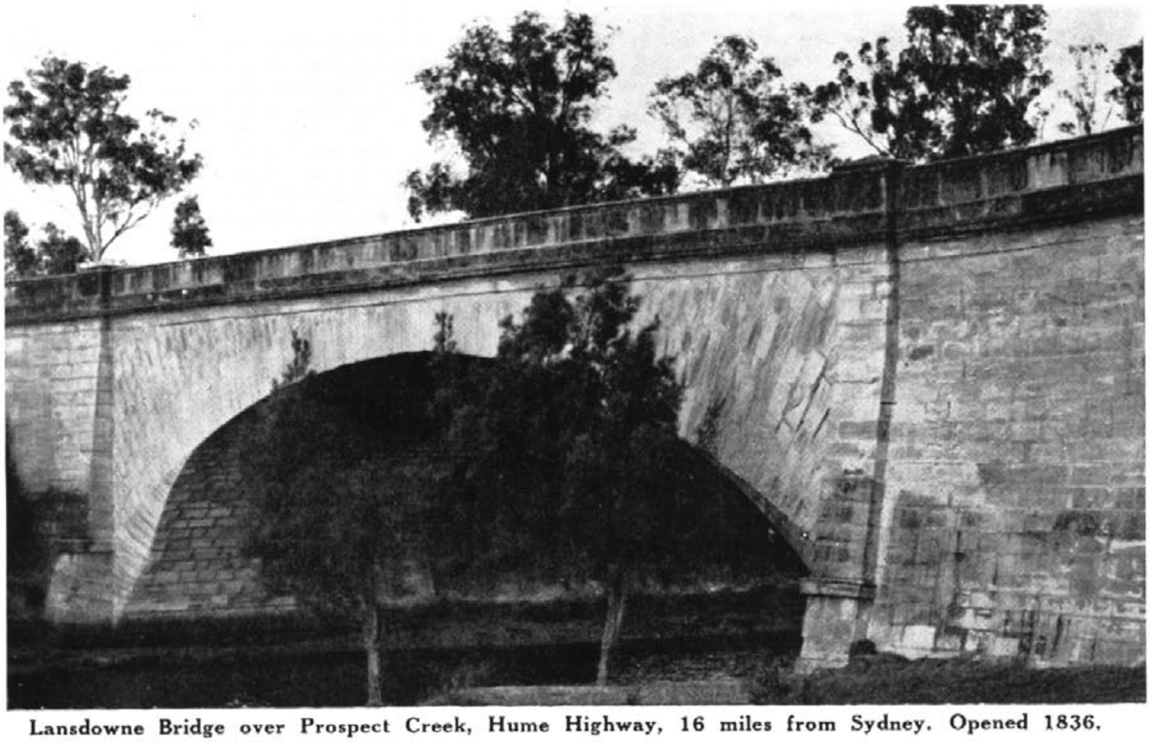
Lennox's design for a single span stone arch, a copy of the one he had worked on over the Severn at Gloucester, was approved by the Governor in preference to one proposed by the Colonial Architect. Before commencing the work Lennox asked Mitchell's permission to retain the services of several prisoners who had served him well at Lapstone, recommending at the same time that the balance of their sentences in irons should be remitted. Mitchell forwarded Lennox's recommendation to the Governor, who immediately remitted the sentences in respect of four of the men, and promised to review the cases of two others after a further period of six months' good behaviour.

Stone was quarried some seven miles downstream on the right bank of George's River, whence it was carried to the site in punts. Since this involved night work, Lennox obtained extra rations for his men. On one occasion a number of prisoners at the quarry, taking advantage of Lennox's temporary absence, plundered a private still and became drunk. They threatened to kill the overseer and burn the camp; and eventually police assistance had to be obtained from Liverpool. This was one of the few occasions on which Lennox had trouble with his men.

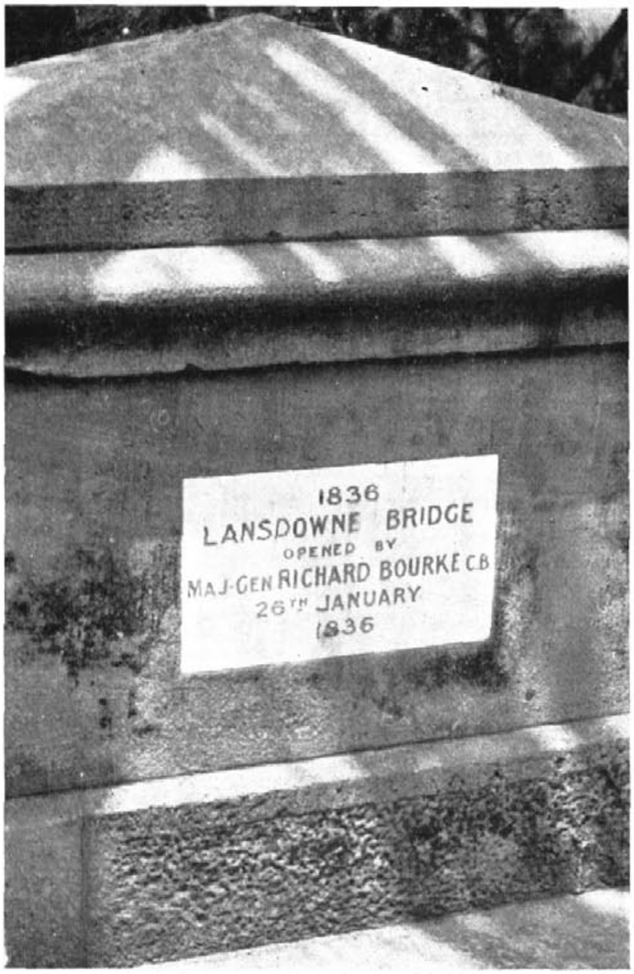
On New Year's Day, 1834, the foundation stone for the new bridge was ceremonially laid by the Governor, Sir Richard Bourke, who directed that the bridge should be named after the President of His Majesty's Council, Lord Lansdowne. Some days after the ceremony it was found that the coins and inscription plate enclosed in the foundation stone were missing. Mitchell thereupon gave instructions for a new plate to be prepared and substituted; but this proved unnecessary as the original one was meanwhile recovered.

Work on the bridge was slow mainly because of a shortage of lime and skilled labour. Lennox himself, although too conscientious to allow his personal feelings to affect his work, was at this time dissatisfied with his poor salary. Eventually he protested to Mitchell, who prevailed on the Governor to increase Lennox's salary from £120 per annum without allowance to £250 per annum with 2s. 6d. per day allowance.

Towards the end of 1835 construction was sufficiently advanced for the Governor to decide that the bridge should be opened on 26th January of the following year, the 48th anniversary of the Colony's foundation. The day of the ceremony was fine and clear, and present as spectators was "a gallant show of well-dressed dames and gentlemen." After the ceremony a small procession passed over the bridge; and a "cold collation" was provided for the official party in a nearby marquee. The celebrations reached a climax that evening with a vice-regal ball at Government House, Parramatta. The only disagreeable note in the otherwise festive day was the Governor's annoyance at the unexpected absence of Mitchell. This did not prevent his asking Lennox if there were any of his prisoner-labourers whose conduct warranted some reward.



Lansdowne Bridge over Prospect Creek, Hume Highway, 16 miles from Sydney. Opened 1836.



Inscription on Lansdowne Bridge.

Lennox himself was honoured by a bonus of £200 voted him by the Legislative Council on the Governor's recommendation.

In the light of present-day costs and money values it is interesting to note that the Lansdowne Bridge was erected for £1,000. This figure, low even for those days, was of course greatly affected by the cheapness of convict labour. The Governor was probably not exaggerating when he remarked in a letter to one of his friends: "Such a structure in England would have cost £7,000."

The Lansdowne Bridge, with its 110 ft. arch and 22 ft. wide roadway, still carries traffic on one of the principal Highways of the State, although designs are being prepared at present for a second bridge to be built nearby to relieve the traffic congestion.

Berrima Bridge.—For his new stone bridge over the Wingecarribee River at Berrima on the Hume Highway, Lennox in 1833 proposed a replica on a reduced scale of the Lansdowne Bridge, the construction of which had not then begun. This proposal was approved, and operations were soon under way, although for some time the progress of the work was delayed by a labour shortage. It is interesting to note that Lennox's overseer at Berrima was a prisoner, and that in commending his capacity and worth Lennox wrote: "I do not think there is another man in the Colony that would have got on so well with the same means." The Berrima bridge was opened in June, 1836.

In a heavy flood in 1858 the 50 ft. long arch was seriously damaged, and extensive repairs were necessary. Two years later the bridge was swept away by a severe flood. The existing bridge at this site was erected in 1897 by the Public Works Department and is of timber trusses resting on masonry piers.

Black Bob's Creek Bridge.—Shortly after the Governor laid the foundation stone of the Lansdowne Bridge, Lennox selected the site for a stone bridge on the Hume Highway at Crawford's (or Black Bob's) Creek, about nine miles south of Berrima. The bridge was set out in 1834 by Lennox as a single span (30 ft.) timber beam bridge—a copy of one of the Gloucester-Berkley Canal Bridges. Mitchell reported that the new bridge would be "a still more striking specimen than that of Midway of the improving character of these constructions, and the advantage of having a practical man like Lennox to superintend the work." Lennox's original design was subsequently amended in several important particulars.

As with his other works at this time, operations at Crawford's Creek were impeded by a labour shortage. Lennox was under the further disadvantage of being situated at some distance from the site. As late as November, 1836, the bridge was still unfinished, although Mitchell recorded in his journal at the time that it was nearly so. The completed bridge had a 30 ft. span. In 1896 it was replaced by a masonry arch erected by the Department of Public Works.

Duck Creek Bridge.—Early in 1834 the timber bridge which had until then spanned Duck Creek at its intersection with the Parramatta Road, 13 miles from Sydney, was destroyed by a bush fire which began on John Macarthur's nearby property at Elizabeth Farm. Lennox was directed to supply estimates of the cost of a substantial stone bridge to replace it, while in the meantime a temporary bridge was built. Because of the shortage of building materials in the area, and the need for deep-sinking the foundations of the abutments, Lennox's estimate was rather high. To the Governor's alternative suggestion for a brick bridge on stone foundations, Lennox replied that the Colony did not possess brick of sufficient hardness, and thereupon proposed as a cheaper alternative a wooden bridge on brick or stone piers providing a waterway of 50 feet and roadway of 30 feet. At this stage the Colonial Architect submitted a design which Lennox claimed he could not understand. Lennox suggested that in the event of its being accepted, the Colonial Architect himself should be asked to undertake the construction. The Governor himself favoured the design until Lennox pointed out it was not suitable for a stream with low banks. Finally Lennox's design for a wooden bridge on stone piers was accepted.

This preliminary delay in beginning the work seems to have continued into the actual building operations, because three years after Lennox's original estimate of costs had been submitted the bridge was still incomplete. Meanwhile, for reasons now unknown, the approved design for a wooden bridge had been departed from; and the bridge as eventually built was a semi-circular brick arch of 30 ft. span on stone foundations. It is not clear whether or not Lennox supervised the work. However, contrary to his declared opinion, time has proved the brickwork to be durable.

In 1937 the old bridge was widened under the direction of the Department of Main Roads, by the addition of a 30 ft. span concrete arch to the existing brick one.

Parramatta River Bridge.—In 1833 Lennox submitted plans for a stone bridge to replace the existing timber bridge in what is now known as Church Street, Parramatta. Two years later, when the Assistant Surveyor at Parramatta reported unfavourably on the state of the old bridge, the Governor directed that construction of the new bridge begin at once. The Governor suggested to Lennox a rather ornate design which Lennox considered most unsuitable, recommending instead a simple stone arch of 90 feet. Captain Perry, acting in the absence of Mitchell, recommended a reduced span—a proposal favoured by the Governor, but vigorously opposed by Lennox, who considered it dangerous in view of the river's tendency to flooding. On returning to his headquarters, Mitchell unsuccessfully urged the acceptance of Lennox's original plan; and by 19th April, 1836, when the "Sydney Gazette" recorded that "the side railings (of the old bridge) gave way and several beasts were precipitated on to the rocks below", there was still no decision about the new bridge.

Although no approval can be traced, construction began towards the end of 1836 and was probably completed during 1839. It is fairly certain that the design of the new bridge was as originally proposed by Lennox.

For sixty-three years after its completion the bridge remained intact without the slightest alteration. Its history is told briefly in the bronze tablet which was affixed to the bridge some years ago and which reads:

"Erected in 1836-39 by David Lennox, then Superintendent of Bridges to the Colony of New South Wales, the stone arch forming part of this structure is one of the oldest remaining bridges in the Commonwealth. It replaced a timber bridge built about 1802 in substitution of a still earlier timber structure which had been destroyed by flood in 1795."

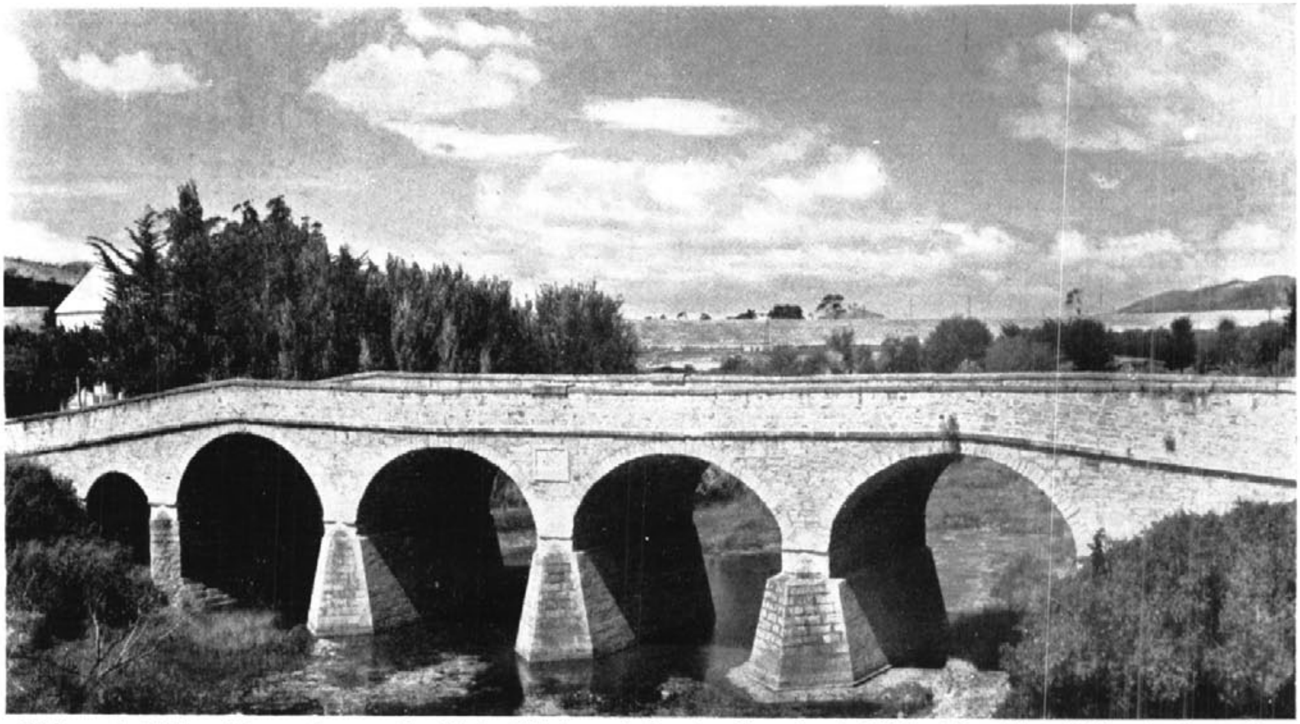
During 1901-1902 a width of 10 feet of the stone arch was strengthened internally for the purpose of carrying the Parramatta-Castle Hill tramway. The parapet on the western side was removed in 1912 and a cantilever footway 5 feet 3 inches wide added.

During 1934-35 the bridge was widened under the direction of the Department of Main Roads. This work comprised the removal of the western footway and erection of a new reinforced concrete structure faced with stone alongside the old, and the renewal of the eastern parapet in reinforced concrete.

The bridge was given the name "Lennox Bridge" by the Parramatta Municipal Council in 1867, and was the last bridge built by Lennox in New South Wales.

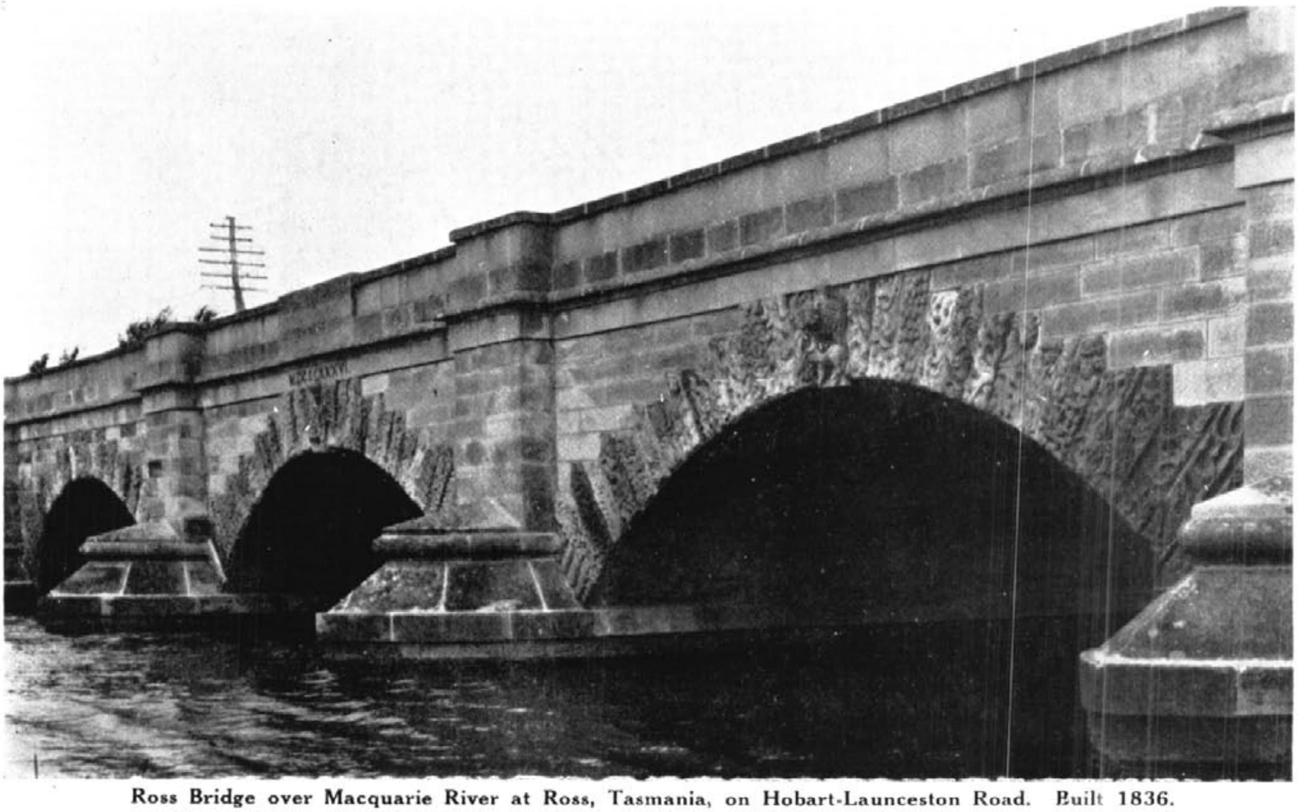
Lennox at Port Phillip.—In October, 1844, Lennox was transferred to Port Phillip as Superintendent of

Lennox Bridge over Parramatta River, Parramatta, State Highway 13. Built 1836-39. Widened by Department of Main Roads 1934-35.

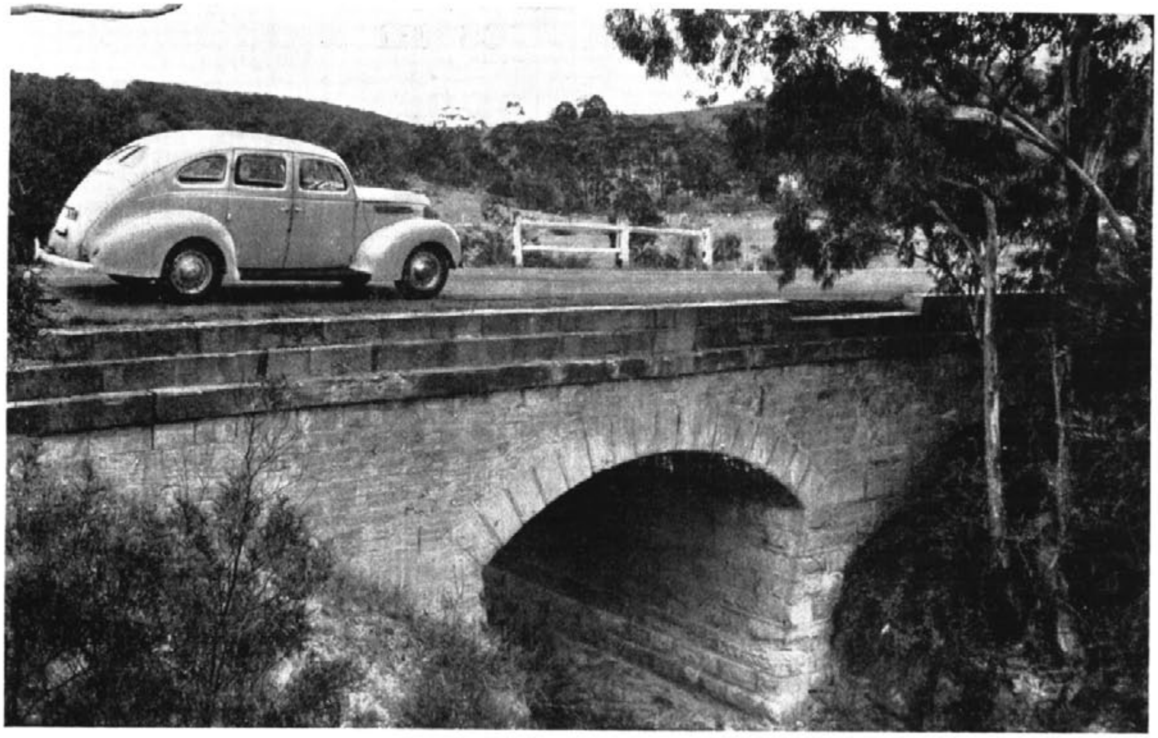


Richmond Bridge, Tasmania, on the Hobart-Richmond Road. Completed 1825. The oldest bridge in Australia.

Bridges. There he was responsible in the first place for the construction of a stone arch bridge of 150 feet span over the Yarra, known as Prince's Bridge, completed in 1850. This was the largest of the bridges built by Lennox. For nine years (1844-53) Lennox had charge of all roads, bridges, wharves and ferries, built 53 bridges and acted as Advisory Engineer to various Government Departments at Port Phillip. In 1853, he resigned from the public service and returned to Sydney.



Ross Bridge over Macquarie River at Ross, Tasmania, on Hobart-Launceston Road. Built 1836.



Arch Culvert at Towrang Creek, north of Goulburn. Built 1839.

Just as the arrival of Lennox had begun a fresh chapter in New South Wales' bridge-building history, so his departure ended it. The Colony was later to possess builders who were perhaps his equal in technical skill, but none ever attained his local celebrity; for he was a pioneer, with the advantages and disadvantages that that situation brings. He was faced with novel problems; but the difficulties of solving them gave him opportunities for fame denied his successors.

Early Bridges in Tasmania.—The Colony of Tasmania was also building bridges at this time; eight years before the completion of Lennox's bridge at Lapstone—that is, in 1825—a stone arch bridge 210 feet long, with four large and two small spans, had been built to the design of Major Bell of the 48th Regiment. This was the Richmond Bridge; the first scientifically constructed stone arch in Australia. The stone was dragged from a quarry half a mile away in carts drawn by small gangs of convicts.

Another pioneer bridge-building achievement in Tasmania was Captain Turner's attractive stone arch built in 1836 over the Macquarie River at Ross, on the Hobart-Launceston road. It is 126 feet long and 26 feet wide between kerbs.

Both bridges were built with convict labour. The photographs on page 42 show their excellent state of preservation to-day.

Culverts.—The story of early bridges in New South Wales is not complete without some reference to the stone culverts, especially those still existing on the original Main Southern Road between Berrima and Goulburn. The keystone of the arch culvert at Towrang Creek north of Goulburn bears the date 1839.

(The later history of bridge building in New South Wales will be continued in subsequent issues of the Journal.)

ACKNOWLEDGMENTS.

Material for this article has been taken from the following publications:—

Various Volumes of the Journal of the Royal Australian Historical Society, especially Vol. VI, Part V: "David Lennox, the Bridge Builder and His Work";

Road Engineering and its Development in Australia (H. H. Newell, C.B.E. M.Inst.C.E., M.I.E. Aust.);

Early Days of Windsor (Jas. Steele);

Bridge Architecture (W.G. Watson);

Bridges and Their Builders (Steinman & Watson);

Bridges in History and Legend (W. G. Watson);

Bridge Engineering (J. A. L. Waddell);

Historical Records of Australia; Ser. I., Vol. 3;

Historical Records of N.S.W., Vol. 5;

Minutes of Proceedings of the Institute of Civil Engineers, Vol. CXLVIII, 1901-2;

The Life of Robert Stephenson, Vol II (J. C. Jeaffreson).

Successes and Failures in Roadside Tree Planting

Past Experience as a Guide to the Future.

The condition of pre-war tree-planting on main roads, particularly on State Highways, has recently been examined throughout the State in order that past experience may serve as a guide to future practice. This article aims at setting out what has been learnt from both successes and failures.

The Main Roads Act provides that Main Roads funds may be expended on roadside tree-planting. In 1934 the Department instituted the policy of planting in appropriate places on the more heavily trafficked State Highways and of planting on Trunk Roads and ordinary Main Roads where agreed on with councils. The work was mainly confined to rural areas. Prior to that time, there had been little roadside planting on Main Roads in New South Wales, except in towns and villages.

Difficulties associated with the successful growth of roadside trees in exposed positions, and often with little moisture, were fully anticipated, and it was decided, therefore, to utilise hardy varieties of trees, judged most likely to be successful. Lists of trees were drawn up considered appropriate to various climatic conditions, and advice was obtained as to methods of planting and care of trees. This information was published in *Main Roads* for February, 1936.

At that time it was proposed that generally trees would be planted as a row on each side of the roadway, parallel to the centre-line of the pavement, although provision was also made for group planting.

Planting took place mainly during the years prior to the war. No planting was done during the war years. Since the war resources have been limited, and efforts have mainly been concentrated on the care of trees already planted, and the replacement of dead trees in past plantings, although in a few cases where conditions have proved particularly adverse and most of the trees planted have been lost, no effort has been made to replant.

Such limited new planting as has been carried out in recent years has been confined mainly to isolated group planting in particularly favourable locations, and to planting avenues in the immediate approaches to country towns, where conditions are suitable.

Climatic Factors.—Climate conditions in New South Wales are extremely diverse. Parts of the North Coast could be classed as sub-tropical, with mild winters and summer rains and humidity. On the tablelands of the New England district and the Monaro, snow may fall in winter, and some areas are subject to bleak winter winds. In the western half of the State the rainfall is scanty and often irregular, and summer temperatures are high. The northern half of the State receives most of its rain in summer and the southern half in winter, Sydney being about on the line of equal summer and winter rainfall.

With such a large variety of climatic conditions, it is apparent that tree types which may appear suitable for one district, may be out of the question for another district.

Unfavourable Conditions for Tree-planting on Roadsides.—Roadsides where tree-planting is warranted are almost invariably less favourable to tree growth than sites in parks and gardens in towns where there is more shelter and moisture. Further, towns are frequently close to streams, and built on alluvial soil having permanent moisture at depth. On nearby higher ground, there may be only a relatively shallow soil cover over rock. For these reasons all trees which will grow successfully in a town are not necessarily suitable for planting along roads, even in the same neighbourhood.

Among the unfavourable circumstances that may affect roadside tree-growth are the following:—

1. *Lack of Moisture.*—Roads are necessarily constructed in such a way as to drain away the water that falls as rain. Artificial watering of trees is out of the question on account of cost, except for the first few years while the young trees are being established. It has been very noticeable in a number of cases where avenues have been planted by the Department that excellent results have been obtained where the trees are on an alluvial flat, but where the road rises over higher ground the trees are inferior and losses more frequent.

   Excellent tree growth can often be secured on roads in irrigation areas, although the country otherwise would be unfavourable to trees.

   There are parts of the State where climatic conditions would appear to be ideal for deciduous trees—natives of cold climate countries overseas. However, unless rainfall conditions are favourable, success may not be achieved. This became particularly apparent during the war years when shortage of labour for watering, and the onset of a period of drought, resulted in substantial losses of young trees, especially in the south-western part of the State.
2. *Lack of Shelter from Wind.*—This is a most important factor in some parts of the Southern Tablelands and the Monaro and New England districts subject to cold winter winds of considerable force. The planting of trees in groups, surrounded by quicker growing "nurse" trees or shrubs to provide shelter, may permit tree growth in such circumstances.
3. *Absence of Top-soil.*—On roadsides there is sometimes little or no top-soil. This has

occurred mainly as a result of surface erosion due to travelling stock. Stock eat grass and young tree growth, and the feet of the animals disturb the soil surface. Wind and rain remove the surface soil. Both past destruction of mature trees on roadsides and the operations involved in constructing and maintaining the road, may also have contributed to loss of surface soil.

4. *High Water-table.*—Where the ground water level is close to the natural surface, most tree varieties will not grow. Drainage of areas of this type for purposes of tree planting is usually out of the question, and any planting must be confined to the few varieties of trees which thrive under these conditions, such as Swamp Oaks (Casuarina Glauca), and Willows.

5. *Adverse Soil Conditions.*—Apart from insufficiency or excess of moisture, soil conditions may be adverse to tree growth in other respects. For example, depth of soil from natural surface to rock may be insufficient to support tree growth. This situation may often arise in granite country. With soft rocks, if a sufficient shattering of the rock is effected before a young tree is planted, its roots will usually develop satisfactorily and ultimately find their way into the joint planes in the rock.

Then again some trees appear to be naturally shallow rooted, and others deep rooted. For example, the Native White Box, which grows so extensively throughout the central west of New South Wales, is shallow rooted, and grows well in shallow soils overlying a clay subsoil. On the other hand, the Yellow Box is deep rooted, and grows naturally on deep alluvial soils, where, no doubt, its roots reach down to underlying moisture.

Nature of soil is also of significance. Some native trees grow best in sandy soil, others in clay. However, generally it is the presence or absence of moisture which has greater influence in determining success or failure rather than soil type.

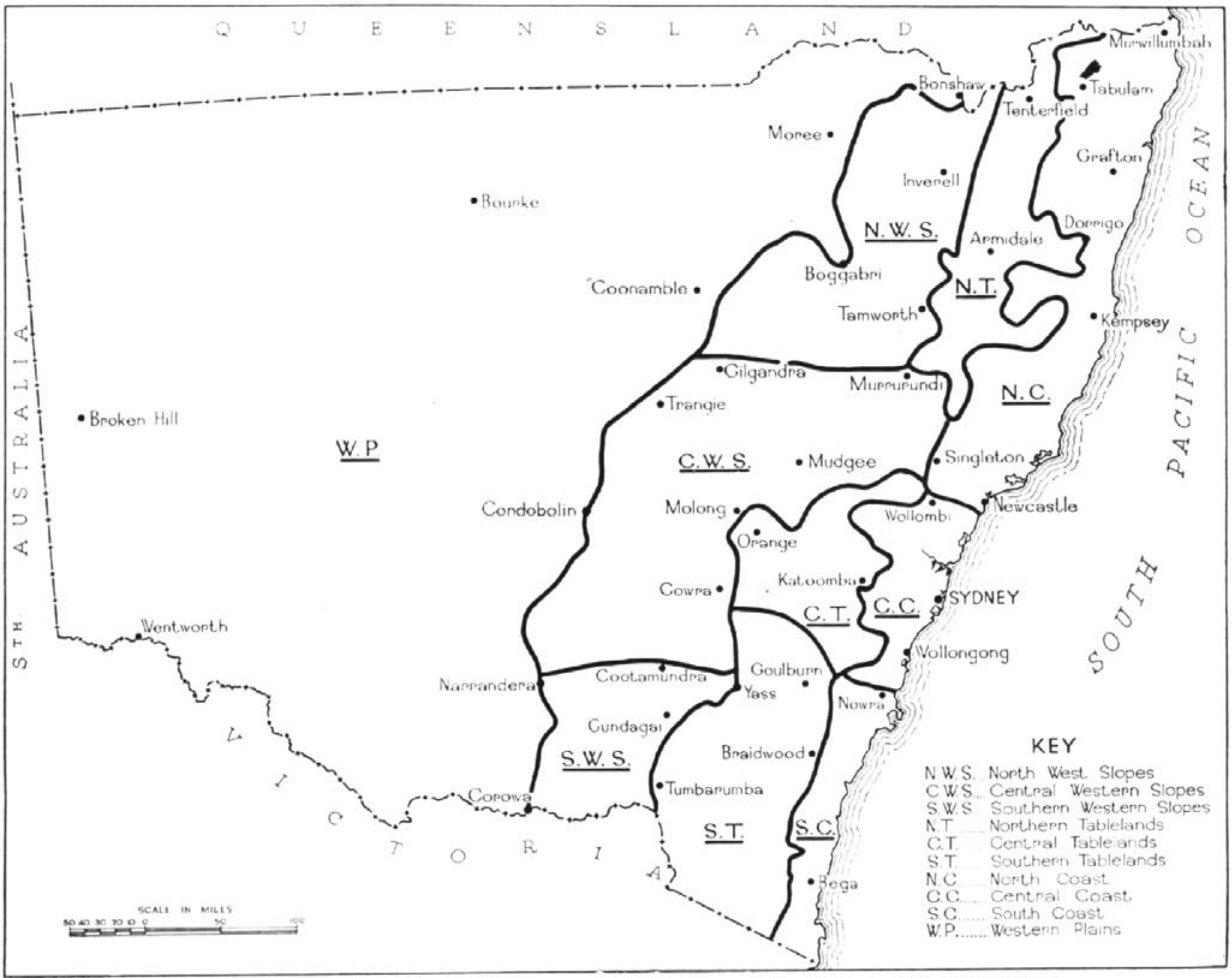


Fig. 1. Map showing Climatic Divisions and Subdivisions of the State as defined in "Trees of New South Wales" by R. H. Anderson.

Other Adverse Factors.—Trees planted on roadsides are liable to damage arising from grass fires, stock and vehicles. Destructiveness by persons has not been extensive, and has been more than offset by the interest and care for trees generally displayed by nearby residents.

The presence of overhead wires is adverse to tree-planting, and planting under or near wires has generally been avoided, on account of the cost of pruning which would be involved later, but in a few cases low growing trees have been planted under wires.

RESULTS OBTAINED IN VARIOUS PARTS OF THE STATE.

The description that follows deals separately with experience in each of the climatic divisions and sub-divisions of the State, as defined in "Trees of New South Wales" by R. H. Anderson (Government Printer), from which Fig. 1 has been adapted.

Coastal Areas.—Much of the coastal lands of New South Wales are forested, and roadside tree-planting has been confined to the vicinity of towns and adjacent farming areas from which natural vegetation has been removed. In such locations, both soil and moisture conditions usually favour tree growth. As a result there is a wide variety of satisfactory tree types available from which a selection may be made. Nevertheless, in selection of tree type, full consideration must be given to soil, moisture and shelter at the particular site, if good results are to be secured.

The North Coast has an almost sub-tropical climate. Natural tree growth occurs along much of the main road mileage, but tree-planting in and near towns has been widely carried out. The popular Jacaranda has been extensively planted, following its great success at Grafton. It grows very well on alluvial flats, but has been killed when young by frost in some cases, particularly in the Gosford district. It has also been killed by partial submergence in time of flood. Jacarandas planted in basaltic soil on high ground, well drained, in the Lismore district have not grown well. Jacarandas planted on a poorly drained black soil flat near Woodburn have also not grown successfully. Other trees that have given good results on roads on the North Coast include Camphor Laurels, White Cedar, Lombardy Poplar and Coral, all of which are very hardy and will grow successfully and quickly under most conditions. There are a number of other trees which will grow well on roadsides on the North Coast provided some care is exercised in selecting suitable conditions.

Ficus Hillii is rather subject to frost, and trees planted in low-lying areas have been retarded in growth or destroyed by frost action. Elsewhere this tree does very well.

The Weeping Fig (*Ficus Benjamina*) is somewhat more attractive in appearance than the *Ficus Hillii*, but is even more susceptible to frost damage. Where this can be avoided, good results have been obtained in the lower Richmond district.

Swamp Oak (*Casuarina Glauca*), self-planted, forms an extensive avenue on a section of the Pacific Highway between Murwillumbah and Tweed Heads. The country is swampy.

Illawarra Flame Tree has had only limited trial, and appears to have failed in one case due to too heavy a clay soil, and in the other to lack of shelter. In view of this being a coastal tree, further trials are warranted, but in better positions.

The beautiful red-flowering *Poinciana Regia* is very susceptible to frost, and trials along the Tweed and Clarence Rivers have shown this. In view of the beauty of this tree, further trial is warranted, giving frost protection until established. Specimen trees in North Coast towns demonstrate that the tree can be successfully grown.

Poor growth of Blue Gums on the Southern Tablelands owing to exposure to severe winds.

Stunted growth of Poplars 8-10 years old on the North-Western Slopes owing to conditions being too hot and dry.

The Lilly Pilly tree has proved successful for roadside use on the North Coast, but is somewhat slow growing.

Other trees tried include Bauhinia, Queensland Wheel Tree, Cape Chestnut and Magnolia. Results have been indecisive, and none of these could yet be recommended for main road use on the North Coast.

In the rural parts of the County of Cumberland, surrounding Sydney, satisfactory roadside growth has been secured with Brush Box, Camphor Laurel, Poplars, Common Olive, Tallowwood, Kurrajong, Silky Oak, Elm, Queensland Wheel Tree, Pepper, White Cedar, Red-flowering Ironbark, Jacaranda, Tasmanian Blue Gum, Sugar Gum, *Ficus Hillii* and Illawarra Flame Tree. The Wheel Tree and the Flame Tree require sheltered positions. There have been some failures with most of these types of trees from various causes, but principally due to insufficient regard to moisture conditions when selecting sites for planting. The County of Cumberland is liable to protracted dry periods, and experience shows that reasonably favourable local moisture conditions must exist in this area for successful tree growth. For example, while Poplars and Camphor Laurel grow well in lower country where there is moisture, on higher levels they have frequently failed.

Some trees have failed due to general unsuitability to climate and roadside conditions, including Liquidamber, Prunis Angophora (Red Apple), Cypress and Horse Chestnut.

On the Hornsby-Peat's Ferry section of the Pacific Highway, many losses have occurred due to bush fires and to vandalism.

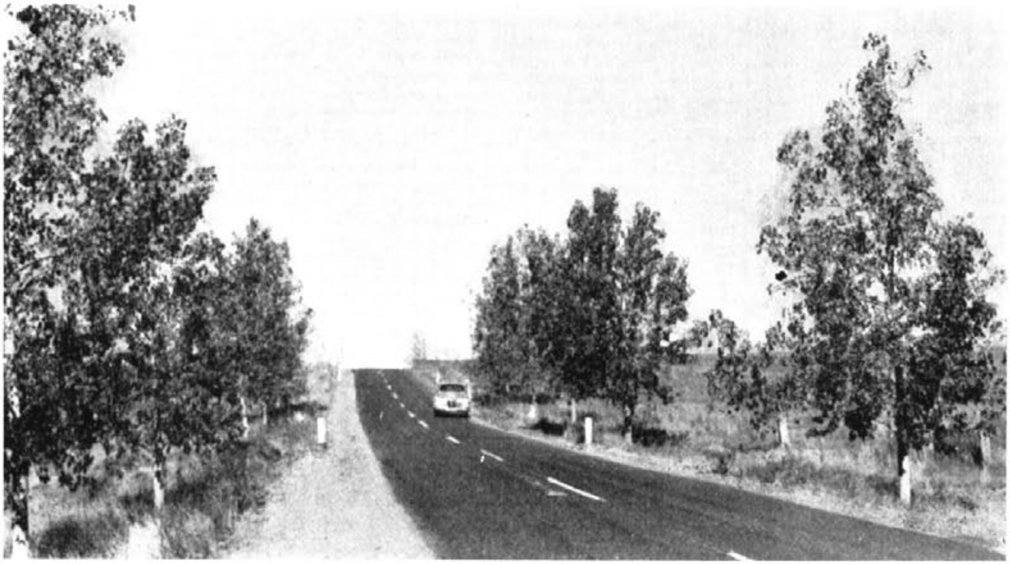
In the Illawarra area, good results have been obtained in reasonably favourable situations from Norfolk Island Pine, Silky Oak, Illawarra Flame Tree, Brush Box, Flowering Gum (*Eucalyptus Ficifolia*), New Zealand Christmas Tree (*Metrosideros Tomentosa*) and Poplars. Failures have included Cape Chestnut due to insufficient shelter, and Jacarandas, probably due to frost.

On the further South Coast, only limited tree-planting has been undertaken. Poplars and Swamp Oaks have given good results on alluvial flats. Silky Oaks grown well, and Turpentines give promise near Bega. *Ficus Hillii* has given satisfactory results adjacent to the sea coast, but elsewhere has failed due to frost. Jacarandas have not been successful, due to frosts, in spite of protection against frost when the trees were planted.

Tableland Areas.—The elevated areas of the State fall into three main parts:—(*a*) The Northern Tablelands, embracing the New England district; (*b*) the Central Tablelands, including the Blue Mountains and the Bathurst-Orange district, the Capertee district, and the Mittagong-Bowral district; and (*c*) the Southern Tablelands, including the Monaro district.

In the New England district, roadside tree planting has mainly been confined to towns and their road approaches. Poplars—Lombardy, Bolleana, Golden and Deltoides, have generally proved very successful. Where sheltered, other deciduous trees have also usually grown fairly well, including Liquidambar, Elms, Lindens, Horse Chestnut, Ash, and Rowan. Generally these varieties have been less successful than poplars, however, apparently due to soil or drainage conditions, to exposure to winds, or to climatic factors. Catalpa and Pin Oak (*Quercus Palustris*) have proved unsuccessful on a main road near Tenterfield, and Nettle near Armidale. Cedars (*Cedrus Deodara*) and Cypresses have grown satisfactorily where sheltered. Camphor Laurels have been a failure on the roadside near Uralla, the climate being too cold.

On the Blue Mountains, a wide range of trees has been planted on the Great Western Highway, with



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Top right: Silky Oak

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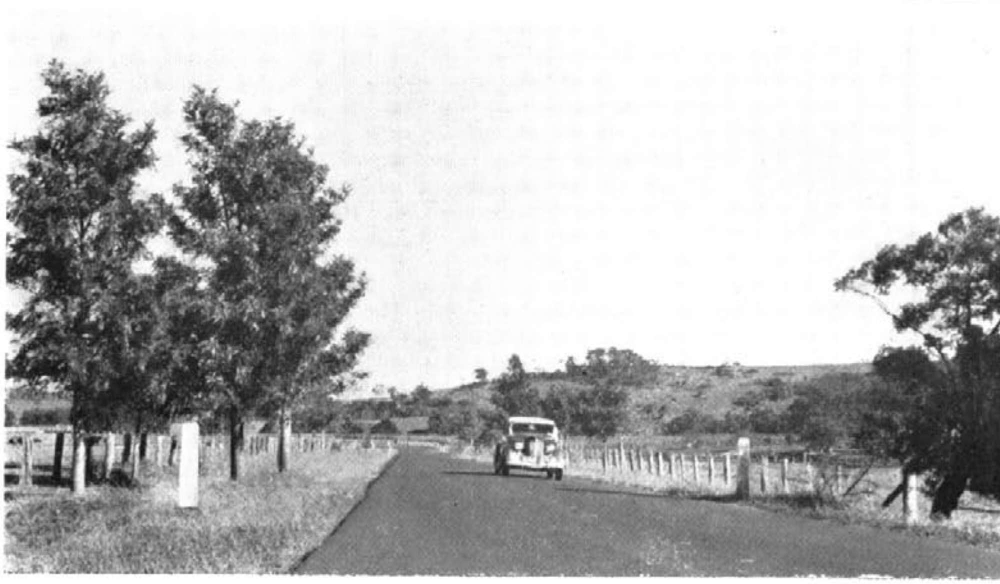


generally successful results. These include Poplars (Silver, Golden and Lombardy), Scarlet Oak (*Quercus Coccinea*), Swamp Cypress (*Taxodum Disticum*), Italian Cypress (*Cupressus Sempervirens*), Pine, Ash, Oriental Plane, Maple (*Acer*), Liquidambar, Arbutus, Kaffir Plum (*Harpephyllum Caffrum*), Evergreen Oak, Holly Oak (*Quercus Ilex*), Cedar and Illawarra Plum (*Podocarpus Elata*). In the case of most of these types of trees, there have been failures as well as successes, but the successes outnumber the failures. The failures appear mainly to be due to insufficient depth of soil or insufficient moisture, particularly the former, and indicate the need for more careful preliminary study of sites before trees are planted. Failures have been most pronounced with the Plane, the Maples (Norwegian and variegated) and the Liquidambar. Flowering Cherries (*Cerasus Japonica*) have proved unsuccessful.

Jacarandas and Camphor Laurels are growing successfully on the Great Western Highway as far west as Valley Heights (elevation 1,056 feet).

In the Orange district, Elms, Planes, Cedars and Italian Cypress have been successful as roadside trees.

The Southern Tablelands and Monaro districts extend over a vast area, with differing soil and moisture conditions. Some areas are subject to prolonged cold winds in winter. Absence of shelter makes it difficult to grow roadside trees unless special measures are adopted, *e.g.*, group planting, first growing bushes, shrubs and low growing trees to shelter the young trees in their early stages.

Experience generally with roadside planting in the Goulburn-Yass-Canberra district indicates that successful results may be obtained only provided full regard is paid to the requirements of soil depth, moisture and shelter.

Results with various tree types are as follows:—

- Poplars (Lombardy, Bolleana and Deltoides): Very successful, especially in moist situations.
- Oaks (*Palustris, Ilex* and *Virginiana*): Generally unsuccessful. Failure attributed mainly to lack of shelter, although moisture conditions may not have been suitable in some cases.
- Silky Oak. Generally unsuccessful. Climate considered too cold and exposed.
- Cedars (*Cedrus deodara*): Growing well, and appear to withstand exposure.
- Oriental Planes: Generally inferior. Difficult to establish on account of amount of watering required.
- *Celtis Australis*: Successful in spite of exposed positions. Slow growing.
- Tasmanian Blue Gum: Successful where reasonably sheltered.
- *Eucalyptus Botryoides*: Successful, but apparently wood is brittle, and limbs are torn off in high winds.
- *Eucalyptus Cinerea*: Successful.
- Yellow Box: Unsuccessful on roadsides, apparently due to exposure and insufficient moisture.
- *Eucalyptus Rubida* and *Eucalyptus Maideni*: Results very variable, and largely dependent on shelter, and on depth of soil.

In the vicinity of Cooma, good results have resulted from the planting of Oriental Planes. Near Adaminaby, both Elms and Silver Birch have been successful, in spite of an exposed position.

The Slopes.—The Slopes lie between the tablelands and the western plains, and climatically they are intermediate. The Slopes are characterised by cool winters

Failure of European Nettle Trees on the Northern Tablelands owing to exposure and unsuitable ground conditions.

Successful group planting. Sugar Gums on the Hume Highway near Jugiong.

and hot summers. The southern strip of the Slopes is subject to prolonged dry periods in summer, but the northern parts usually have some summer rainfall.

All trees which grow successfully on roadsides on the Western Plains will also grow successfully on the Slopes. These include White Cedar, Pepper, Silky Oak, Kurrajong and Athel. Apart from these, successful roadside tree growth on the Slopes is largely dependent on the selection of sites presenting favourable moisture conditions. With this important proviso, a fair range of other tree types has been successfully grown.

On the North West Slopes, Sugar Gums, River Red Gums, Yellow Box, Lombardy Poplars, Planes and Pseudo Acacia have all been grown successfully on roadsides, under favourable moisture conditions.

On the Central West Slopes, successes include Lombardy Poplar, Red Flowering Iron Bark, Sugar Gum, and Lemon-scented Gum. Tasmanian Blue Gum has been successful near Cowra, but elsewhere on the Central Slopes results with this tree are unfavourable, the climate apparently being too dry and hot. Other trees not found suitable, apparently for the same reason, are Liquidambar, Flowering Gum (*Eucalyptus Ficifolia*) and Mahogany Gum (*Eucalyptus Botryoides*). Failures have occurred with Jacaranda, and are attributed to inadequate frost protection. This tree is best planted immediately after the winter to avoid frost.

The Hunter River Valley above Maitland is regarded as part of the Central West Slopes. Best results on roadsides in this area have been obtained with Silky Oak, Brush Box, Red-flowering Ironbark and Yellow Box (on flats). Tasmanian Blue Gum, Sugar Gum and Kurrajong have also grown successfully, but rather slowly in most cases. Except in particularly favourable locations the following have failed or made poor growth —Poplars, Cape Chestnuts, European Nettles and Oriental Planes.

In the South West Slopes, successful tree planting on roadsides has included Poplar, Sugar Gum, Tasmanian Blue Gum, and Oriental Plane. As on the Central Slopes, success with these tree types is largely determined by moisture conditions. In one case the failure of Planes was attributed to excess moisture. Chinese Elm has grown well as a street tree in Barmedman. Red Box (*Eucalyptus polyanthemos*) has failed on dry ridge country west of Wagga, presumably because of insufficient moisture and hot dry summer.

The Plains.—As previously indicated, the principal trees which will grow on roadsides on the western plains comprise the White Cedar, Pepper, Silky Oak, Kurrajong and Athel. Where moisture conditions are reasonably favourable, as in irrigation districts or near streams, other trees grown successfully include Sugar Gums, Jacaranda (requires frost protection in early stages), Fig, Plane and Poplar. The small native trees, Wilga and Myall (or Boree), have possibilities for roadside planting in the western parts of the State, but have not yet been fully tested for this purpose. Flowering Gums have suffered from frost and from lack of moisture, but in some cases are successful. This tree is brittle and requires a reasonably sheltered position.

Reason for Failures.—Failures in tree planting on main roads have not been extensive. The principal failures have been on the Southern Tablelands, owing to planting in over-exposed positions, and on the Southern Slopes owing to irregular rainfall and drought. Elsewhere such failures as have occurred have generally been isolated, due to local causes such as insufficient depth of soil, climate too hot or too cold for particular type of tree, rainfall irregular, insufficient ground moisture, insufficient shelter, frost action, lack of watering and cultivation in initial stages, failure to maintain tree-guards, site too wet. Failures in some cases clearly would have been avoided if trees more suitable to the local conditions had been selected. The fact that specimen trees will grow well in the private gardens or public parks of a town is no sure indication that the same types of trees will succeed on roadsides in the same locality, where conditions of moisture and exposure may be much more rigorous. Only the hardiest varieties, adapted to the climatic conditions, should be considered, and past experience should be the guide.

DESIRABLE PROCEDURE IN NEW ROADSIDE TREE PLANTING.

Experiences of past planting indicates that in any further planting undertaken, the following procedure should be carefully followed:—

1. Make a list of trees known to be climatically suitable for the district, and which have preferably already been proved suitable for roadside planting.
2. Examine the site closely, especially in respect of moisture conditions, depth and type of soil, and extent of exposure to winds.
3. Select from the list, the type of tree to be planted, taking full account of the conditions at the site in making the selection.
4. Provide tree-guards or fencing and prepare the ground thoroughly. Provide stakes.
5. Plant at the correct time. This is autumn for most varieties, but spring for young trees subject to frost damage.
6. Include an item in the annual Maintenance Programme to cover Care and Maintenance of Trees.
7. Set up a proper organisation to ensure care and maintenance. This should cover cultivation around the young trees, including removal of weeds and grass, especially in dry weather, frequent watering in dry weather for the first few years, repair of tree-guards or fencing, and fire protection. In addition, the tree itself may require spraying or other attention to cope with insect infestation or fungus growth, and pruning to ensure strong straight growth, or to deal with damage by wind or frost.
8. Ideally, specially trained personnel should be available to undertake the planting and care of roadside trees. However, most country main road maintenance organisations in New South Wales have not enough tree work to call for a specialist. The best procedure is to select employees who display a special interest in trees, and to guide and assist them to become proficient in the work. Advice on tree care and pruning can often be obtained from either parks or forestry officials.

AVENUE PLANTING VERSUS GROUP PLANTING.

Careful attention to detail as described above can result in the satisfactory growth of roadside trees in most locations. However, tree-planting does not just consist of planting the hardiest tree and making it grow successfully, but rather it is an aspect of landscape architecture. Its success is judged not alone by healthy tree growth, but also by the general landscape effect created.

The Australian rural landscape is essentially unorganised, and experience shows that the planting of avenues of trees in country areas should generally be confined to the approaches to towns, or to large bridges or other man-made features. Elsewhere, avenues seem to lack significance, and long avenues tend to become monotonous. Where travel speeds are high, regularly spaced trees may become irritating to the eye. On the other hand, the monotony may induce drowsiness, as is always liable to occur on any road which lacks some degree of variety.

Not only will group planting be found more satisfying than avenue planting, but it is also cheaper to carry out and to maintain.

Where avenue planting has been undertaken, the effect has been spoiled in some cases by replacing dead trees by trees of another variety. While the mixing of tree types can be successful as in streets in Grafton where the trees meet overhead, the ordinary avenue requires to be uniform in type if it is to convey a true dignity and formality of appearance. There are many older examples where street trees are of mixed type, with the result that the trees add little to the appearance of their surroundings.

Experience with avenue planting indicates also that the eucalyptus is generally unsuitable on account of its unsymmetrical habit of growth, and because its form is so much associated with the natural landscape. However, satisfactory results have been obtained with Tasmanian Blue Gum, Sugar Gum and Tallow Wood on the tableland, slopes and coast respectively.

The alternative to avenue planting is group planting. On roads one chain wide, when space has been set aside for overhead telephone and electricity wires, there is generally no space left for free-growing trees, unless low growing species are available and suitable. Even in the case of roads one and a half chains wide, there is only just sufficient space for avenue planting after allowance has been made for overhead wires. If group planting is desired, the only way to achieve it in such circumstances is to take advantage of any local widenings of the road reserve, *e.g.*, as sometimes occurs at bends. Where roads are two chains wide or more, there is no difficulty in group planting.

Group planting provides an opportunity to introduce contrast and variety by the use of exotic or other trees not native to the district, and not similar to the background trees. Groups should not be planted in regular rows, but to a scheme which will take into account the growing habits of the trees. For example, smaller growing trees might be placed on the fringes of the group, creating ultimately a pyramidal effect, the smaller trees also in this way protecting the taller trees.

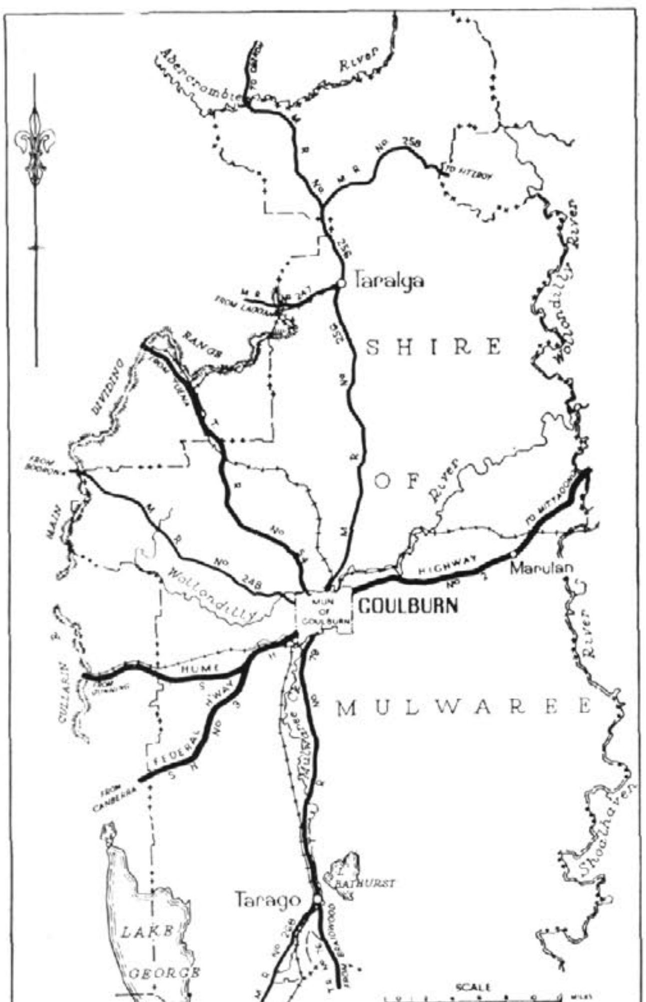
Group planting has the advantage that it is flexible, and the tree types can be selected to suit the exact conditions at each site. Further, group planting may be undertaken on as small a scale as desired, and yet give pleasing results. In fencing areas for group planting, the needs of travelling stock must not be overlooked.

The Organisation of Roadworks in the Mulwaree Shire.

By H. B. Darke, B.E., A.M.I.E. Aust., Shire Engineer, Mulwaree Shire Council.

The Shire of Mulwaree is situated on the Southern Highlands of New South Wales, with headquarters in the City of Goulburn, which is virtually at the centre of the Shire, and accordingly the choice of Goulburn as the administrative headquarters of the Shire is wise and logical. The Shire is intersected east and west by the Hume Highway, State Highway No. 2, connecting Sydney and Melbourne, and north and south by Trunk Roads leading to Bathurst, and to Braidwood, Queanbeyan and Bateman's Bay, respectively.

There is no large centre of population within the Shire, the main towns being Taralga, 28 miles north of Goulburn with a population of 380, and Marulan, 18 miles east of Goulburn with a population of 250. Bradfordville and Kenmore with a population of 310 are immediately adjacent to Goulburn. The total population of the Shire of Mulwaree is 5,600.



Locality Map.

The area of the Shire is 1,946 square miles, the elevation varying from 2,000 feet to 3,500 feet above sea level; the average annual rainfall is 26 inches, distributed fairly evenly throughout the year. The unimproved capital value of rateable lands (Valuer-General's valuation) is £2,120,000, the rate yield on the present rate of 3¾d. in the £ is £33,122.

The mileage of roads within the Shire is:—State Highways, 45½ miles; Trunk Roads, 41 miles; Ordinary Main Roads, 100 miles, and roads other than Main Roads, 600 miles, a total of 786 miles.

The Council is responsible for the maintenance and construction of all roads within its area, and accordingly the organisation has to cater for all classes of works from those on State Highways, to those on roads of relatively minor importance serving only a few landholders.

The Council's central depot is located in Goulburn, stores and materials are housed there, and issued to jobs as required, plant operates from this centre. A full-time storeman and blacksmith are employed. To date the Council has provided for the maintenance of its plant through local garages and workshops, supplemented as required by the services of field mechanics supplied by the distributors of the various makes of plant. Consideration is being given to the establishment of a workshop for the maintenance of plant by Council with its own staff, but no decision has yet been made.

The Council is at present carrying out all works by day labour, some minor contracts for gravel resheeting have been let, but it has been found that prices tendered

Low Level Bridge over Abercrombie River. M.R. 256.

for this work, even if available, are substantially in excess of the cost of similar work carried out by Council's own organisation.

PLANT.

The Council has, over the past six years in particular, been expanding its plant. Additional plant is on order and consideration is being given to further additions.

The main items of plant now in use are:—

- Portable diesel engined compressor 110 cu.ft./min.
- Drill—flexible shaft—power operated.
- 2 Heavy-duty motor graders.
- 1 Light-duty motor grader.
- 1 Pneumatic-tyred front-end loader.
- 3 Concrete mixers.
- 1 Pile driving frame and monkey.
- 2 Road rippers—manual control.
- 2 Steam rollers—10-12 ton.
- 1 6-8 ton internal-combustion roller.
- 2 2 cu.yd. wheeled scoop.
- 3 Sleeping vans.
- 4 Crawler tractors—group 6 (35-40 h.p.), complete with power control units and dozer blades.
- 1 Winch—power operated.
- 8 Tipping trucks (four equipped with "Berriman" loaders).
- 3 Pneumatic tyred trailer graders.

Additional plants on order comprises:—

Medium duty power grader, 3 motor trucks, crawler tractor 60 h.p., sleeping van, and trailer for plant transport.

Heavy Duty Motor Grader cutting outlet from Table Drain.


Two Horse Grader used for work on minor Shire roads.

ORGANISATION.

The organisation has been built up to meet the needs of the Shire as a whole. Some units work almost constantly on specified lengths, such as the State Highways maintenance gang, but there is sufficient fluidity to allow of gangs being moved from one work to another without delay.

The main gangs operating are as under:—

Gravelling Gang.—This consists of a ganger and two tractor operators, labourer, tipping trucks and grader operator. The method now employed is to use two crawler tractors, ripping, dozing and loading gravel through a "Chinaman" or portable side loader. The bulk of the available gravel requires ripping and the use of two tractors has been found to be necessary. Haulage is carried out by contract trucks at piecework haulage rates, gravel is spread by motor grader, which also prepares the road in advance and maintains gravel spread. Yardages of over 400 cu. yds. per day are being obtained with this organisation. On some minor jobs the pneumatic tyred front end loader is used in conjunction with a crawler tractor.

Bridge and Culvert Gang.—This consists of a ganger and three men equipped with motor trucks and appropriate tools. This gang carries out routine repairs to


Loading Gravel with Berryman Loader.

Tractors bringing in and loading gravel into truck through side loader.

bridges and culverts, and also construction of structures. Additional labour and plant (such as crawler tractor) is made available when required.

Culvert and Crossing Gang.—A second gang comprising ganger and two or three men with truck equipped with Berriman loader works on maintenance and construction of culverts and concrete crossings, and also on routine maintenance jobs as required.

State Highways Maintenance Gang.—This gang consisting of ganger and three men equipped with a motor truck is employed constantly on routine maintenance of the State Highways. Additional gangs, truck equipped, are brought in also as required. The use of the pneumatic tyred front end loader has proved most advantageous in the removal of failed areas of gravel pavement, and the loading of gravel for replacement either from stock piles, or from gravel deposits, a crawler tractor generally ripping and dozing the material into windrows.

Truck Maintenance Gangs.—Two gangs are operating in the Taralga area, each of four men with motor truck and trailer grader, carrying out routine maintenance on main roads and other roads. Minor gravelling may also be carried out by these gangs. Two gangs of similar size also operate from Goulburn.

Horse Grader Gangs.—There are at present five units consisting of two men with two horses and grader equipment, operating generally on roads other than main roads. In spite of the general trend towards mechanisation, it is considered that these small units, with horse drawn equipment, working on specified lengths are invaluable, particularly on routine maintenance work requiring attention to detail; these men have a good knowledge of and a personal interest in their respective lengths, often lacking in gangs with mechanical equipment, operating from a remote centre.

Maintenance Grading.—The maintenance grading on the Main Roads system is carried out by motor graders; this applies to the more important of the other roads. On roads of minor importance grading is carried out by horse graders, but as far as possible periodical gradings are carried out on these roads with the power graders.

ESTIMATES.

Apart from work on Main Roads and other specific works such as those for which grants are available, the annual estimates are made out on the basis of the cost of the organisation. To some extent this also applies to the Main Roads programmes.

View of Truck being loaded.

Deviation of the Goulburn-Taralga Road (M.R. 256) at Grindstone Hill. Constructed by Mulwaree Shire Council, 1940. Old road can be seen on the left.

No attempt is made by Council to allocate amounts to particular roads for routine maintenance, but an overall amount is voted on the basis of the estimated cost of maintaining a specified organisation. Being located so as to be readily available for work in any part of the Shire, the organisation is so directed to give regular attention to the roads in proportion to their importance. This system has proved to work most satisfactorily.

The same percentages to cover costs such as holidays, tools, payroll tax, etc., are used in estimating and in costing works on roads other than Main Roads as are used in the Main Roads Programmes; thus providing a uniform system.

COSTING.

Costing of works is not carried out within the Engineer's Department. However, an experienced clerk in Council's Office is engaged almost entirely on the making up of time sheets, preparation of vouchers, allocation of appropriate plant hire charges, the costing of the above and the preparation of Certificates of Expenditure. Basic information for this work is supplied by the Engineer, who is consulted throughout and who may obtain necessary information as to costing when required.

This method is necessary to provide co-ordination between the costing of works and the general accounts of the Council.

PLANT ACCOUNTING.

The Council operates a Plant Account within the General Fund. To this account all plant earnings (at D.M.R. rates) are paid, and from it costs of operating and maintaining the plant is paid. By this means it has been possible to provide a fund for the purchase of plant to replace that which may have been uneconomical to operate.

Individual accounts are kept for each item of plant, so that the Council has information as to the position of each individual item, as well as the overall financial plant position.

All charges for use of plant are made at the D.M.R. rates applicable.

Woolshed Creek Bridge and minor deviation of the Taralga-Oberon Rd. (M.R. 256) constructed by Mulwaree Shire Council in 1946.

ANNUAL EXPENDITURE ON ROADS—MULWAREE SHIRE.

Year.	Main Roads.			Other Roads.			Grand Total.
	Maintenance.	Construction and Reconstruction.	Total.	Maintenance.	Construction and Reconstruction.	Total.	
	£	£	£	£	£	£	£
1940	11,245	27,568	38,813	8,906	735	9,641	48,454
1941	12,474	18,038	30,512	7,826	451	8,277	38,789
1942	10,827	2,324	13,151	9,538	638	10,176	23,327
1943	12,307	66	12,373	7,576	506	8,082	20,455
1944	11,203	207	11,410	7,867	208	8,075	19,485
1945	11,184	507	11,691	8,614	1,254	9,868	21,559
1946	20,040	7,384	27,424	8,024	267	8,291	35,715
1947	20,530	11,694	32,224	9,064	1,686	10,750	42,974
1948	16,669	3,455	20,124	10,840	3,093	13,933	34,057
1949	23,864	4,522	28,386	13,304	3,566	16,870	45,256
	150,343	75,765	226,108	91,559	12,404	103,963	330,071

PAVEMENT TYPES—MULWAREE SHIRE.

	State Highways.	Trunk Roads.	Main Roads.	Other Roads.	Total.
	m. ch.	m. ch.	m. ch.	m. ch.	m. ch.
Concrete	9 71	....	....	....	9 71
Bitumen Surfaced	35 35	16 57	7 52	1 48	61 32
Gravel	....	24 19	91 4	404 32	519 55
Formed only	....	....	0 76	109 69	110 65
Cleared only	....	....	....	91 00	91 00
Total	45 26	40 76	99 52	606 69	792 63

New South Wales Limestones.

Use in Road Construction.

Availability.—In New South Wales limestone is the most widely distributed and most common of the rocks suitable for aggregate production. Massive limestone beds are found in almost all the sedimentary series from Cambrian to Lower Marine inclusive, and limestone will probably be found within reasonable distance in any district where there are extensive exposures of sedimentary rocks of earlier date than the coal measures. Rocks of these periods cover about 50 per cent. of the eastern half of the State and a small portion of the western half.

In the alluvial areas of the west, where no true rock is found within reasonable depths, concretionary lime-rock is frequently found within a few feet of the surface. In many districts this is the only stone of any type.

Properties.—The limestones proper are largely pure calcium carbonate, and have been formed mainly by the compaction and cementation, over periods of geological time, of thick deposits of shells, coral, etc. Calcium carbonate is slightly soluble in ground water, and the cementation was due mainly to solution and recrystallisation. In some cases this recrystallisation is complete, the rock being holocrystalline and showing no trace of the original components. Other rocks may still contain almost unchanged fragments of the original components or much amorphous calcium carbonate.

Crystalline calcium carbonate is not very hard but of sufficient hardness to be satisfactory for road purposes. Amorphous calcium carbonate varies from a hardness approaching that of the crystalline variety to chalk. The toughness of the rock depends on the structure; generally fine grained holocrystalline materials are of adequate toughness, but coarse grained crystalline limestones and poorly cemented granular materials are lacking in toughness. Unlike basalts, etc., which can often be accepted for structural qualities by inspection, most limestone deposits have to be tested for hardness and toughness prior to use. One important advantage of limestone for bituminous work is that the material does not seem liable to "stripping" troubles.

The concretionary lime-rocks of the west are much softer than the true limestones. They are used of necessity only as there is no alternative. This class of material is extremely variable, and great care must be exercised in selection to secure even the "fair to poor" results which are the best that can be expected from such materials.

Use of Limestone.—In New South Wales, the only two deposits of limestone that have been used to any great extent for road purposes are those situated at Attunga and Marulan. Some small use has been made of the Wingham and Wellington deposits, and exploitation of a deposit at Molong has recently been undertaken. Other sites have been projected but, so far as is known, not yet used for road work. This is only a fraction of the possible field of use of limestone in road construction. As a commercial quarrying proposition, limestone appears to have the following advantages as compared with many igneous rocks:—

(*a*) Less expensive drilling, blasting and crushing, as limestone is a relatively soft stone.

(*b*) Freedom from weathered rock that has to be excavated and discarded. Limestone weathers by solution, and there is no transition zone of soft rock.

(*c*) Ready market for agricultural purposes for dust produced in crushing.

(*d*) Often a better working face can be developed because limestone deposits are mostly of great thickness.

Tenders Accepted

The following Tenders (exceeding £1,000) were accepted by the respective Councils during the months of July, August and September, 1950:—

Council.	Road No.	Work.	Tenderer.	Amount. £ s. d.
Amaroo Shire	234, 359	Supply and delivery of 7,140 cu. yds. gravel	C. G. Staines & F. L. Grundy.	1,874 5 0
Baulkham Hills Shire.	160, 157	Reconstruction in cement concrete between Cecil Avenue and Anzac Hall.	Constructors (Australia) Pty. Ltd.	52,357 1 0
Bland Shire	398	Gravel resheeting	I. N. Miller	1,339 0 0
Do	231	Gravel resheeting	I. N. Miller	1,976 13 4
Blaxland Shire	55	Construction of approaches to bridge over Jew's Creek	J. Pearce	4,755 7 0
Carrathool Shire	539	Loam resheeting 0 m. to 2.9 m. and 9.6 m. to 13.2 m.	P. H. Miechel	2,247 10 0
Coolamon Shire	240	Supply, delivery and spreading gravel	C. G. Staines & F. L. Grundy.	1,123 9 4
Grafton City	83	Re-surfacing	B.H.P. By-Products Pty. Ltd.	1,026 11 10
Guyra Shire	73, 135	Supply, delivery and spreading 13,472 cu. yds. gravel	L. W. Keft	3,472 0 0
Harwood Shire	152	Supply and delivery 445 cub. yds. ¾-in. and 150 cub. yds. ⅜-in. aggregate.	Oxenfords Pty. Ltd.	1,138 2 6
Holbrook Shire	331	Surfacing 0 m. to 6 m.	B.H.P. By-Products Pty. Ltd.	3,114 10 2
Illabo Shire	57	Supply Ridge Gravel	F. A. Delaney	3,440 5 4
Kyeamba Shire	1177	Reconstruction 45 m. 2,600 ft. to 47 m. 4,800 ft.	C. A. Maloney	2,824 4 6
Lachlan Shire	57	Supply, delivery and spreading 7,425 cub. yds. gravel at various mileages.	R. E. Scarce	2,597 1 3
Tamarang Shire	72	Supply of 83 tons bitumen F.O.R. Willow Tree	Bitumen and Oil Refineries (Aust.) Ltd.	1,774 2 6
Do	129	Supply, delivery and spreading 5,300 cu. yds. gravel	McClellan and Death	2,097 2 6
Terania Shire	...	Supply and application of binder	B.H.P. By-Products Pty. Ltd.	3,193 12 2
Timbrebongie Shire.	57	Supply, delivery and spreading 7,180 cu. yds. of loam	J. C. Beaumont	1,221 9 2
Tintenbar Shire	10	Temporary bituminous surfacing of existing pavement	B.H.P. By-Products Pty. Ltd.	1,049 11 5
Wakool Shire	388	Construction of timber beam bridge over Shaw's Creek at 34.5 m. from Deniliquin.	R. Lowe	3,189 6 0
Waugoola Shire	310	Supply, delivery and spreading 4,837 cu. yds. gravel	C. J. Gavin	1,064 17 0
Do	56	Supply, delivery and spreading 7,000 cu. yds. gravel	C. J. Gavin	1,797 0 0
Do	310	Supply, delivery and spreading 5,280 cu. yds. gravel	C. J. Gavin	1,434 6 0
Wingadee Shire	...	Supply, delivery and spreading 35,000 cu. yds. loam at various locations on Main Roads Nos. 129, 202, 205 and 383.	G. G. Gillham	5,878 6 8

Cook's River Bridge.

New Structure Necessitated by Airport Extension.

The construction of a large reinforced concrete girder bridge over the future channel of Cook's River, near Brighton-le-Sands, on Main Road No. 194, General Holmes Drive, is now approaching completion. The bridge was made necessary by the diversion of Cook's River to make possible the expansion of the Kingsford-Smith Airport by the Commonwealth Government. The work has been carried out by the Department of Main Roads by day-labour. The major part of the cost is being borne by the Commonwealth Government.

The new bridge is a dual structure, with carriageways 16 feet apart. Its total length is 566 feet 4 inches, comprising eight spans, each 62 feet 8 inches long, together with abutments. Each carriageway is 24 feet wide, and there are two footways each 7 feet wide—the total overall width thus being 78 feet. The required horizontal and vertical clearances for navigation purposes were given as 50 feet and 14 feet respectively.

A reinforced concrete structure was selected in preference to a steel structure on account of the shortage of rolled steel sections, and because of the nearness of the site to the sea. Preliminary investigations of foundations indicated that spans of about 60 feet length, with piers founded on driven piles, would be most economical. The adopted design provides three main girders for each half of the bridge with three groups of driven concrete piles supporting each pier.

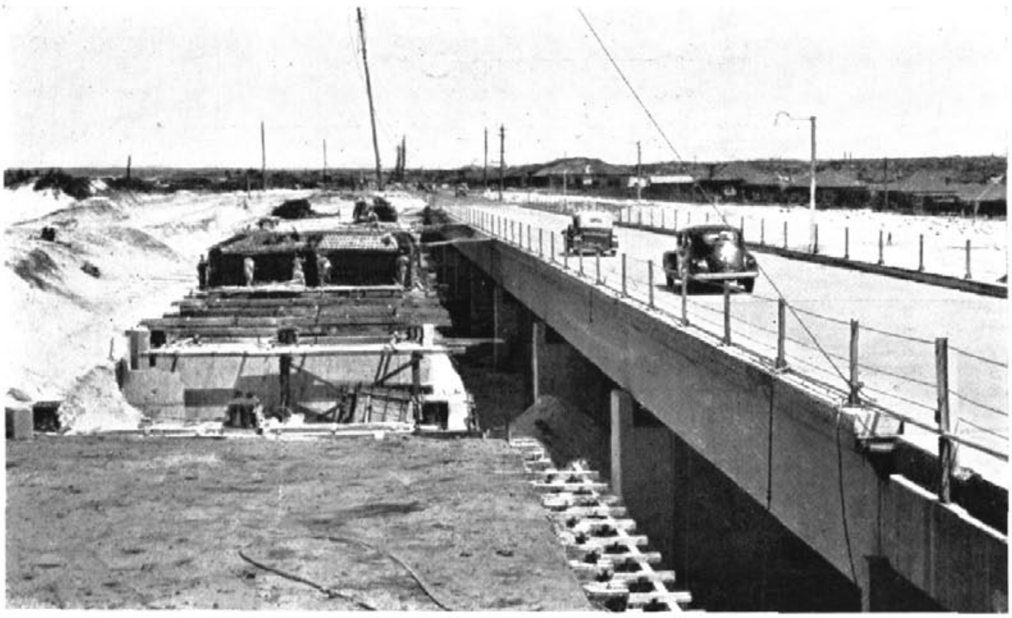
It was hoped in the early stages that the foundation conditions would be suitable for a continuous bridge, this having a superior appearance in concrete to the simply supported type, but detailed investigation of the material through which the piles were to be driven indicated there was a possibility of slight settlement. The superstructure was therefore designed to be simply supported.

The abutments each form one unit, giving the appearance of one wide bridge with a central dividing strip. The wing walls and parapets of the abutments will be built of sawn sandstone masonry. A steel grille-type railing will be provided on each side of each half of the bridge.

Construction was commenced in September, 1947, with the assembling of plant, equipment and materials and the establishment of a depot and camp. The area immediately adjacent to the bridge site was not suitable for a camp and depot site, and this was established on Ascot Racecourse, about 1½ miles from the bridge. This area had been acquired by the Commonwealth Authorities to form part of the ultimate airport extension. Substantial buildings were temporarily available for use as workshops, stores and offices. The depot was planned to undertake there the prefabrication of all formwork, the cutting and bending of reinforcement, the assembling of reinforcement in units for girders, columns, piles, etc., and the casting of reinforced concrete piles. A travelling gantry was used for handling piles in the casting yard, and also for handling reinforcement units for the superstructure. The various units of formwork, reinforcement, and concrete piles were transported to the bridge site by road vehicle as required.

As a first step in construction, traffic was diverted to a temporary road south-east of the bridge site. The area to be occupied by the new structure was then excavated to approximately high-water level, and all construction work proceeded on dry land. Attention was first concentrated on the upstream half of the structure, in which pile driving was commenced in April, 1948, and completed in November, 1949. Concurrently with pile driving, construction of piers, abutments and superstructure proceeded. The whole of the

Bridge foundations under construction in partly excavated channel.



Bridge approaching completion. Upstream half opened to traffic.

upstream half, with the exception of the railing and minor features, was completed by April, 1950. Since that date all pile driving has been completed for the downstream half, pier and abutment construction is almost completed, and four spans of the superstructure have been cast.

At the bridge site, all material and equipment is handled by means of a steam-powered flying fox which commands the whole area occupied by one half of the bridge. While the flying fox was still occupied in the upstream superstructure, pile driving in the downstream half was effected by steam hammer assisted by a heavy duty mobile crane for handling piles and driving gear.

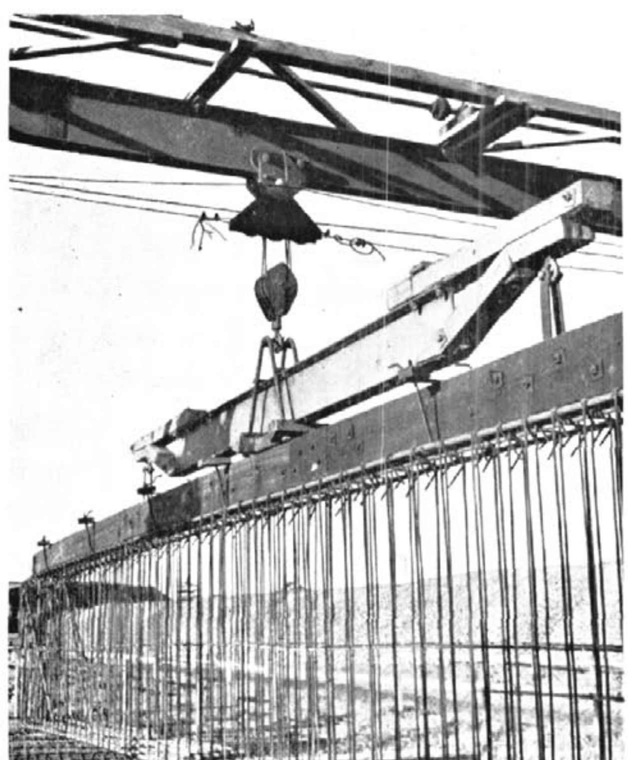
Each group of reinforced concrete piles was driven inside a concrete cylinder six feet deep, sunk into the ground with its top just above high water level. The driving was by means of a six-ton single-acting steam hammer. On occasions a two and a half ton drop hammer was used in addition to the steam unit, but was only satisfactory for the shorter piles. The maximum designed load on a pile is 30 tons and penetration at finished level varied from zero to 1.2 inches per blow.

As a check on the normal load bearing test for single piles, groups of seven piles were tested as a unit in both upstream and downstream structures. This involved the application of an external load consisting of 200 tons of pig lead which, by the co-operation of manufacturers, was made available on loan to the Department free of cost. The tests were entirely satisfactory in both cases.

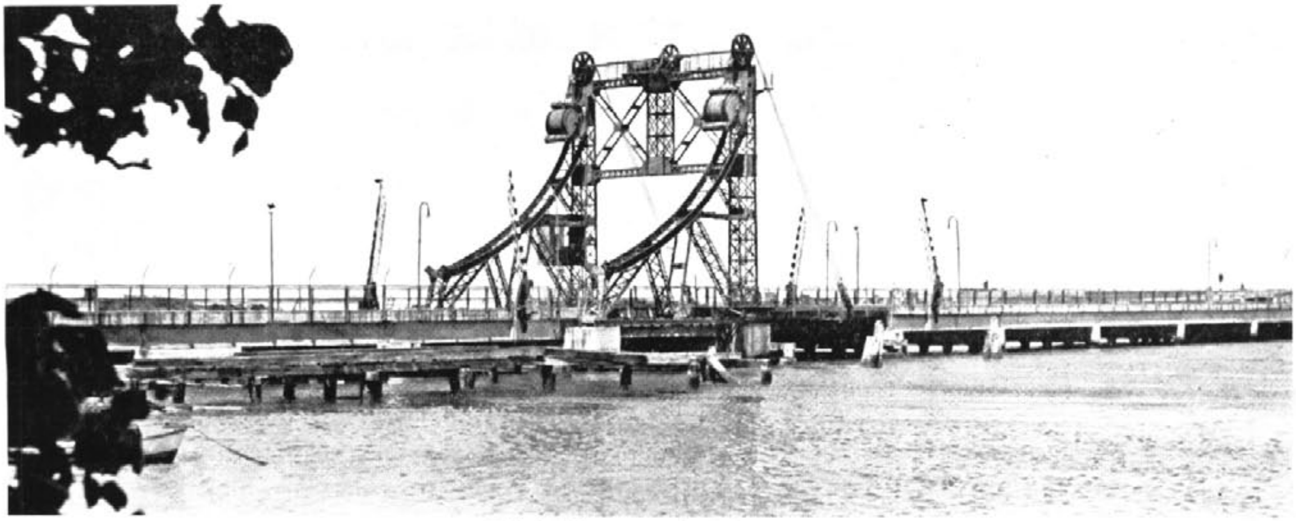
The water soaking through the soil, practically pure sand, almost filled each cylinder as pile-driving proceeded. This was removed to allow the pouring of concrete in the dry by a series of spear-points jetted into the sand in a ring round the outside of the cylinder.

Falsework for the superstructure was supported on timber sills placed directly on the natural sand. During dry weather it was necessary to keep the sills under observation to ensure that they were not undermined by wind erosion, but otherwise the method of support proved satisfactory.

Most of the concrete used in the work was ready-mixed. It was delivered to the site of the work in the supplier's mixing trucks and for the main pours was then transported in dump buckets by flying fox or mobile crane to the point of final deposition. Compaction was effected by hand tools and mechanical vibrators.



Gantry lifting reinforcement unit for a girder.



Old Bridge over Cook's River

The upstream half of the bridge was opened to traffic on 10th October, 1950, and it is anticipated that the downstream half will be ready for traffic early in 1951. At a later stage of the Airport extension work, the old opening bridge over the original river channel will be dismantled and that section of the river filled in.

Quantities and Cost.—The quantities of the principal items comprising the work are as follows:—

Excavation, 20,000 cubic yards.
Concrete class AA in whole structure, 5,527 cubic yards.
Reinforced concrete piles, 16,060 lin. feet.
Concrete cylinders, 294 lin. feet.
Steel reinforcement in whole structure, 484 tons.
Dressed masonry, 123 cubic yards.
Iron hand railing, 2,053 lin. feet.

The total cost of the structure on completion is expected to be approximately £200,000.

Supervision.—The work was carried out under the supervision of the Department's Metropolitan Engineer, this position being occupied during the period of construction, in succession, by Messrs. F. W. Laws, A. J. Clinch and L. W. Hawley. The engineers directly in charge of the work have been, in succession, Messrs. V. Packer, F. C. Cook, and S. Kaldor.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the Department during the months of July August and September, 1950:—

Council.	Road No.	Work or Service.	Name of Accepted Tenderer.	Amount. £ s. d.
Deniliquin Municipal.	...	Erection of Office Premises, Deniliquin	R. W. Bateman Pty. Ltd.	16,300 0 0
Hornsby Shire ...	13	Construction between Thompson's Corner and Observatory Park.	Constructors (Aust.) Pty. Ltd.	61,686 1 9
Jerilderie Shire ...	17	Construction of 2-span timber beam bridge over Algudgerie Creek.	N. E. White	1,870 18 0
Ryde Municipal ...	165	Adjustment of Properties, Victoria Road	Messrs. Ryan & Thompson.	2,674 10 0
Sydney City ...	...	Erection of Local Office in basement of southern pylon Sydney Harbour Bridge.	H. Mills	2,500 0 0
	...	Supply of up to 500 tons of 80/100 penetration bitumen in drums delivered into road vehicles at the refinery at Altona, Victoria.	Vacuum Oil Company Pty. Ltd.	9,250 0 0
	...	Supply of up to 3,300 tons of 80/100 penetration bitumen in drums loaded on to road vehicles or into rail trucks F.O.W., Sydney.	The Commonwealth Oil Refineries Ltd.	59,743 15 0
	...	Supply of up to 2,250 tons of 80/100 penetration bitumen in bulk and 1,100 tons in drums delivered into road vehicles or rail trucks ex the refinery at Matraville.	Bitumen and Oil Refineries (Aust.) Ltd.	56,350 0 0
	...	Supply of up to 2,850 tons of 80/100 penetration bitumen and up to 500 tons of 180/200 penetration bitumen in bulk or in drums delivered into road vehicles or rail trucks ex the refinery at Clyde.	The Shell Company of Australia, Ltd.	56,350 0 0

Reconstruction of Parramatta Road, Ashfield.

Battle Bridge to Rogers Avenue.

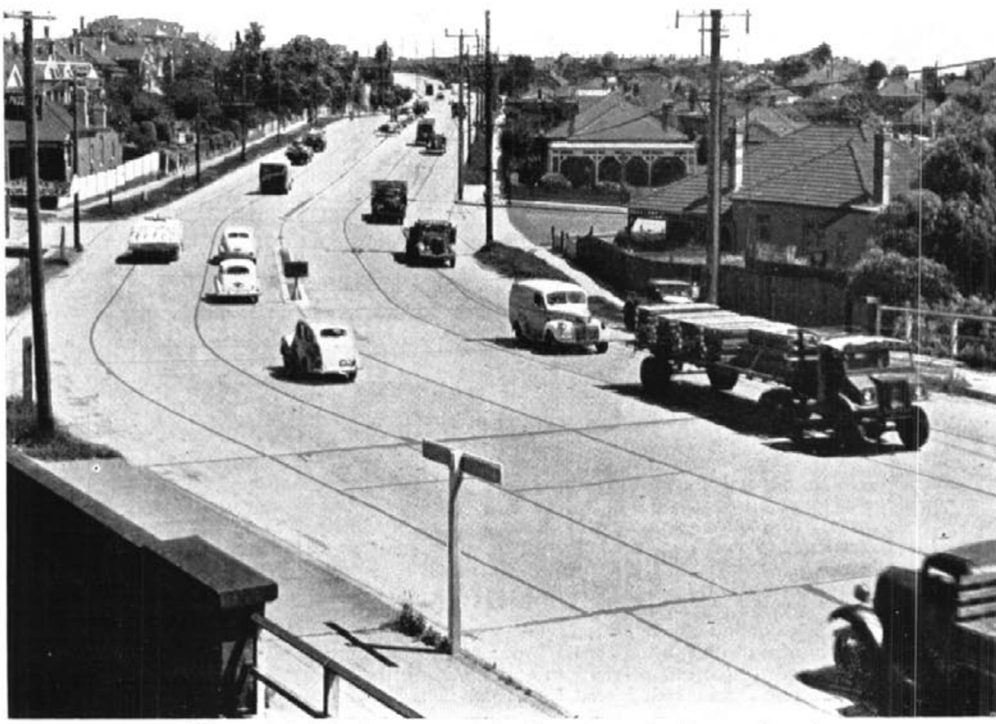
From the early days of New South Wales, Parramatta-road has ranked as a road of major importance. Originally it served as the connection between Port Jackson and the settlement of Parramatta, fifteen miles west. Then with the crossing of the Blue Mountains it carried all traffic between Sydney and the western part of the State.

Parramatta-road, now part of the Great Western Highway, still serves as a road connection between Sydney, Parramatta and the west, but it serves also the road transport needs of the extensive industrial and residential areas which now join Sydney and Parramatta. To-day it is one of the most heavily trafficked arterial roads in Australia.

Prior to the war, most of Parramatta-road was rebuilt with a cement concrete pavement. A further extension of this work has been recently completed, commencing at Battle Bridge, Ashfield, five miles by road west of the city business centre. The length of the work carried out is 3,900 feet. The Hume Highway, leading to Melbourne, commences on this portion of Parramatta-road.

Design.—The old bituminous pavement had been built up over the years to an excessive camber, and in some cases the thickness of metal and binder in the centre was as much as 22 inches. The central portion of the road was in reasonably good condition, but was too narrow for the traffic, the sides being too steep for moving vehicles. In an endeavour to save the central portion, a road design was prepared which necessitated raising kerbs and levels on building alignment by amounts of up to eighteen inches, but the interference with property, especially on the northern side, was severe and would have created hardship to owners. In addition, there was little saving in cost compared with reconstructing on the basis of leaving the kerb levels substantially unchanged. The latter method was consequently adopted. The new pavement has a maximum crossfall of 1 in 48, and only in a few isolated instances has it been necessary to alter kerb levels.

The reconstructed roadway provides for a six-lane 66-feet wide carriageway from Battle Bridge to the junction with the Hume Highway, 2,400 linear feet, and a six-lane 57 feet carriageway from the junction with Hume Highway to Rogers-avenue, 1,500 linear feet. There are 12 feet wide footpaths throughout. The concrete pavement is of 1 : 2 : 3 nominal mix, steel reinforced, 7 inches thick, with thickened edges at centre and kerbs. No change was made in the alignment of the road, which is built-up throughout, but grades were reduced slightly at the junction with the Hume Highway, and near Orpington-street. A 3-feet wide median strip has been constructed between Battle Bridge and the junction with the Hume Highway, incorporating sloping mountable kerbs.



View of finished pavement looking towards Sloane Street.

Junction of Great Western and Hume Highways.

At the junction with the Hume Highway, a traffic island has been provided, separating traffic entering Parramatta-road into two streams, one towards Parramatta and the other towards Sydney. Traffic will be controlled by signal lights. The junction has been designed to accommodate a future six-lane pavement in the Hume Highway.

Construction.—A depot was established on land at the corner of Parramatta-road and Dobroyd-parade, Haberfield, 1¼ miles west of the work. At the depot were situated the Local Office, store, blacksmith's shop and subsidiary buildings. It also contained a hutted camp complete with mess room, kitchen and washroom to accommodate 22 new Australian employees. Road work commenced in June, 1948.

A considerable amount of preliminary work by public utility authorities was necessary. In particular, the lowering by some feet of a large main between Sloane-street and the Hume Highway was a long and costly job, since lowering had to be done very gradually to maintain supply.

The reconstruction of the roadway had to be carried out in small sections, in order to minimise interference with traffic.

Extra cement was used in the pavement at some locations to permit earlier opening to traffic. A large amount of temporary work was required to allow traffic to pass from the old to the new sections of the pavement, there being as much as 20 inches difference in level.

Excavation totalled 16,020 cubic yards, consisting of old pavement, shale and clay. The material was, whenever possible, broken up and loaded by a skimmer shovel.

As space for stock-piling of aggregates was not readily available in the vicinity of the work, ready-mixed

View showing difference in levels between new and old pavements.

concrete was used, being transported from the mixing plant to the site in motor trucks equipped with special agitators.

After the concrete was spread by hand, final packing and levelling was carried out by two to three passes of a screed board fitted with a vibrator, followed by transverse screeding with a long-handled float. The surface was then finished by dragging longitudinally with wet hessian. When the concrete in the slab was sufficiently hard, the surface was covered with sand, loam or earth to a depth of two (2) inches. This covering was kept moist for at least ten (10) days and remained on the concrete for at least fourteen (14) days. Traffic was not permitted on the concrete for at least seven days after the removal of this covering. Where use of the pavement was required quickly, 12½ per cent. extra cement was added to the mix and the time for curing reduced by 50 per cent.

Quantities of Work.—

- Earthworks—Clay, shale and old bituminous macadam pavements—total, 16,020 c. yds. (solid measurement).
- Trimming and consolidating subgrade and footpaths—33,889 sq. yds.
- Excavation in all classes of materials for stormwater drains—798 c. yds.
- Concrete pipe culverts—sizes 9 in. to 24 in. dia.—2,362 l. ft.
- Subbase Sand 3 in.—28,723 sq. yds.
- Cement Concrete Slab 7 in. to 9 in. thick—28,723 sq. yds.
- Steel reinforcement—Dowels 20.3 tons, Barmat 74.1 tons—total 94.4 tons.
- Joints—Transverse 10,506 l. ft., longitudinal 16,081 l. ft.

Unit Costs of Main Items of Work.—(Direct costs only exclusive of Worker's Compensation Insurance, Pay Roll Tax, Holidays, Camp, Depot, Engineering Supervision and Clerical Costs).

- Earthworks—18s. 1d. per cu. yd. (solid measurement).
- Trimming and consolidating of subgrade, footpaths—1s. 9d. per sq. yd.
- Excavation in all classes of materials for stormwater drains—£1 4s. 1d. per cu. yd. (solid measurement).
- Concrete pipe culverts—Average for all sizes—9s. 3d. per l. ft.
- Subbase Sand 3-in.—1s. 8d. per sq. yd.
- Cement Concrete Slab 7 in. to 9 in. thick (1⅛ : 2 : 3 mix 40 per cent., 1 : 2 : 3 mix 60 per cent.)—20s. 7d. per sq. yd.
- Steel reinforcement in place: Dowels, £28 16s. 5d. per ton; Barmat, £34 19s. per ton.
- Joints: Transverse, 1s. 6d. per l. ft.; Longitudinal, 1s. per l. ft.

Supervision.—Construction was under the general direction of the Department's Metropolitan Engineer, being Mr. A. J. Clinch in the first instance, and latterly Mr. L. W. Hawley. The engineer in immediate charge was Mr. R. J. Milner assisted by Mr. K. Twartz.

PAYMENTS FROM THE ROAD FUNDS FOR PERIOD 1st JULY, 1950, TO 30th SEPTEMBER, 1950.

	Amount Paid.
County of Cumberland Main Roads Fund:	£
Construction of Roads and Bridges	150,705
Acquisition of Land and Buildings for Road Widening	20,242
Maintenance of Roads and Bridges	158,905
Interest, Exchange and Repayment of Loans	13,401
Other Expenditure	41,845
Total	£385,098
Country Main Roads Fund:	£
Construction of Roads and Bridges	281,213
Acquisition of Land and Buildings for Road Widening	5,078
Maintenance of Roads and Bridges	723,538
Interest, Exchange and Repayment of Loans	34,553
Purchase and Repair of Plant and Motor Vehicles	81,796
Other Expenditure	49,139
Total	£1,175,317
Developmental Roads Fund:	£
Construction of Roads and Bridges	5,443
Other Expenditure	403
Total	£5,846
Summary All Funds:	£
Construction of Roads and Bridges	437,361
Acquisition of Land and Buildings for Road Widening	25,320
Maintenance of Roads and Bridges	882,443
Interest, Exchange and Repayment of Loans	47,954
Purchase and Repair of Plant and Motor Vehicles	81,796
Other Expenditure	91,387
Total	£1,566,261

MAIN ROADS STANDARDS.

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

Form No.

EARTHWORKS AND FORMATION.

70 Formation. (Revised, June, 1949.
A 1532 Standard Typical Cross-sections.
A 1149 Flat Country Cross-section, Type A. (Revised, 1930.
A 1150 Flat Country Cross-section, Type B. (Revised, 1936.)
A 1151 Flat Country Cross-section, Type D1. (Revised, 1936.
A 1152 Flat Country Cross-section Type D2. (Revised, 1930.)
A 1476 Flat Country Cross-section, Type E1. (Revised, 1937.)
A 1101 Typical Cross-section One-way Feeder Road. (1936.)
A 1102 Typical Cross-section Two-way Feeder Road. (1931.)
A 114 Rubble Retaining Wall. (1941.)

PAVEMENTS.

71 Gravel Pavement. (Revised, June, 1949.)
228 Reconstruction with Gravel of Existing Pavements. (Revised, January, 1939.)
254 Supply and Delivery of Gravel. (Revised, August, 1939.)
72 Broken Stone Base Course. (Reprinted with amendments, August, 1947.)
68 Reconstruction with Broken Stone of Existing Pavement to form a Base Course. (Revised, October, 1933.)
296 Tar. (Revised, May, 1949.)
337 Bitumen. (Revised, February, 1939.)
305 Bitumen Emulsion. (Revised, September, 1942.)
351 Supply and Delivery of Aggregate. (Revised, July, 1941.)
65 Waterbound Macadam Surface Course. (July, 1939.)
301 Supply and Application of Tar and/or Bitumen. (Revised, June, 1950.)
122 Surfacing with Tar. (Revised, January, 1949.)
145 Surfacing with Bitumen. (Revised, January, 1949.)
93 Re-surfacing with Tar. (Revised, January, 1949.)
94 Re-surfacing with Bitumen. (Revised, January, 1949.)
230 Tar or Bitumen Penetration Macadam, Surface Course, 2 inches thick. (Revised, December, 1936.)
66 Tar or Bitumen Penetration Macadam, Surface Course, inches thick. (Revised, September, 1936.)
125 Cement Concrete Pavement (April, 1939) and Plan and Cross-section A 1147 (March, 1932).
466 Bituminous Flush Seals and Reseals—Fluxing of Binders. (January, 1949.)

GENERAL.

342 Cover Sheet for Specifications, Council Contract. (Revised, January, 1948.)
24B General Conditions of Contract, Council Contract. (Revised, September 1950.)
64 Schedule of Quantities.
39 Bulk Sum Tender Form, Council Contract. (Revised, August, 1946.)
38 Bulk Sum Contract Form, Council Contract.
121 Provision for Traffic (Revised, June, 1947) with general arrangement, A 1323 and details A 1325 of temporary signs. (Revised January, 1947.)
A 1342 Warning Signs, Details of Construction.
A 1346 Iron Trestles for Road Barriers.
A 1341 Timber Trestle and Barrier.
A 1824 Light Broom Drag. (1941.
A 1924 Pipe Frame Drag.
A 178 Mould for Concrete Test Cylinder.
A 1381–3, A 1452–5 } Tree Guards, Types A, B, C, D, E, F, and G.
197 Hire of Council's Plant. (Revised, April, 1937.)
A 478 Specimen Drawings, Rural Road Design, with drawings A478A and A 478B.
A 478C Specimen Drawing, Flat Country Road Design.
A 1113 Rural Road Plan and Longitudinal Section Form tracing cloth).
A 1114 Rural Road Cross-section Form (tracing cloth).
A 1115 Urban Road Plan Forms (tracing cloth).
193 Duties of Superintending Officer (instructions). (Revised, July, 1938.)
314 Standard Regulations for Running of Ferries. (Revised, December, 1948.)
A 1645 Stadia Reduction Diagram. (1939.)
355 Instructions for Design of Two-lane Rural Highways (1937)
A 1487 Horizontal Curve Transitions (diagrams).
A 1488, A 1488A, A 1488B, and A 1488C.—Horizontal Curve Transitions (tables for speeds of 30, 40, 50, and 60 miles per hour).
A 1614 Widening of Shoulders on Crests.
369 Instructions for Design of Urban Roads (1939).
288 Instructions for Design of Intersections (Revised, January, 1948.)
402 Instructions for Design of Rural Intersections (acceleration and deceleration lanes). (1941.)

Form No.

KERBS, GUTTERS, AND GULLY PITS.

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

FENCING.

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

BRIDGES AND CULVERTS.

A 4 Standard Bridge Loading (general instruction). (1948.)
A 4A Standard Bridge Loading (instruction for dead-end Developmental Roads.) (Revised, 1938.)
18 Data for Bridge Design. (Revised, November, 1948.)
84 Data accompanying Bridge or Culvert Designs.
A 26 Waterway Diagram. (Revised, 1943.)
371 Waterway Calculations. (1939.)
A 421 Boring Gear. 2 inches. (1930.)
A 44 Boring Gear, 3½ inches. (1949.)
A 2995 Rod Sounding Apparatus, with tripod (1947).
25 Pipe Culverts and Headwalls (Revised, December, 1939) and drawings. Single Rows of Pipes, 15 in. to 21 in. dia. (A 143), 2–3 ft. dia. (A 139),, 3 ft. 6 in. dia. (A 172), 4 ft. dia. (A 173), 4 ft. 6 in. dia. (A 174), 5 ft. dia. (A 175) 6 ft. dia. (A 177); Double Rows of Pipes, 15 in. to 21 in. dia. (A 211) 2–3 ft. dia. (A 203), 3 ft. 6 in. dia. (A 215), 4 ft. dia. (A 208), 4 ft. 6 in. dia. (A 207), 5 ft. dia. (A 206), 6 ft. dia. (A 213); Treble Rows of Pipes, 15 in. to 21 in. dia. (A 210), 2–3 ft. dia. (A 216), and Straight Headwalls for Pipe Culverts, 15–24 in. dia. (A 1153).
A 1 Joint for Concrete Pipes. (Revised, August, 1933.)
A 142 Inlet Sump Pipe Culverts for 3 ft. dia. or less. (Revised, December, 1947.
138 Pre-Cast Concrete Box Culvert (Revised, February, 1948) and drawings 9 in. high (A 485), 12 in. (A 446), 1 ft. 6 in. (A 447), 2 ft. (A 448) 2 ft. 6 in. (A 449).
206 Reinforced Concrete Culvert (Revised, February, 1948) and instruction sheets (A 305, A 359, A 306, A 304).
A 1832 Cast-in-Place Concrete Pipe Culverts. (1942.)
A 309 Concrete Culvert Posts. (Revised, June, 1937.)
300 Pile Drivers, specification for 25 ft., and drawings for 50 ft. (A 209) 40 ft (A 253), and 25 ft. portable (A 1148).
A 1886 Arrangement of Bolting Planks for various widths of deck. (Revised, September, 1948.)
A 45 Timber Bridge, Standard Details. (Revised, May, 1949.)
A 1791 Timber Beam Skew Bridge Details. (Revised, May, 1949.)
164 Timber Beam Bridge (Revised, April, 1947) and instruction sheets, 12 ft. (A 3469), 20 ft. (A 70) revised, May, 1949, and 22 ft. (A 1761). (Revised, May, 1949.)
A 3470 and A 3471.—Low Level Timber Bridges—Instruction sheets for 12 feet and 20ft. between kerbs. (Revised, May, 1949.)
A 1223 (Revised, May, 1949) and A 3472 (Revised, May, 1949) Single Span Timber Culverts instruction sheets for 20 ft. and 22 ft. between kerbs.
139 Timber Culvert (Revised, January, 1950) and drawings, 1 ft. 6 in. high (A 427), 2 ft (A 428), 3 ft. (A 429), 4 ft. (A 430), 5 ft. to 8 ft. high, (A 431). (1928.)
326 Extermination of Termites in Timber Bridges. (Revised, October, 1940).
A 222 Pipe Handrailing Details. (Revised, July, 1947.)
350 Reinforced Concrete Bridge. (Revised, April, 1949.
495 Design of Forms and Falsework for Concrete Bridge Construction (September, 1947.)

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

Sydney: A. H. Pettifer, Government Printer—1950.

State Highway System
of the
State of New South Wales

Area of New South Wales, 309,433 square miles.
Length of public roads within New South Wales, 126,272 miles.

MILEAGE OF ROADS CLASSIFIED UNDER THE MAIN ROADS ACT, AS AT 1st JULY, 1950.

State Highways	6,513
Trunk Roads	4,031
Main Roads	12,628
Secondary Roads (County of Cumberland only)	68
Developmental Roads	2,783
	26,023
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	2,617
TOTAL ...	28,640