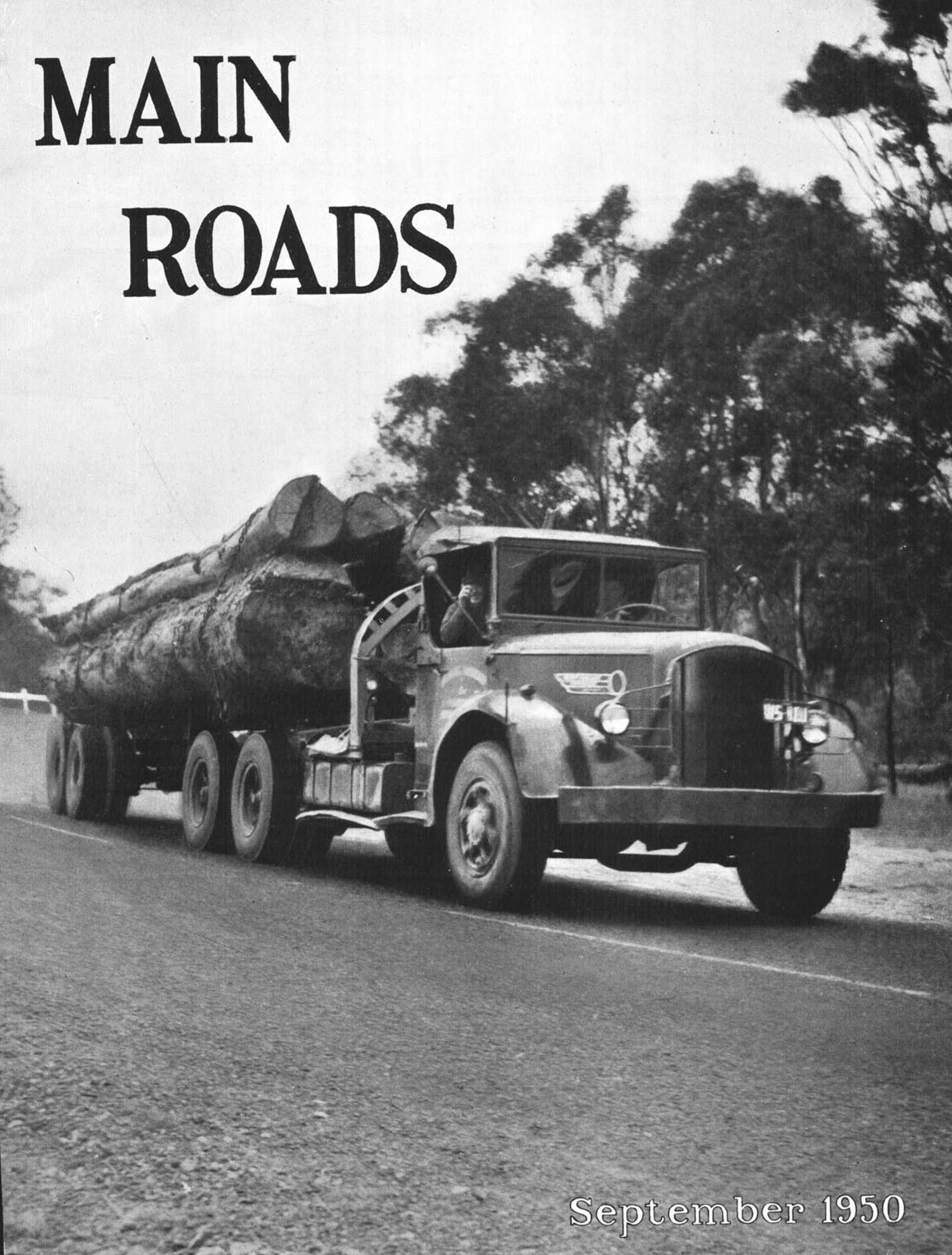
MAIN ROADS



September 1950

MAIN ROADS.

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Cover Page.

Timber haulage on the Prince's Highway between Kiama and Wollongong.

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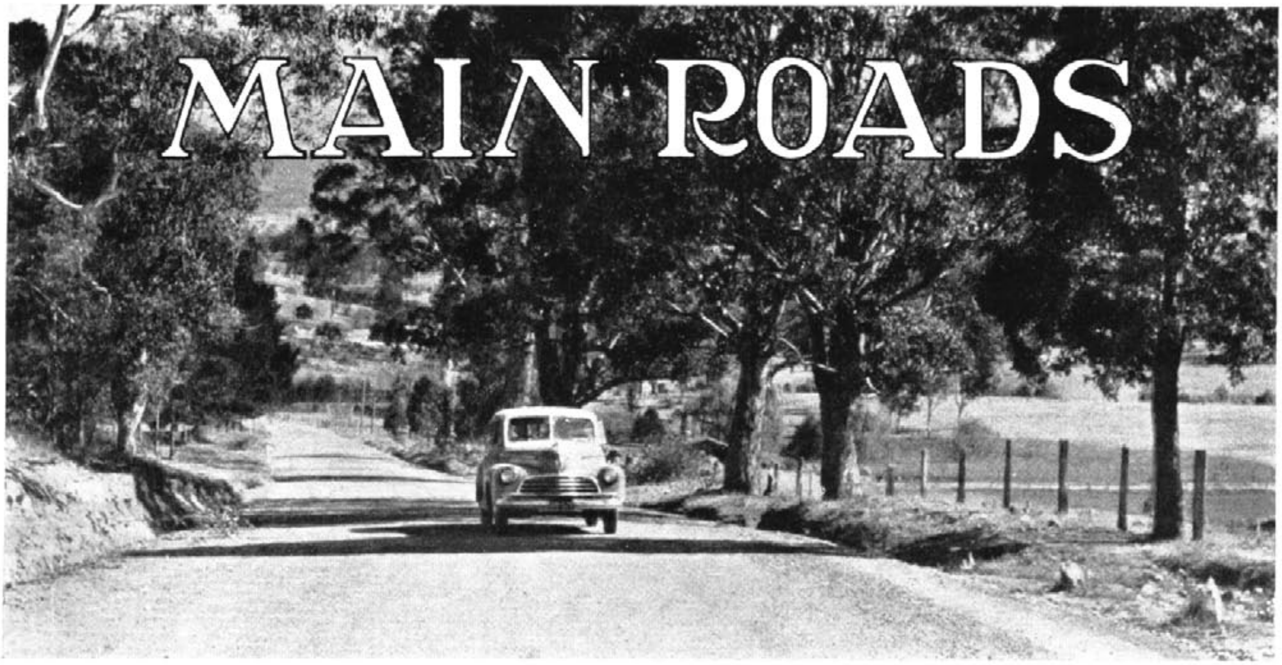

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Loads and Roads

Effect of Heavy Vehicles on Road Pavements

Ordinance 30c now Revised

Prior to the war, the principal highways of the State successfully carried the traffic imposed on them. Since the war, there has been a large increase in the use of heavy road vehicles, including long distance haulage, and considerable damage to roads has occurred. This has been especially noticeable on those of the principal State Highways which carry the bulk of the long distance traffic. The roads from Sydney to Albury (Hume Highway), to Bathurst and Dubbo (Great Western and Mitchell Highways), and to Newcastle and the New England District (Pacific and New England Highways), have been particularly affected. Main Roads in some of the larger towns have also suffered.

In addition to the sudden increase in volume of traffic on the principal State Highways, there has been also a gradual change in the type of traffic using the roads due partly to the greater increase in registrations of motor lorries when compared with cars, and partly to the new types of lorries brought into use.

In 1930 lorries were 19 per cent. of all registered vehicles; in 1935, 22 per cent.; in 1940, 24 per cent.; in 1945, 29 per cent., and in 1949, 32 per cent.

It was just about the time when the war broke out that large semi-trailer vehicles first appeared in significant numbers in New South Wales. Since then, 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. This type of vehicle appears to find its greatest use in relatively short hauls of bulk materials, such as broken stone and coal, although it is also used on long hauls, frequently with a trailer.

The introduction and widespread use of these two new types of vehicles, and the tendency to overload them, has accentuated the damage which has been occurring on main roads. The pavements of the principal roads of the State were not built to carry traffic of the type and volume using them during recent years. The cost of repairing damage which has already occurred to the State Highways is very considerable.

Weight of vehicular loads on main roads in New South Wales is controlled under the Local Government Act, Ordinance 30c. A similar Ordinance (No. 30D) applies to roads other than proclaimed main roads.

Control of weight of loads to protect roadways necessarily has to cover two aspects,—(a) the road pavement, and (b) bridges. A limit on wheel or axle load provides the means to protect road pavements, while a limit on the total weight of a vehicle plus load is sufficient to protect bridges, although the length over which the load is distributed (*i.e.*, in effect, the length of the vehicle) must also be considered.

Prior to the war, Ordinance 30C proved generally adequate to protect main roads from damage. Individual over-weight vehicles appeared from time to time, but appropriate action was taken by Councils or the Department of Main Roads. Where necessary, prosecutions were launched, and overloading was kept under control.

In recognition of the change during recent years in types of vehicles, and following discussions with representatives of other States with the object of securing uniformity, and with other interested parties, the Department of Main Roads recommended an amendment of Ordinance No. 30C.

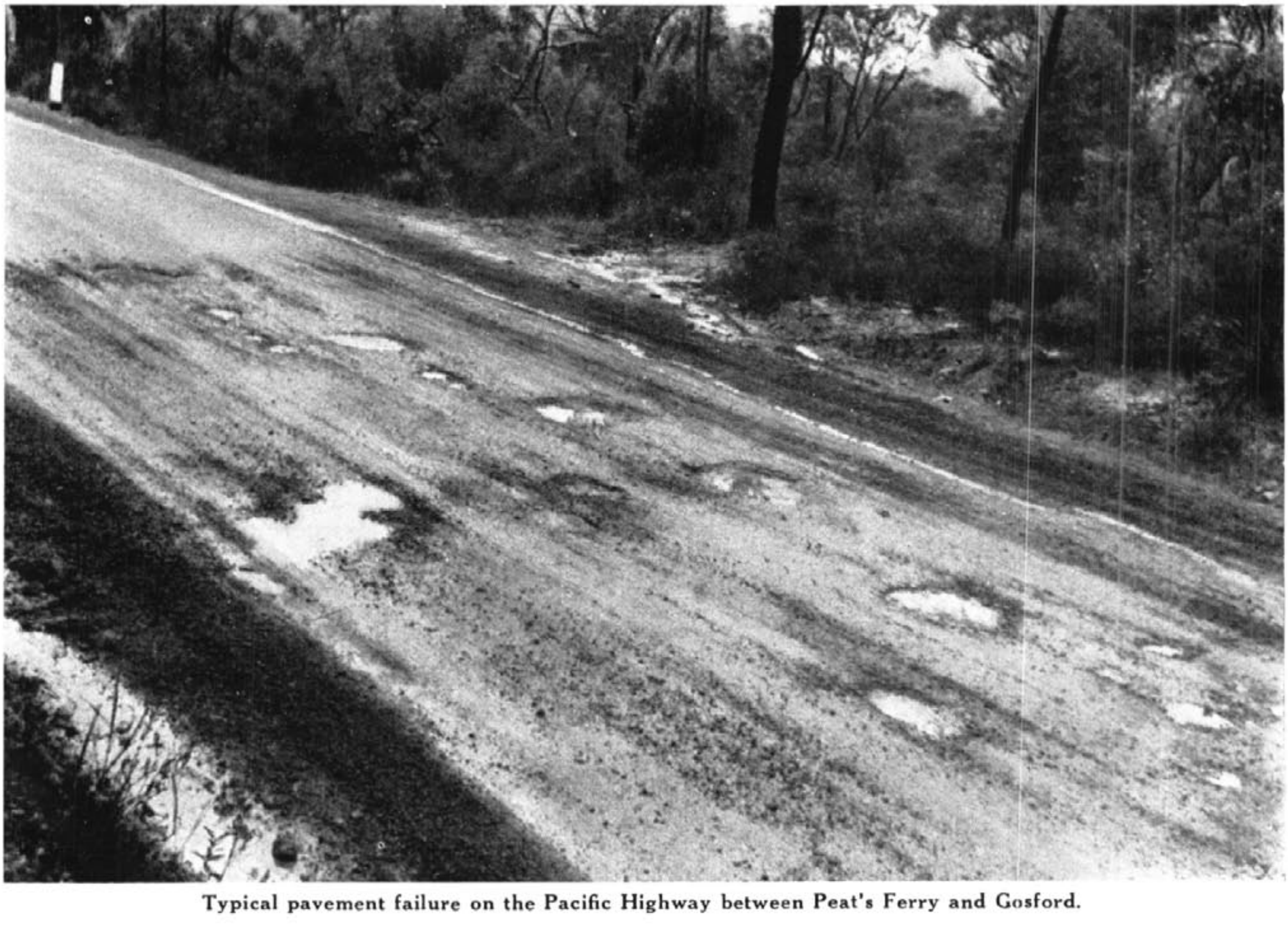
The trend towards higher total vehicular loads and higher axle loads is not unreasonable in itself provided it does not result in destruction of roads and bridges. The capital asset, represented by the roads and bridges, has been created by the community in the past and must be protected against undue damage.

Looking to the future, it is apparent that a balance must somehow be struck between Loads and Roads. The point at which this should occur, should be determined by road transport costs, and will be the point at which the total costs per ton-mile are a minimum, including in total costs both cost of road upkeep as well as direct cost of vehicle operation. This point of balance will not be the same in every country owing to variations in cost of vehicles, fuel, labour, road construction and maintenance and other components of total road transport cost. Likewise, it will not necessarily be the same in all parts of any particular country.

While it may be in the community interest to provide heavily constructed pavements on some routes, adapted for heavy wheel and vehicle loadings, there will remain a far greater mileage of roads where it would not be economical for pavement construction to be much heavier than that existing, and where in any event the necessary funds could not be found for more costly roadways.

The problem of road damage resulting from heavier vehicular loadings has received considerable public notice in the United States during recent years, as a result of a trend there also towards the use of heavier vehicles. Highway authorities have not been slow to point out the inevitable results of the trend, and the need for calling a halt to it.

The economics of road transport in respect of vehicular weights and roads costs has received some study in Australia. The subject is under special research in the United States by the United States Highway Research Board. Such research and studies will gradually build up a body of reliable information



Typical pavement failure on the Pacific Highway between Peat's Ferry and Gosford.

Example of pavement failure on Hume Highway on Breadalbane Plains between Goulburn and Gunning.

leading to the theoretically correct economic adjustment of roads and loads under various conditions. Should investigation indicate that heavier road pavements are necessary in the interests of the community, to secure cheaper total cost of road transport, such heavier pavements could only be provided over a lengthy period on account of cost involved. It is apparent, therefore, that at this stage all efforts must be directed at preserving from undue damage the asset in the road system already created by the community.

The amendment of Ordinance 30C which appeared in Government Gazette No. 122 of 28th July, 1950, provides, in general, for some increase in the loading for most types of vehicles which, because of their axle and tyre equipment and axle spacing, may carry heavier loads without undue damage to roads and bridges. In the case of those vehicles with inadequate tyre equipment or unsuitable axle spacing, the amendment provides for some reduction in loading. An important provision of the amendment is that the one scale of limitations applies to main roads, instead of different limitations within and outside the Metropolitan Traffic Area as provided in the Ordinance before amendment.

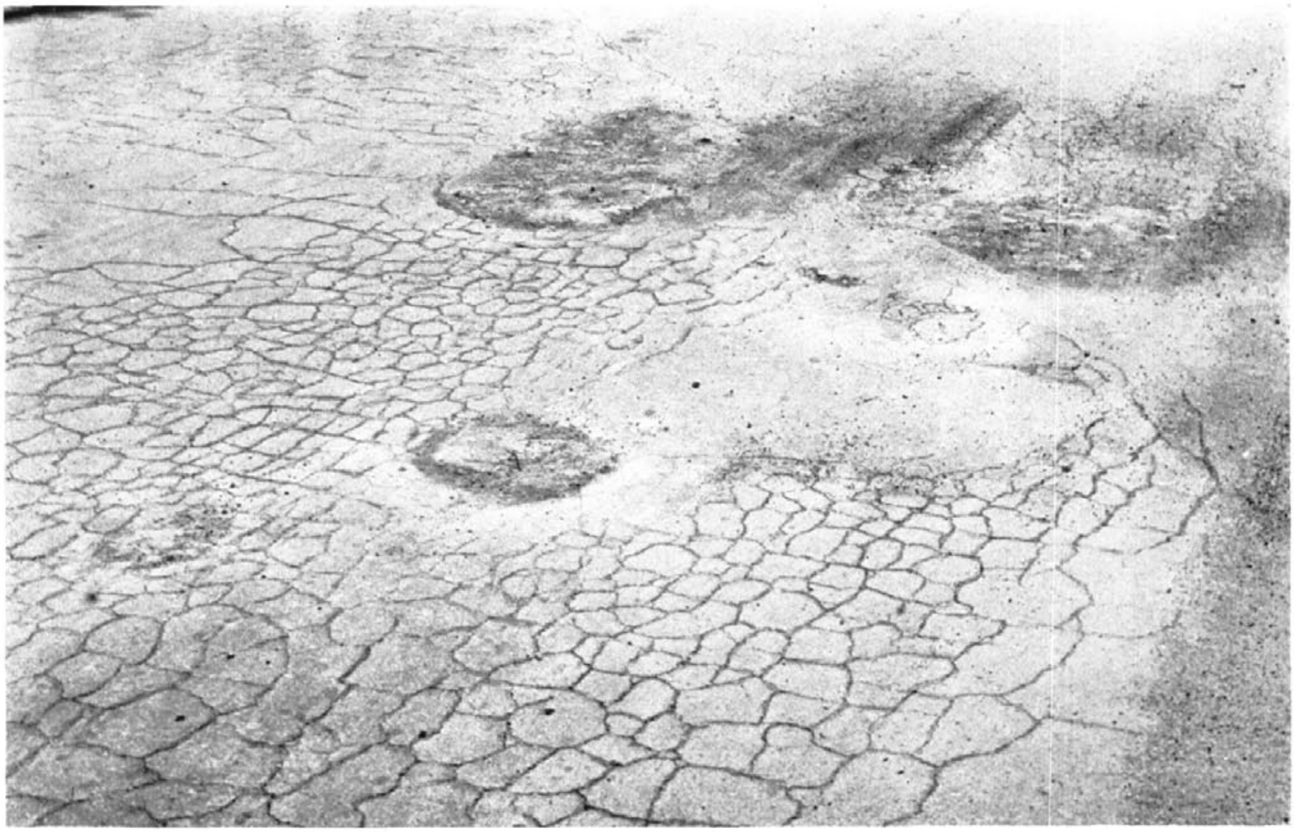
The amended limitations are based on a maximum axle load of 18,000 lb. (8 tons) on dual tyred axles, corresponding to that recommended by the American Association of State Highway Officials and adopted in most American States. On this basis of an 18,000 lb. (8 tons) axle load, the following limitations have been provided for single and bogie axles with varied tyre equipment and for tyre pressure not exceeding 100 lb. per square inch:—

(a) (i) Single axle, single tyres (2 tyres only), 4½ tons.
(ii) Single axle, single tyres (2 tyres only), if the tyre pressure does not exceed 75 lb. per square inch, 5½ tons.
(b) Single axle, dual (or more) tyres, 8 tons.
(c) Two (or more) axles (bogie), single tyres, 9 tons.
(d) Two (or more) axles (bogie), dual tyres, 13 tons.

The overall loading or, in other words, the maximum permissible vehicle loaded weight, is covered by a tabulation of limitations based on the formula $W = C (L - 40)$, also developed by the American Association of State Highway Officials, and applies to all axle groups. In this formula—

W = Weight in lb.
C = A coefficient.
L = The length in feet.

The coefficient adopted in the amendment of Ordinance 30C is 600 for axle spacing to 18 feet and 650 for axle spacing in excess of 18 feet. The break at 18 feet has been adjusted to a smooth curve. Overall loadings are as set out in the tabulation on page 6 which extends to 60 feet. The length of vehicles in this State is limited by the regulations under the Motor



Pavement failure on Great Western Highway on the Blue Mountains.

Traffic Act to 45 feet overall and it is, therefore, necessary for prior reference to the Police Department should any increase in vehicle length in excess of the legal limit of 45 feet overall be proposed.

Distance between extreme axles of vehicle or any group of axles of the vehicle.	Maximum loaded weight of vehicle or group of axles.	
	tons.	cwts.
Exceeding 40 inches and not exceeding 8 feet......	13	0
Exceeding 8 feet and not exceeding 9 feet	13	3
Exceeding 9 feet and not exceeding 10 feet	13	10
Exceeding 10 feet and not exceeding 11 feet	13	17
Exceeding 11 feet and not exceeding 12 feet	14	3
Exceeding 12 feet and not exceeding 13 feet	14	10
Exceeding 13 feet and not exceeding 14 feet	14	17
Exceeding 14 feet and not exceeding 15 feet	15	3
Exceeding 15 feet and not exceeding 16 feet	15	10
Exceeding 16 feet and not exceeding 17 feet	15	17
Exceeding 17 feet and not exceeding 18 feet	16	3
Exceeding 18 feet and not exceeding 19 feet	16	10
Exceeding 19 feet and not exceeding 20 feet	16	16
Exceeding 20 feet and not exceeding 21 feet	17	3
Exceeding 21 feet and not exceeding 22 feet	17	9
Exceeding 22 feet and not exceeding 23 feet	17	16
Exceeding 23 feet and not exceeding 24 feet	18	2
Exceeding 24 feet and not exceeding 25 feet	18	9
Exceeding 25 feet and not exceeding 26 feet	18	15
Exceeding 26 feet and not exceeding 27 feet	19	2
Exceeding 27 feet and not exceeding 28 feet	19	8
Exceeding 28 feet and not exceeding 29 feet	19	14
Exceeding 29 feet and not exceeding 30 feet	20	1
Exceeding 30 feet and not exceeding 31 feet	20	7
Exceeding 31 feet and not exceeding 32 feet	20	13
Exceeding 32 feet and not exceeding 33 feet	21	0
Exceeding 33 feet and not exceeding 34 feet	21	6
Exceeding 34 feet and not exceeding 35 feet	21	12
Exceeding 35 feet and not exceeding 36 feet	21	18
Exceeding 36 feet and not exceeding 37 feet	22	4
Exceeding 37 feet and not exceeding 38 feet	22	10
Exceeding 38 feet and not exceeding 39 feet	22	16
Exceeding 39 feet and not exceeding 40 feet	23	3
Exceeding 40 feet and not exceeding 41 feet	23	9
Exceeding 41 feet and not exceeding 42 feet	23	15
Exceeding 42 feet and not exceeding 43 feet	24	1
Exceeding 43 feet and not exceeding 44 feet	24	7
Exceeding 44 feet and not exceeding 45 feet	24	12
Exceeding 45 feet and not exceeding 46 feet	24	18
Exceeding 46 feet and not exceeding 47 feet	25	4
Exceeding 47 feet and not exceeding 48 feet	25	10
Exceeding 48 feet and not exceeding 49 feet	25	16
Exceeding 49 feet and not exceeding 50 feet	26	1
Exceeding 50 feet and not exceeding 51 feet	26	7
Exceeding 51 feet and not exceeding 52 feet	26	13
Exceeding 52 feet and not exceeding 53 feet	26	19
Exceeding 53 feet and not exceeding 54 feet	27	5
Exceeding 54 feet and not exceeding 55 feet	27	10
Exceeding 55 feet and not exceeding 56 feet	27	16
Exceeding 56 feet and not exceeding 57 feet	28	2
Exceeding 57 feet and not exceeding 58 feet	28	8
Exceeding 58 feet and not exceeding 59 feet	28	14
Exceeding 59 feet and not exceeding 60 feet	28	19

Provision is included in the amendment, similarly to that included in the original Ordinance, for some increased overall loading to operate for two years to enable adjustment of vehicles and loading to the new limitations. As from 1st July, 1952, the increased overall limitations will cease, and the foregoing table of overall limitations will automatically apply.

Provision is also made for increased overall loading up to 4½ tons for four-axled rigid vehicles having two steering axles which are registered within twelve months of 28th July, 1950.

In both cases the increased loading applies to overall loading, or gross vehicle weight only, and axle limitations remain unchanged.

The increased overall loading, to apply for the two year transition period, is set out in the following tabulation:—

Distance between extreme axles of vehicle or any group of axles of the vehicle.	Maximum loaded weight of vehicle or group of axles.	
	tons.	cwts.
Exceeding 8 feet and not exceeding 9 feet	15	0
Exceeding 9 feet and not exceeding 10 feet	15	8
Exceeding 10 feet and not exceeding 11 feet	15	17
Exceeding 11 feet and not exceeding 12 feet	16	6
Exceeding 12 feet and not exceeding 13 feet	16	14
Exceeding 13 feet and not exceeding 14 feet	17	3
Exceeding 14 feet and not exceeding 15 feet	17	11
Exceeding 15 feet and not exceeding 16 feet	17	19
Exceeding 16 feet and not exceeding 17 feet	18	8
Exceeding 17 feet and not exceeding 18 feet	18	16
Exceeding 18 feet and not exceeding 19 feet	19	4
Exceeding 19 feet and not exceeding 20 feet	19	12
Exceeding 20 feet and not exceeding 21 feet	20	0
Exceeding 21 feet and not exceeding 22 feet	20	8
Exceeding 22 feet and not exceeding 23 feet	20	16
Exceeding 23 feet and not exceeding 24 feet	21	4
Exceeding 24 feet and not exceeding 25 feet	21	12
Exceeding 25 feet and not exceeding 26 feet	21	19
Exceeding 26 feet and not exceeding 27 feet	22	7
Exceeding 27 feet and not exceeding 28 feet	22	15
Exceeding 28 feet and not exceeding 29 feet	23	3
Exceeding 29 feet and not exceeding 30 feet	23	10
Exceeding 30 feet and not exceeding 31 feet	23	18
Exceeding 31 feet and not exceeding 32 feet	24	5
Exceeding 32 feet and not exceeding 33 feet	24	13
Exceeding 33 feet and not exceeding 34 feet	25	0
Exceeding 34 feet and not exceeding 35 feet	25	7
Exceeding 35 feet and not exceeding 36 feet	25	14
Exceeding 36 feet and not exceeding 37 feet	26	2
Exceeding 37 feet and not exceeding 38 feet	26	9
Exceeding 38 feet and not exceeding 39 feet	26	16
Exceeding 39 feet and not exceeding 40 feet	27	3
Exceeding 40 feet and not exceeding 41 feet	27	10
Exceeding 41 feet and not exceeding 42 feet	27	17
Exceeding 42 feet and not exceeding 43 feet	28	4
Exceeding 43 feet and not exceeding 44 feet	28	10
Exceeding 44 feet and not exceeding 45 feet	28	17
Exceeding 45 feet and not exceeding 46 feet	29	4
Exceeding 46 feet and not exceeding 47 feet	29	11
Exceeding 47 feet and not exceeding 48 feet	29	17
Exceeding 48 feet and not exceeding 49 feet	30	4
Exceeding 49 feet and not exceeding 50 feet	30	10
Exceeding 50 feet and not exceeding 51 feet	30	17
Exceeding 51 feet and not exceeding 52 feet	31	3
Exceeding 52 feet and not exceeding 53 feet	31	9
Exceeding 53 feet and not exceeding 54 feet	31	16
Exceeding 54 feet and not exceeding 55 feet	32	2
Exceeding 55 feet and not exceeding 56 feet	32	8
Exceeding 56 feet and not exceeding 57 feet	32	14

Consideration is now being given by local government authorities to the amendment of Ordinance 30D which applies to roads other than main roads. Pending any such amendment, the limitations, which correspond to the limitations of Ordinance 30C prior to the recent amendment, will continue to apply to other than main roads.

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for Period 1st July, 1949, to 30th June, 1950.

Income.

	£
Road Tolls	438,898
Contributions—	
Railway Passengers	129,000
Tramway Passengers	13,800
Omnibus Passengers	13,500
Rent from Properties	12,768
Miscellaneous	149
	£608,115

Expenditure.

	£	£
Cost of Collecting Road Tolls		30,343
Maintenance and Minor Improvements		70,570
Alterations to Archways		3,243
Construction of new Toll Barrier and Office ..		19,098
Administrative Expenses		2,233
Loan Charges—		
Interest	241,957	
Exchange	26,172	
Sinking Fund	68,949	
Management Expenses	1,932	
		339,010
Miscellaneous		607
		£465,104

NOTE.—The figures in this Statement are subject to adjustment upon completion of accounts for the year.

United States Highway Practice

Extracts from a report by C. A. Hawkins, B.E., M.I.E. (Aust.), Deputy Chief Engineer, following a visit to the United States in 1949.

Continued from p. 120, June, 1950, issue *Main Roads*.

FOUNDATIONS AND PAVEMENTS.

Concrete Pavements.—Practices and trends in regard to concrete pavement construction noted in the United States were:—

(1) In all States visited, a minimum of 6 inches thickness of granular sub-base is being used under concrete pavements. (A sub-committee of the Highway Research Board which investigated failures due to pumping found that no pumping occurred where subgrade soil contained at least 55 per cent. of material retained on a 200 sieve, and the Plastic Index was less than seven.)

In California, sub-base treatment is carried out for a depth of up to 3 feet below the surface, depending on the nature of the subgrade.

(2) With one exception, all States visited were using 8 inches uniform thickness slab.

(3) No States were using edge or corner bar reinforcement.

(4) In regard to joint practice, variation noted was as follows:—

Indiana: Contraction joints *only*, 40-ft. spacing, with ¾-in. diameter load-transfer steel 2 feet long at 1-ft. centres.

Ohio: Contraction joints at 40-ft. spacing, with expansion joints at 300 feet to 700 feet spacing, depending on the air temperature at the time of pouring. Load transfer steel at contraction joints was 1-in. diameter bars 18 inches long at 1-ft. centres.

California: Dummy contraction joints at 15-feet centres with no load transfer steel. No expansion joints.

Washington and Oregon: Dummy contraction joints at 15-feet centres, with no load transfer steel. Expansion joints at 300 feet centres with load transfer steel.

(5) All States visited are using tie bars across the longitudinal contraction joint. The West Coast States are constructing all pavement a lane at a time. Ohio and Indiana are using a dummy centre joint with thin mastic ribbon inserted immediately after the spreading and screeding.

(6) Ohio and Indiana are using bar mat throughout; the West Coast States are using none.

(7) On the west coast, finishing is by "Johnston" finishing machine (see illustration on page 10), with further striking off of joint with steel screed pulled across the concrete after partial set.

Finishing in Indiana is by mechanical bull float and transverse belting; in Ohio by transverse belting only.

Present practice in California is not to hand-tool contraction joints after finishing with the "Johnston" finishing machine, but to allow the joint to crack.

(8) Indiana is curing all slabs with straw which is subsequently used for mulching the side slopes. All other States visited are using membrane curing.

(9) New Jersey and Pennsylvania were not visited, but it is understood that these two States, New Jersey particularly, are adhering to close spacing of expansion joints with heavy steel load transfer and steel reinforcement throughout the slab.

Bituminous Pavements.—In this field, the principal divergence of practice is between the use of dense-graded and open-graded plant-mixed bituminous paving mixtures.

For city streets, sheet asphalt or sand asphalt is in general use. For heavily trafficked roads, normal practice is to use either asphaltic concrete or stone-filled sheet asphalt, although both are normally referred to as asphaltic concrete in the United States, this description being related rather to the consistency of the binder than to the grading of the aggregate. It is with the medium traffic volume roads that the main divergence of practice occurs.

Densely graded plant mix is being used on medium traffic volume highways in the southern States, Georgia, North and South Carolina, and Virginia; open graded mixes are being used in Ohio and Indiana, and thin mats, ¾-in., 1¼-in. and 2¼-in. of bituminous penetration are being used successfully in Oregon. Bituminous penetration is also extensively used in the New England States.

Road mixes using crushed stone or gravel were seen being laid in Georgia and in Ohio. These contained a certain amount of fines, but less fines and filler than used in asphaltic concrete.

In California, satisfactory bituminous wearing courses have been obtained by road mixing asphaltic cut-backs with suitable weathered granite or sand-clays. No surface treatment is superimposed on the road mix other than a fog coat to enrich the surface, and one pavement was seen that had been down ten years without retreatment. The Californian climate, with all the rainfall in the winter and a dry summer, is most suitable for carrying out this type of work.

In Georgia and the two Carolinas, a considerable volume of bituminous and cement stabilisation of sand clays is undertaken, but this work is always covered by what is referred to in the south as bituminous surface treatment, and in California as armour coat. This surface treatment or armour coat is also used direct on sand clays, top soils and crushed-stone pavements. The procedure is similar to that adopted for bituminous surface treatment in this State, but usually the treatment is such as to give a mat about 1-inch thick.

The South Carolina surface treatment process, which is typical, is, briefly, as follows:—

Tar primer—
0.3 to 0.35 U.S. gall. per sq. yd.
First application asphalt—
0.4 to 0.45 U.S. gall. per sq. yd.
Crushed stone—
1 inch down to ½ inch.
Second application asphalt—
0.2 to 0.25 U.S. gall. per sq. yd.
Crushed stone—
⅜ inch gauge.
Third application asphalt—
0.2 to 0.25 U.S. gall. per sq. yd.

No final cover stone is used and traffic is kept off the final spray for up to three days.

As in New South Wales, failures of some low-cost pavements have occurred due to variation in the quality of gravel or sand-clay used in base courses.

A considerable amount of blending of base-course material is carried out and, in Georgia, sand-clay base courses are remixed in the road bed in order to obtain greater uniformity, and, in California, 2 per cent. of cement has been added to reduce the Plastic Index of the material and take care of any pockets in the base-course material where the plasticity is above average.

There is no hard and fast line between subgrade treatment and base-course construction and, generally, the tendency is to provide more sub-base treatment and less base course than is the practice in New South Wales. For example, a typical Federal Aid Secondary work on San Mateo County, California, comprised:—

Sub-grade treatment—
8-inch selected local material.
6-inch imported borrow.
Pavement—
5-inch crusher run base.
1-inch armour coat.

Some States are still placing sub-grade treatment and base course in boxing, but most States visited are carrying the sub-grade treatment and base course across the shoulder to the table drain.

CONSTRUCTION.

Concrete Pavements.—All concrete mixing seen in the United States of America was being carried out with double-drum 34E type-pavers. One interesting development seen was a 16E double-drum paver mounted on pneumatic types. This unit has aproximately the same capacity as the single-drum paver in use by the Department of Main Roads. Apart from the adoption of the double-drum principle, there has been no recent fundamental change in paver design.

Water for concrete mixing was being piped to the paver on only one concrete paving job seen in progress. In all other instances, water was being provided from a tank trailer coupled to the paver and being towed by the latter as it moved forward. The water in the tank trailer was regularly replenished by a water truck. Tank trailers and water trucks are usually of 2,000 gall. capacity or more, and one unit seen in use in California for watering the subgrade had a capacity of 4,500 U.S. galls.

All forms seen in use were steel.

The greatest divergence in concrete pavement construction methods was in the spreading and finishing equipment used. The two spreaders most in evidence were those fitted with butterfly-like spreading action in which the concrete is distributed by a screed which travels across the pavement surface from side form to side form as the spreader moves forward, the angle of the screed being reversed at the end of such traverse, and those with screw-type spreading action.

In one instance seen in the State of Washington, a screeding unit with a twin transverse horizontal tube type vibrator mounted in front of the screeding unit, and plunged into the dumped concrete ahead of the screeding unit, was used as a spreading unit.

Screeding units generally consist of two transverse vibrating forward-moving screeds. In some later-type machines the angle of the rear screed can be altered, and in others a tamper bar is incorporated.

In the States where both lanes of a two-lane pavement are poured in the one operation, the screeding unit is followed by the unit used for inserting the bitumastic ribbon, which is used as the separating medium in the dummy centre joint. The bitumastic jointing material used for the dummy contraction joints is also carried on this unit and inserted at the specified intervals. Where the concrete is being poured one lane at a time, as in California, this bitumastic jointing is carried on the back of the screeding unit.

In Indiana, the next action is longitudinal floating by a mechanical "bull float" followed by transverse belting as the final operation. In Ohio, the "bull float" is not required, but the final finish is by transverse belting as in Indiana.

In both States, the transverse operating belts for final finishing are mounted on a light bridge carried on wheels on the side forms, and the belt is worked across the pavement by operating a long vertical handle, like that fitted to a low-down force pump. Pumping on this handle not only works the belt across the pavement but, through a ratchet action, gives a slow forward movement to the bridge supporting the belt.

In California, Oregon and Washington, concrete is poured one lane at a time and, after the concrete has been screeded and the transverse contraction jointing material has been inserted, finishing is carried out with "Johnston" type finishing machine. This machine acts in a similar manner to smoothing drags used on gravel pavements in New South Wales, is engine-driven and is carried on the side forms.

"Johnston" concrete pavement finishing machine used in West Coast States.

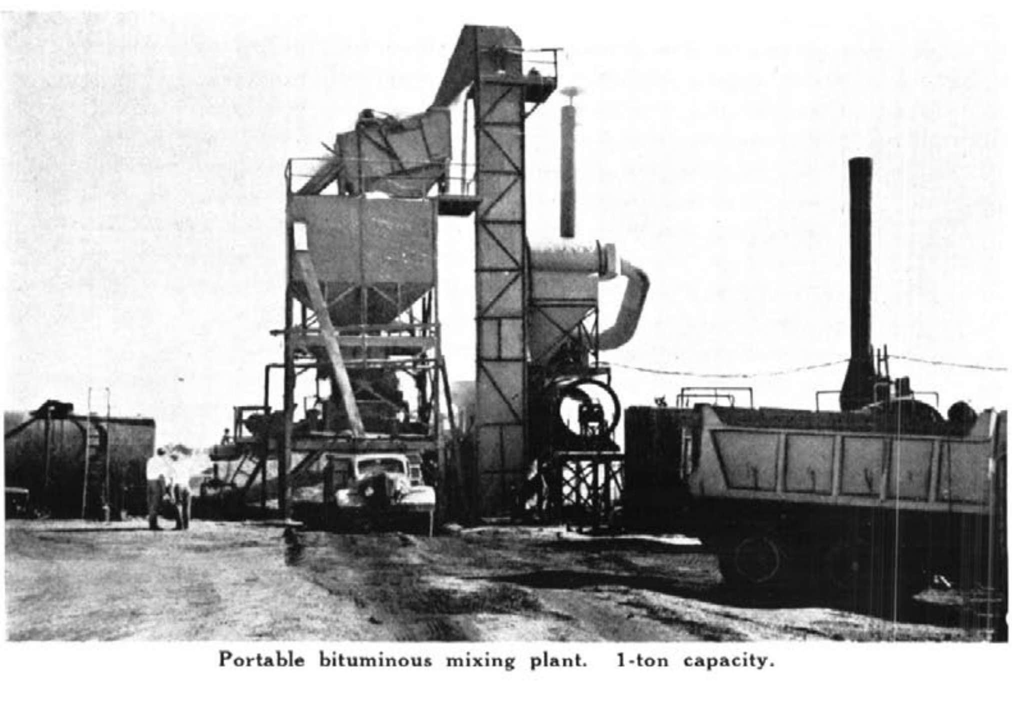
In California, a sheet of hessian is dragged behind the "Johnston" finisher on its last pass to give the surface a final roughening, whereas in Indiana and the State of Washington the final finish is carried out by transverse brooming of the partly set concrete.

Bituminous Pavements.—Portable mixing plants in general use have a minimum batch capacity of 1 ton, giving an output of 50-70 tons per hour under favourable conditions. Portable machines were seen in use with a capacity of 100-120 tons per hour.

The relative merits of portable and mobile units were discussed with a number of contractors, and the view was generally expressed that the value of mobile equipment in the bigger plants was questionable, as the units had to be capable of being broken down for movement from site to site into sections which could be moved on motor transport. Highway engineers and contractors agreed that the cost of setting up was high (in South Carolina about 5,000 dollars for each set-up), and that for profitable working, it was necessary to provide for a minimum of 20 miles of pavement work for each plant set up.

Pavement construction using dense-graded road-mixes with locally occurring material and bituminous (also cement) stabilisation, is undertaken extensively for base and surface courses of medium and low traffic density highways.

One large machine seen costs in the vicinity of 40,000 dollars and undertakes in one operation the tyning and pulverising of the pavement surface and its mixing with cement or bituminous binder. Over twenty units of this type are reported as being used in the United States of America, and where locally occurring material suitable for the addition of Portland



Portable bituminous mixing plant. 1-ton capacity.

Box of roadmixing machine used for blending aggregates, mixing aggregates with bituminous binders and also for soil stabilisation.

cement, or bitumen, is available in considerable quantity, satisfactory results at low cost were said to have been obtained.

Another machine, used extensively for blending aggregates and mixing with bituminous binders in eastern and central United States and in Canada, is similar in construction to a rotary hoe, but has a greater number of cutting teeth, which gives a greater turnover of material mixed for each foot of travel. This machine is not so specialised as that described in the preceding paragraph. It can be used for mixing stony material and is suitable for use on small jobs. Where seen on works, mixing by this machine was followed by spreading with a motor grader.

A third road-mixer seen resembles a motor grader in appearance, but with a set of paddles mounted longitudinally in a box under the grader frame where the blade is normally mounted. The material to be mixed is first windrowed. The forward movement of the machine then forces the material from the windrow into the mixing box, where the binder is added and mixed with the aggregate. This machine is reported to be very quick and efficient in sandy material but, as there is no mechanism for breaking up the clods, it is at a disadvantage in clayey material. Spreading was done with a motor grader.

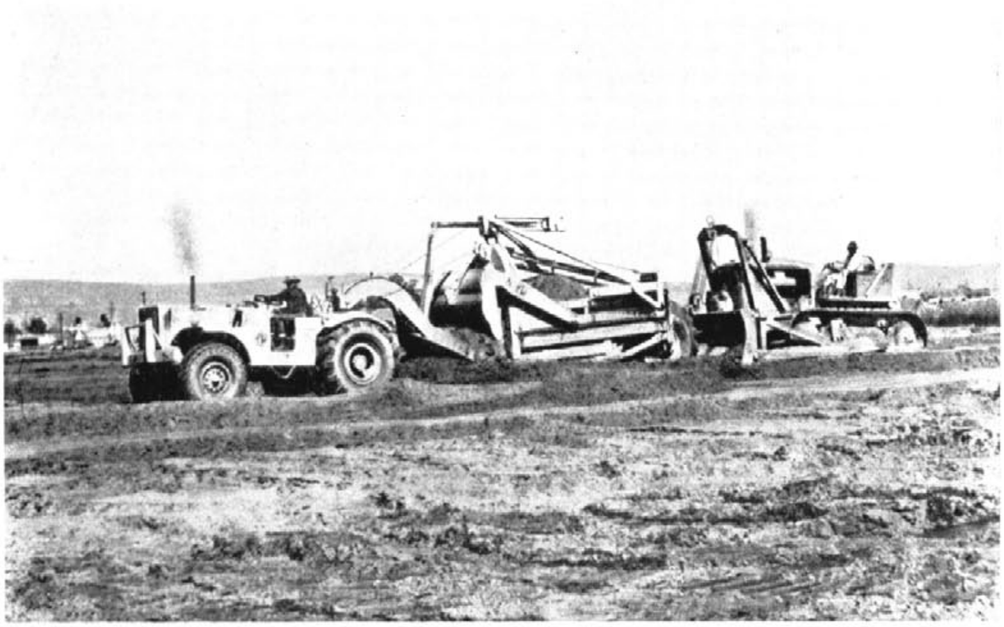
Bituminous penetration pavements are constructed in the New England States and Oregon. No work under construction was seen, but methods were discussed in Connecticut and in Oregon. In Connecticut, the method of construction resembles that followed in New South Wales. It was learned over the last eight to ten years that the State had carried out a very extensive programme of subsoil drainage which had substantially overcome drainage trouble previously experienced. All excavation for the subsoil drainage had been carried out with back-ditchers, drains being constructed in the shoulder on the high side of pavements, 30 inches wide, and averaging about 5 feet deep with a 6-inch or 8-inch perforated pipe in the bottom of the stone-filled trench. No light bituminous pavements have been built in Connecticut.

In Oregon, all light bituminous construction is by the penetration method. The State has standard specification for ¾-inch-thick, 1¼-inch-thick and 2½-inch-thick bituminous penetration pavements. For the ¾-inch-thick and the 1¼-inch-thick pavements, the broken stone is spread by motor grader, and for the 2½-inch-thick pavement with mechanical spreaders. The secret of smooth spreading of aggregate for the thinner pavements is stated to be that a full blade of stone should be kept moving in front of the grader.

A considerable number of pavements were seen which had been constructed in this manner, and they provided a riding surface comparable with that obtained in this State from the well-finished surface treatment work.

Bituminous surface treatment seen in Georgia, South and North Carolina, and armour-coat work in California, were similar in nature to surface treatment work in New South Wales, although generally of greater depth (*i.e.*, approximately 1 inch). However, the method and equipment used is the same except chip-spreaders were not used. All spreading was done from the body of the truck direct with a special tailgate or with spreader boxes.

Earthworks.—For loosening of rock, multi-second or micro-second or short-period delay-action detonators are coming into use in the United States of America. The detonators, which are rated in increments 25/1000 second delays, were introduced to cut down vibration and noise in connection with quarrying work and proved successful in this. They have also increased fragmentation.



Four-wheeled Tractor and 12 cu. yd. scoop used for earth movement on long leads. Bulldozer used to assist loading.

In the field of earth-moving equipment, considerable use is being made of pneumatic-tyred tractor units for all other than very short leads.

In addition to motorised scoops, much use is being made of four-wheel tractors and 12-cubic-yard scoops. While not as fast as motorised scoops on good haulage roads, they can be used at higher speeds on good haulage roads.

On all earthwork jobs seen, the scoops in use were larger than could be loaded by the towing tractor, even where track-type tractors are being used. In all scoop loading, a pusher tractor was used to assist in the loading.

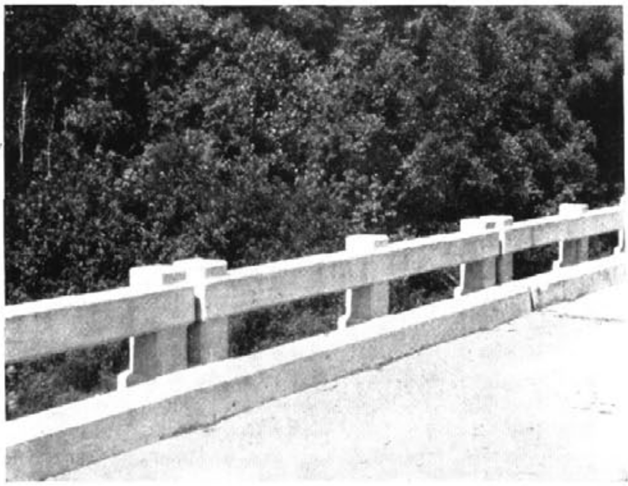
All foundations to high-class pavements are watered and rolled to compaction at optimum moisture content. Mobile water tanks in use are of much greater capacity than those generally in use in Australia. One was seen in use in California of 4,500 U.S. galls. capacity. Discharge is also much more rapid, being effected through a nozzle similar to those used in street-watering units in Sydney, rather than through a sprinkler bar of the type usually used locally on construction work. Other earthmoving equipment seen did not represent any material departure from the type of equipment in use in New South Wales.

Removal of Buildings from Right-of-Way.—The extensive freeway construction now in progress in the larger cities throughout the United States of America involves considerable clearing of buildings from the new right-of-way. Generally these buildings are demolished, but in special circumstances it has been found preferable to move the buildings complete to a new site.

The impression was gained that, in general, it was cheaper to demolish buildings than to attempt their removal and re-siting, but sometimes, when agreement with the owners was a primary consideration, buildings were shifted complete.

Timber-framed buildings are often shifted on wheeled dollies for considerable distances. As many of the timber-framed houses in the United States have plaster internal walls and ceilings, which necessitate care in jacking off the foundations in the first instance, and in re-siting, it is also common practice to move the brick chimneys complete with the buildings. These removals are, therefore, more complex than the removal of timber buildings with timber lining, and exclusive of chimneys, as is often carried out in New South Wales.

Type of Screw Jack and long handle spanner used in connection with moving of complete buildings from right-of-way. A large number of these simple jacks is used under each building.

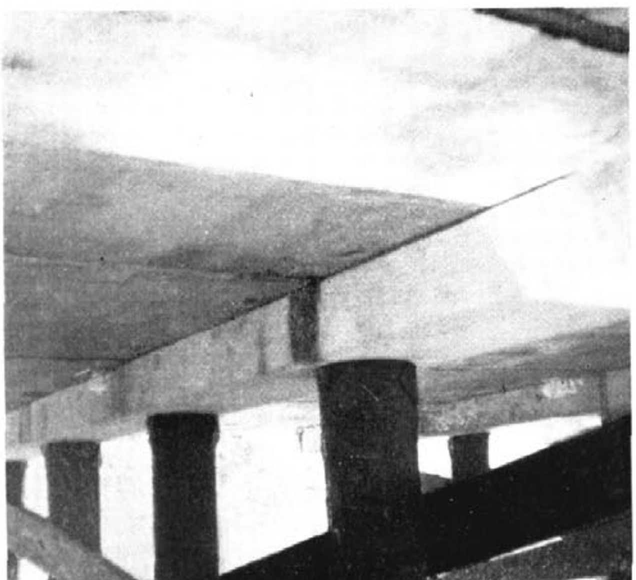


Low concrete guard rail on bridge where no provision is necessary for pedestrians.

In addition to the removal of timber-framed buildings, large brick buildings are sometimes moved and re-sited but, in these cases, the removal is only for relatively short distances of a few hundred yards, the buildings being moved from the old site to the new on crib work and rollers.

A six-storey brick and concrete store building was seen in Chicago in the process of being moved a distance of about 100 yards. It had taken two months to move it off its foundations, one month to move it about 20 yards, and it was estimated it would take an additional two to three months to complete the transfer.

Methods of house removal were discussed with the superintendent of a contracting firm which has been carrying out this type of work for many years and has recently moved a large church and a large fire station. On cottages of similar dimensions to Sydney suburban homes, the company would expect to use eight to ten men for about one month. The method followed is fundamentally the same, irrespective of the size of the building; only the number of men required is changed. For the fire station referred to above, 20 men were employed. The lifting off the foundation is done with simple screw jacks specially made for this purpose. The lift is carried out ¼-inch at a time, i.e., a quarter full turn of each jack. Each man works about ten jacks. He starts on a whilstle blast from the supervisor and gives each jack a quarter turn. He carries through to the last of his ten jacks and then, on the next whistle blast, works back the other way.



Bridge built with pre-cast concrete headstock and slabdeck on timber piles.

Apart from careful levelling with survey instruments as work progresses, height stakes, marked in ¼-inchs., are places at the centre of each group of jacks to give a check at each point as lifting proceeds.

Hydraulic jacks are sometimes used to make the lift easier on screw jacks. They are not depended upon to take the weight.

Buildings are moved from the old to the new site on steel rollers carried on old railway rails supported on crib work.

Rollers are in groups covering about five feet in the direction of travel. Immediately above each set of rollers is a thin plate of sheet steel about ¼-inch thick which separates the rollers from the softwood timber bearers carrying the building. This method of support has been developed over a number of years as the most effective, and is the method now in general use by the company, irrespective of the size of the building.

MAINTENANCE.

Apart from arrangement for winter snow clearance, State Highway maintenance organizations seen in the United States of America did not vary to any marked extent from the organization of the Department of Main Roads day-labour maintenance in New South Wales. Mowing and grading is carried out with individual units or, more often, with two units working together.

Patching of bituminous pavements is carried out by truck patrols, with one or two trucks and four to six men under the supervision of a leading hand. For work beyond the scope of normal maintenance operations, special gangs are organised or work is carried out by contract. In the majority of States visited, day-labour operations are limited to work which in New South Wales would be defined as routine maintenance.

For truck patrols, 30-cwt. steel-bodied trucks are in general use, and where special work, involving the use of gangs, is undertaken by day-labour, three-ton steel bodied tipping trucks are normally used.

In several States, extensive use is made of force-feed type mechanical loaders for picking up material after it has been cleaned out of the table drains, and for all loading from windrows, thus taking the place of much of the usual hand loading in maintenance operations.

In patching bituminous pavements with pre-mixed material, the mixtures used tend to be finer graded than those used in New South Wales, and approach a sand asphalt. In California, fine-graded river gravel

Motor grader fitted with 'dozer blade operated through scarifier controls.

and sand was spread in a windrow on a wide shoulder and then mixed with cut-back asphalt by a grader. After mixing it was left in a windrow until required for patching the pavement.

In Connecticut, small pug-mill type portable mixers were being used to produce similar material for patching.

Roadmix bituminous resurfacing, in which the aggregate includes sand but no filler, is used extensively. The most common method of mixing and spreading this material is by motor grader. No drags were seen in use on this work.

A mobile plant-mixing unit for open-graded mixes similar to those used in road-mixes, was seen in use in Ohio. It consists of a continuous mixer and a spreader built into one mobile unit, with operater control of the rate of combination of the binder and aggregate, and is suitable for small sections of plant-mix work in widely-scattered locations. With this unit, the only other equipment required is bitumen heaters.

Roadside Amenities and Erosion Control.—In Ohio and Indiana, small sections of highway reserve not wanted for road construction are converted to wayside parks and are maintained by the maintenance staff under the general supervision of a park superintendent. These parks, although often very limited in area, not only provide pleasant wayside stopping places for the motorist, but create a relief from the otherwise monotonous regularity of the road alignment.

In the eastern States, it is the general practice to establish grass on all road slopes immediately following construction. In Indiana and Ohio, the section of the shoulders adjacent to the pavement and the bottom of the depression in depressed medians is sodded; the balance of the area is seeded and mulched. In Connecticut seed fertilizer and water together are

Mobile bituminous plant mixing unit for open graded mixes. Mixer and spreader combined in the one unit.

sprayed on to the embankments and covered by chopped-up mulch distributed over the area with a blower.

In some of the States where grass cannot be so easily re-established, shrubs are planted in trenches across the face of batters in cuttings.

SIGN-POSTING, CENTRE-LINE MARKING, TRAFFIC OPERATION AND CONTROL.

Advance direction signs are in universal use in the United States of America, and route markers are used extensively. In the State of Connecticut, route markers are supplemented by direction signs sited at positions where fingerboards are normally placed in Australia, but the signs differ from Australian practice by reason of all boards being at right angles to the direction of travel. Drivers of vehicles thus can read the sign before arriving at the intersection.

In South Carolina, boards measuring up to 20 feet long and 8 feet to 10 feet high, carrying diagonal black and white stripes, are erected as warning signs facing the end of a highway which joins another highway in a "T" junction, and are very effective.

The majority of warning signs are either outlined with cats-eyes or use a background of scotchlite or similar material.

Line marking on the road pavement in the United States of America is used to define traffic lanes rather than as a means of enforcing traffic regulations. In this regard, it was noted that as a general practice all lanes were marked where there were four or more travelling lanes.

With regard to centre-line marking equipment, every State visited had different ideas and, in some States, the type of machine used varied as between maintenance districts. In those States where new equipment has recently been brought into use, the tendency is towards the use of spraying units mounted on heavy truck chassis.

In the majority of States, the spray guns are mounted at the back of the truck, with the main aligning responsibility resting with the truck driver, and only slight final adjustment being required by the sprayer operator.

In Connecticut, with this type of equipment and with the particularly long wheel base truck in use, it has been found possible to omit spotting. This cannot be done with the California-type buggy pushed in front of the truck, as used in New South Wales.

Roadside sign explaining purpose of double centre line on road where sight distance is restricted.

Glass beads are used extensively in centre-line marking. There is difference of opiinon as to whether they should be mixed with the paint, or applied after the paint has been spread on the pavement. Approximately half the States visited adopted one practice and half the other. The objection taken to mixing the beads with the paint is that they wear the spray nozzles, and there is little reflection from the beads until the traffic has worn off the top covering of paint. The objection to applying after spraying is that beads are lost due to being swept off the centre-line by traffic.

RETIREMENT OF SECRETARY

Mr. S. R. Henderson, Secretary, retired from the service of the Department on the 15th June, 1950.

Mr. Henderson entered the Public Service in 1908 and was appointed Secretary and Accountant to the Main Roads Board in 1925.

From January, 1928, to August, 1930, he acted as Deputy Member of the Board during the absence of the President, Mr. Garlick. Upon the creation of the Department of Main Roads in 1932, Mr. Henderson was appointed Secretary; he continued in this position until his retirement.

Mr. Henderson saw overseas service with the Australian Imperial Forces in the 1914-18 war. He is an Associate of the Institute of Commonwealth Accountants.

Mr. R. S. Johnston has succeeded Mr. Henderson as Secretary of the Department. Mr. Johnston, who is a graduate in Law of the University of Sydney, joined the Main Roads Board in 1925 and was appointed Legal Officer to the Department of Main Roads in 1932; he occupied this position until his appointment as Secretary.

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The Bell's Line Road (Main Road No. 184)

History and Recent Improvement

The reconstruction of Main Road No. 184, known as Bell's Line Road, from Kurrajong Heights to Bell and Mt. Victoria, a distance of slightly over 34 miles, has recently been brought to an advanced stage towards completion. The earthworks are finished, a pavement with bituminous surface has been provided over 16½ miles from Mt. Victoria, and a temporary sandstone pavement, later to serve as a base course, has been built over the remainder of the length. This section will also be provided with a bituminous surface course as soon as materials can be secured. The reconstructed road will provide an alternative route to the Great Western Highway across the Blue Mountains, and give improved access to settlements at Kurrajong Heights, Bilpin, Mt. Tomah, Mt. Wilson, Mt. Irvine, Bell, Mt. Victoria, Lithgow, and points further west. The growing primary producing districts at Bilpin and Mt. Tomah will have better connection to markets, and the effect of dust on orchards and vegetables will be eliminated. In addition, the considerable recreational possibilities of the northern part of the Blue Mountains area will become available for development and use.

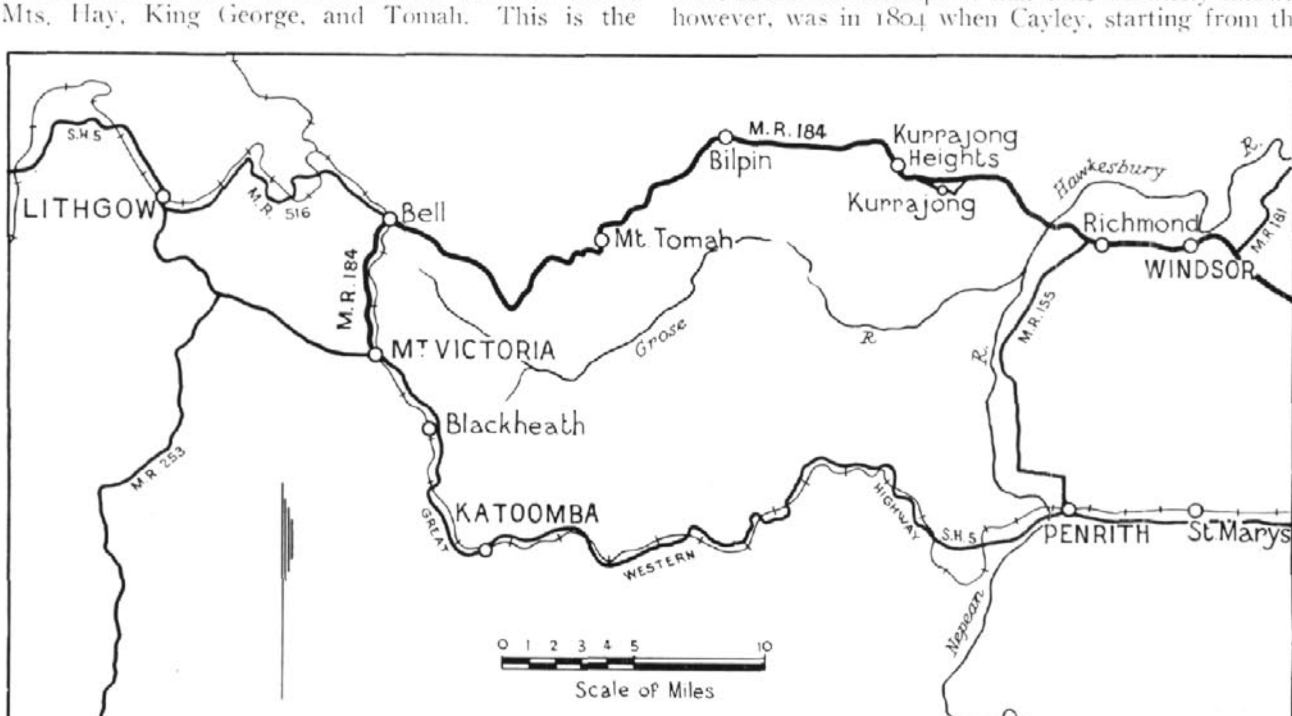
The new road has a special significance in relation to defence, as referred to later.

From many points around Sydney the general location of the two great passes over the Blue Mountains may be seen. Three outstanding peaks can be noted on the western horizon named, from south to north, Mts. Hay, King George, and Tomah. This is the horizon which greeted the view of Governor Phillip who, in 1789, named the ridge the Blue Mountains and the peaks the Carmarthen Hills.

The pass known as the Great Western Highway, State Highway No. 5, crosses the ridge almost due west of Sydney to the left of Mt. Hay and the other pass, Bell's Line, crosses Mt. Tomah slightly to the north of the highest part of that peak. It is not until one actually arrives at the ridges that it is clear why only two passes are possible, and from the summit of Mt. Tomah the two routes are clearly seen to follow the south and north watersheds of the Grose River, the latter meeting on the ridge connecting Mt. Victoria and Bell.

Early History.—The puzzle set the early settlers was how to find even one track through the maze of steep gorges in the mountains, and many unsuccessful attempts were made to penetrate what appeared from the distance to be easy country. Most of the explorers, discouraged by the rugged nature of the terrain around the Grose River, concentrated on the escarpments between Camden and Castlereagh.

The first approach to this barrier to the west was made by Governor Phillip in 1789 without success. The Grose was named by Wm. Patterson in 1794, and it is thought from the somewhat obscure records, that Bass might have reached Mt. Tomah in 1796. The most successful attempt at that time definitely known, however, was in 1804 when Cayley, starting from the



Locality Map.

View of the Grose Valley.

country near where Richmond is to-day, set out west and north-west along the ridge leading to Kurrajong Heights. The account of Cayley's journey is scanty, but it is now considered that after severe hardship, he ventured as far as Mt. King George which had been marked on a map of the infant colony, published 1791—

> "This hill appears of much easier ascent than Round Hill after you get to the foot of it."

Cayley's reports of the type of country traversed were evidently so dismal that his account deterred others from attempting to penetrate the rugged country north of the Grose. Gregory Blaxland, who developed the theory that if one followed the ridge between two valleys in the Blue Mountains most of the huge boulders and cliffs would be avoided resolved, with the encouragement of Governor Macquarie, to try the ridge between the Grose River and Glen Brook Creek, rather than that between the Grose River and the Bowman Creek Valleys. This choice actually determined the ultimate development of the Blue Mountains.

The success of Blaxland's venture has been described in the September, 1949, issue of this Journal. In this article we are concerned with the discovery and development of the country north of the Grose River.

Over eighteen years had elapsed after Cayley's attempt when the following appeared in the *Sydney Gazette*, 9th October, 1823:—

> "We are happy to announce that Mr. Archibald Bell, junior, of Richmond Hill, has, after one unsuccessful attempt, effected a passage from that part of the country, to the Cox's River, travelling north-west from Richmond about 14M. to Picture Hill, and then due west to Tomah. On going west, about half-way up, he turned south and after proceeding about 1M. in that direction, found an excellent passage down it. He then proceeded round the side of the opposite hill" (now Mt. Bell) "about 1½M. in a north-west direction and then bore west for the remainder of the day and north-west the next day till he reached the Cox's River."

Bell started out from Richmond on 1st September, 1823. Apparently the authorities wasted no time in acting on the discovery of Bell's Pass for Surveyor Hoddle was despatched to set out a trial line for a road along Bell's track and the following extracts are condensed from Hoddle's report dated 4th November, 1823, after he had completed, with the aid of five assistants and two natives, and with equipment including three horses, the location survey of a road which, with slight variation, in general is the present line of Main Road No. 184 between Kurrajong and Bell.

> "I have traced and marked a new route from the Ford on the Hawkesbury to the Ford at Cox's River discovered by Mr. Bell, junior. Diamond Ridge is very narrow, no wider than one chain in width. It is steep for 5 chains from Mr. Bell's view and the second descent steep" (now Cut Rock) "for 6 or 7 chains, after which ascents and descents are easy. Bull Comatta, distance 10M., plenty of water, soil varies—generally a clayey loam. Towards Tomah soil is of excellent quality."
>
> "On the summit of Tomah, distance about 20M., soil is rich. There are several trees 20 to 30 feet in circumference. There was one white gum 70 ft. from the root to the branches, of 20 ft. girth. Tomah bore from Bell's View west 72½ degrees south. Steep and dangerous with loose stones. For a distance of a mile had ravines, which were nearly perpendicular, close to us which made our situation dangerous. The obstacles would soon be

removed by road party. This part would require the most labour as there are many sandstone rocks."

"Stony Hill distant about 23M., rather dangerous for a few chains. Brisbane's Crown Hill is rather steep, at the other side of it—a fine view of the Grose River."

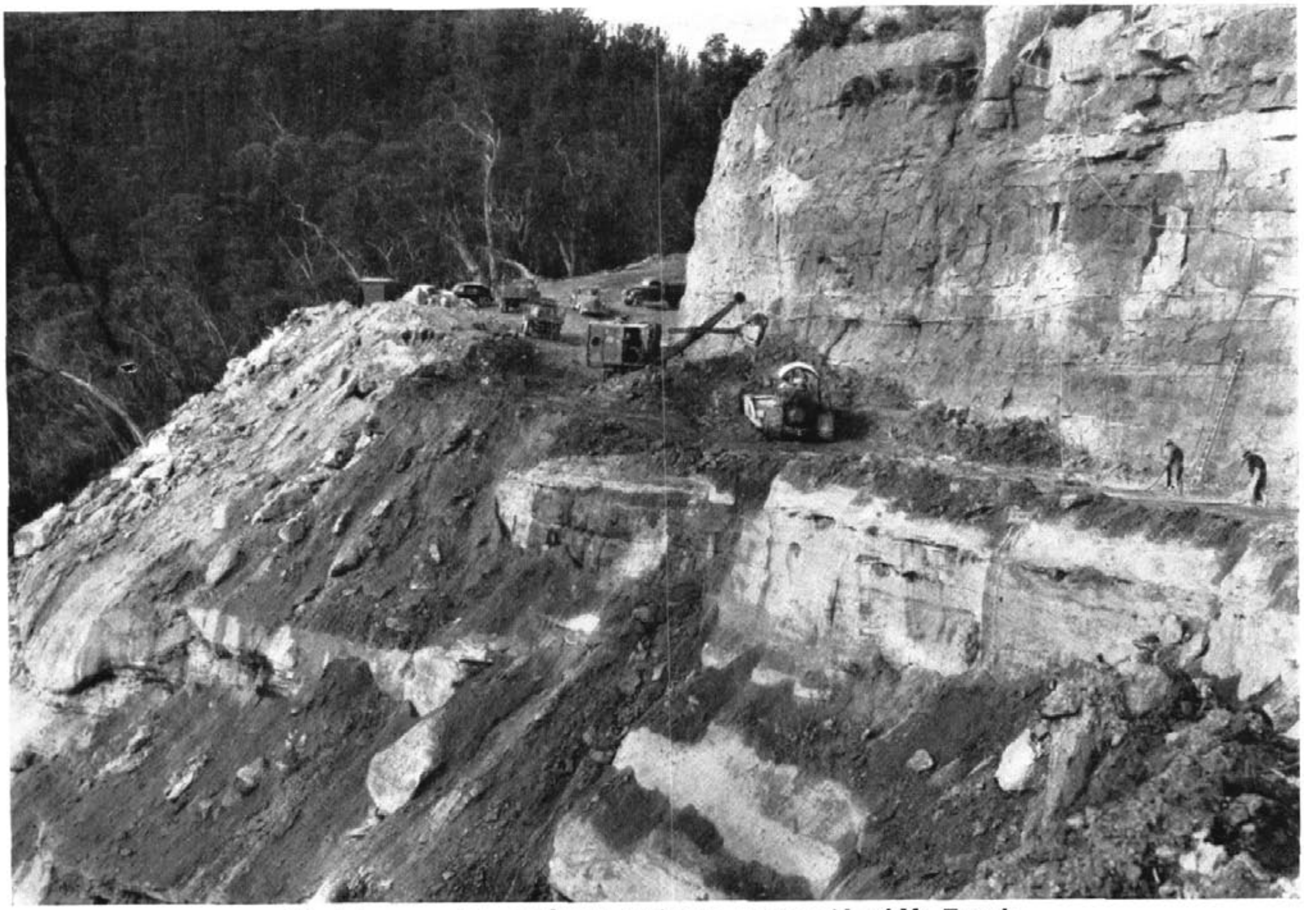
"After leaving Brisbane's Crown the ascents and descents are moderate, but the route is stony. At 33M. it was dangerous for 2 chains—obliged to keep on the side of the ravine for half a mile. There was little impediment to a good road. We then came on to some good cattle runs where there was an abundance of coarse grass—hitherto there was little grass. Soil sandy and barren from Mt. Tomah. The line runs into the road at Collett's Inn."

"The new route is superior in every way to the old Bathurst Road. The worst part, the descent from Tomah, is less dangerous than many places in the old road. In making the road some small alteration may be made in the line marked to render it easier to ascend and descend the hills."

A track was cleared along Surveyor Hoddle's line and the first road had two difficult locations—first, the Kurrajong Ridge which was crossed by ascent immediately west of the present Kurrajong Heights Post Office, thence northwards to a point approximately 300 yards south of the existing road. Then descent was made westward by a steep track and zigzag down the Cut Rock spur. The second difficult section was the western descent from Mt. Tomah where the road was located on the ridge along the western spur towards Mt. Bell and descent was also made by a steep track and zigzag. West of Mt. Tomah the line followed the ridges, in general on the line of the present-day road.

It should be noted that the western limit of good country on this route is the excellent volcanic soil on Mt. Tomah. There is also volcanic soil on Mt. Irvine on a spur subsidiary to that followed by Bell. Settlers followed the early explorers and as far as Mt. Tomah and north-westwards to Mt. Irvine, the Bell's Line Road served the early pioneers pressing westwards from Kurrajong, but it is clear that for vehicular traffic travel must have been very rough—in fact, it was stated in Raymond's Calendar of 1833 that the road had been largely abandoned as a through road. This road, however, it is reported, was used in moving stock, and, in particular, Mr. Blaxland, brother of the famous explorer, who had a holding in the Hunter Valley, was accustomed to drive his stock along Blaxland Ridge and thence along Bell's Line to the west.

A section of the completed road at top of Mt. Tomah.



Work in progress in sandstone cutting on western side of Mt. Tomah.
(See photo. on page 22.)

In the early thirties of last century, the route of the pass through the Blue Mountains at Mt. Victoria was under consideration. The Governor had laid down the policy that "the existing roads shall be maintained unless a marked improvement is possible in view of the expense incurred in the existing road." The then existing descent at Mt. York to the Cox's River, was in a bad condition, and Major Mitchell was determined to construct the road now known as Victoria Pass on the Great Western Highway. Further development of Bell's Line Road was necessarily shelved by Mitchell because the natural descent from this line on the western escarpment would have been either by further costly construction down ridges near Lithgow, or else into Hartley Vale past Collett's Inn on a route abandoned with the construction of the Victoria Pass.

In 1855 Sir Thomas Mitchell reported on the condition of Bell's Line Road as follows:—

> "Bell's Road has been marked from the River Nepean to Collett's Inn along the dividing range which is to the northward of the River Grose. It separates from Darling's Causeway" (the ridge between Mt. Victoria and Bell) "at the angle of that range near the head of the river" (the Grose) "and extends in an easterly direction towards Tomah. It separates from the ridge joining King George's Mount—at a distance of two miles from its summit. From this point the direction of the ridge is very straight to Tomah but its breadth is in some parts almost too little for a road."

From its eastern end:—

> "Bell's Road crosses the most elevated part of a ridge which is nearly parallel to the Nepean at the distance of about three miles from the river. The trees have been cut down from thence to the summit of Mt. Tomah. Just beyond where the wood has been cut the road has been marked round the side of the southern head of the Hill across a declivity of nearly forty degrees. The passage here is extremely difficult at present. From Tomah the road keeps to the ridge already described . . . To seek a road through such country is only to ascertain the direction of the dividing ridges and the road across Mt. Tomah is better in this respect than the road from Emu" (Great Western Highway). "Tomah presents a formidable but not an insurmountable obstruction."

Considerable sums had been spent on the Emu-Blaxland route and settlement had followed on this line. Two roads across the mountains were not required for the young colony, but it is interesting to speculate what would have been the development of the Blue Mountains had Blaxland selected Kurrajong Ridge for his exploration westward.

The first track, west of Kurrajong at Cut Rock with its very steep grade, was later deviated by the construction of an easier but still steep grade in side cutting on the southern slopes of the Cut Rock Ridge. This latter road is still trafficable and was used as a detour during recent construction.

Later in the century further improvements were made—first at Kurrajong Heights where a good location was discovered on the northern side of Cut Rock Spur and at Mt. Tomah where the original road was deviated by following the northern slopes to provide a much better alignment and grade at a lower level. Gradually the middle portion of the length of the road fell into disuse, and it was not until about 1930 that systematic maintenance throughout was re-instituted. However, on account of the narrowness and winding nature of much of the road, it was not in a condition to carry modern long distance traffic, much of it being little better than a bush track.

With the incidence of the financial depression all thoughts of improvements to Main Road No. 184 had to be postponed, but with the return of the State's finances to normal, slightly more than 100 years after the original road had been "abandoned at last as a road to Bathurst," the question of improvement to modern standards was taken up in earnest.

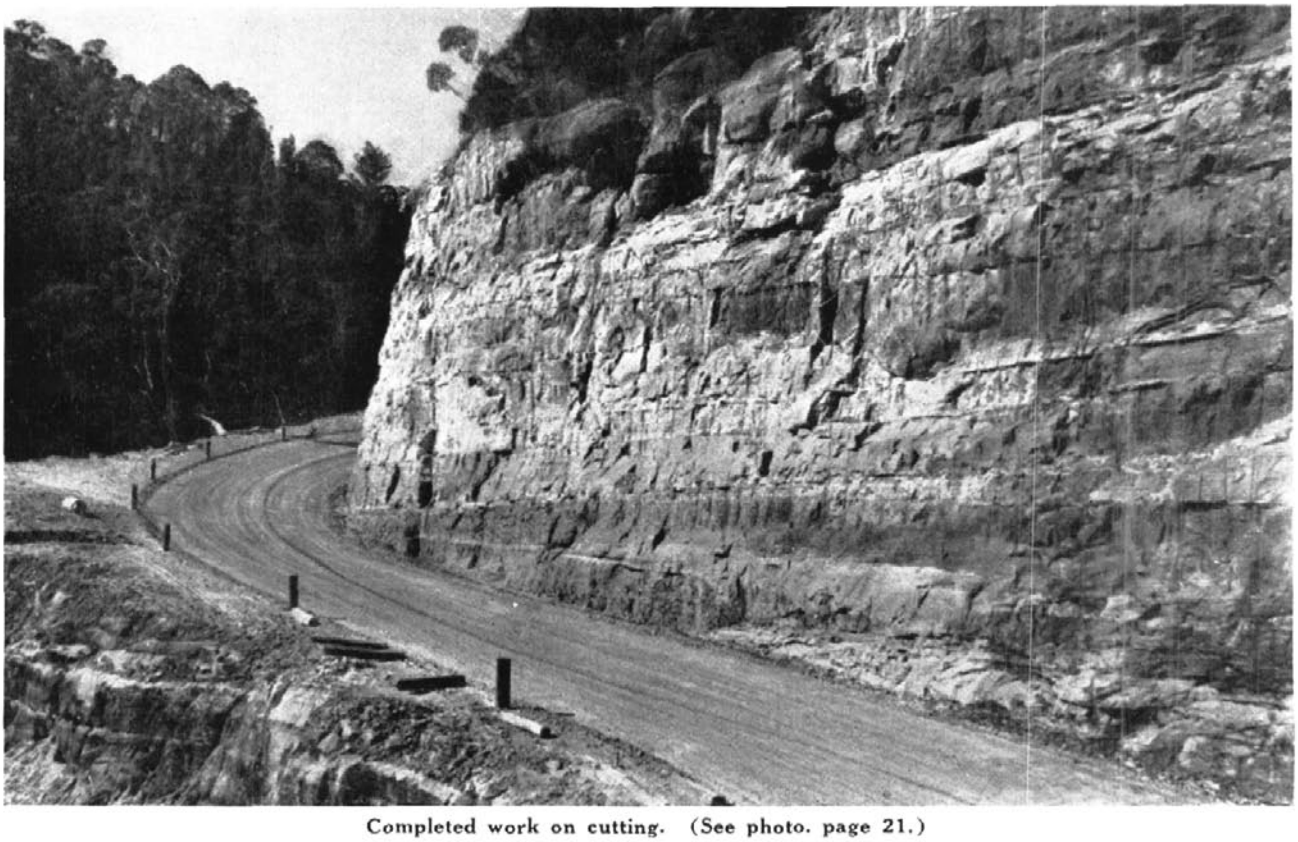
Reconstruction by the Department of Main Roads.— The length of Main Road No. 184 which most required reconstruction was that between Kurrajong Heights and Bell– a distance of slightly over 34 miles, mainly through rough sandstone country. Work on this length has recently been completed throughout, except for the bituminous surface course, of which 17½ miles remain to be provided. The road has been built to a general design standard based on travel at 40 miles per hour, but on some sections the standard has necessarily been reduced to 30 miles per hour. The steepest grade is 12 per cent. for a length of 800 feet near 17¾ miles from Mt. Victoria and the sharpest curve is 200 feet radius on Mt. Tomah at 18M. 1,200 feet from Mt. Victoria.

Main Road No. 184 is within the area which, for purposes of the Main Roads Act, is regarded as the County of Cumberland.

The reconstruction of Main Road No. 184 falls naturally into four phases as follows:—

1. *The Unemployment Relief Phase.*—The Main Roads Department, prior to the Second World War, investigated the possible development of Main Road No. 184 to serve as an alternative route to the west, and in 1939 Executive Council approval was obtained to undertake construction as an unemployment relief project.

   Work was commenced in October, 1939, at the Mt. Victoria end using rationed unemployed relief labour supplemented by full-time key men, plant at this stage being confined to compressors which were necessary to drill before blasting the large quantity of sandstone to be removed for the formation. Work continued on this basis through the



Completed work on cutting. (See photo. page 21.)

Shovel and Bulldozer at work.

early months of the war until, by April, 1941, the earthworks were completed to a point approximately 11 miles from Mt. Victoria.

2. *The War Phase.*—Main Road No. 184 acquired a new importance suddenly in the early part of 1942 when, with the entry of Japan into the war, it was seen that war operations might move to Australia. The Military Authorities desired that the unconstructed sections of this road should be immediately improved, including provision for collecting and passing stations on portions of the road which were only wide enough for one-way traffic, so that the road could be used as an alternative route to the Great Western Highway.

In addition, the State War Effort Co-ordination Committee, supported by representations from the Military Authorities, pressed for the completion of the Department's construction work on this road and on the Windsor-Putty-Singleton Road, so that direct inland access would be available between the Bathurst-Lithgow areas and Newcastle.

To meet the first requirements an inspection was made in February, 1942, with military personnel to determine what immediate work was required to make the route traffickable quickly. There were then two sections which would have been serious bottle-necks in an emergency—first from Kurrajong Village to Cut Rock, approximately 4½ miles with grades up to 13 per cent. and bad alignment, and secondly on the eastern and western sides of Mt. Tomah. At that date earthworks had been completed to 15 miles from Bell, and work was in progress as far as 23½ miles. Base course of pavement had been laid to 14 miles, and surface course completed between Mt. Victoria and Bell. Equipment and personnel were diverted from the construction organisation to carry out the improvements desired and these were completed by 25th August, 1942.

To meet the second requirement the Department was faced with an almost superhuman task. In March, 1942, work was in progress as far as the 25 mile peg from Bell but further depletion of personnel for military service then commenced. It was decided to augment the numbers remaining by transferring men from other works less urgent, and instructions were issued that the road was to be finished between Bell and the 25 mile peg as rapidly as possible, and that final survey and design over outstanding lengths was to be completed as a matter of urgency. Improvements between Kurrajong Heights and the Putty Road turnoff were also listed for further action.

The State War Effort Co-ordination Committee recognised that unfortunately men who might otherwise be available for this work had become absorbed in war industry of higher priority, that construction plant had to be withdrawn for other urgent military work and that it would be difficult to continue the work on a satisfactory basis. Nevertheless it requested the Department, in view of the fact that as a large part of the road had been constructed, to complete the remaining lengths of the road to a satisfactory standard before work was suspended, if that became necessary.

On the 11th September, 1942, construction work ceased. It was evident by then that the theatre of war operations was moving northwards, and that the east coast of New South Wales was no longer in immediate danger. The organisation engaged on the construction was then transferred to urgent works outside the State.

3. *The Post-war Phase: Bilpin-Mt. Tomah Section.*—During the latter period of the war, investigations were made from time to time with a view to carrying on with improvements to Main Road No. 184 when manpower became available again, and the completion of the work was listed for post-war action, so that the work already partly constructed could be completed and made available for general traffic.

In December, 1945, it was decided to recommence the work in a small way and gradually to build up the organisation to full strength as a major construction project. Early in 1946 the work was in hand under the control of a local office established at Bilpin, commencing at 16M. 4,300 feet from Mt. Victoria. The cuts at Mt. Bell were opened up, and in November, 1946, after considerable investigation as to route, the formidable cutting to be made on the western side of Mt. Tomah was started. The determination of route on this section needed courage when one viewed the huge ravine to be filled, and the formidable cliffs which had to be cut down from the mountain to provide access between Mt. Tomah and Mt. Bell. Located under this cliff was the existing road, which had to be kept open to traffic, and which was in the path of most of the debris to be brought down from the excavations above.

To start the cuts on the cliff face, jack-hammer operators had to be slung over the edge in bosun's chairs. Material shot down fell on the old road and was bulldozed over the edge, patrolmen at each end of the scene of operations controlling traffic.

In February and March, 1947, exceptionally wet weather was experienced, and it was found advisable to close the road to through traffic and, to make matters worse, portion of the old road subsided. At the end of March weather conditions improved slightly, and some traffic was allowed through, but by April work on the large cutting had reached a stage when the lower road was being continually blocked by operations on the new road above, and it was impossible to ensure that large boulders did not roll on to the old road; the danger of damage to passing vehicles and of injury to drivers was so serious that the old road was closed until the new formation could be available for traffic at the end of May. "Road Closed" barriers were therefore placed at North Richmond and at Bell, although for light traffic there was an alternative route from Bilpin through Bowen's Creek, Mt. Irvine and Mt. Wilson. By July, 1947, the construction of the base course through the Mt. Tomah cut was completed, and work was pushed ahead east of Mt. Tomah to Bilpin.

During the eighteen months occupied in the construction of the Mt. Tomah-Bilpin section, wet weather caused considerable inconvenience, minor slips occurred on the new work and special precautions had to be taken to assist traffic. Many hundreds of yards of filling were washed away in rainstorms.

The work involved extensive subsoil drainage. The whole length of the route between Mt. Victoria and east of Mt. Tomah passes over sandstone (with the exception of approximately one mile of basalt country on Mt. Tomah), the strata are fissured and absorbent, and the ground water follows ironstone and other hard laminations, developing pressures at low points. Approximately 72,000 linear feet of subsoil drains were inserted over a length of 26 miles east from Mt. Victoria, and

Completed section of road on the Kurrajong side of Bell.

special attention had to be paid to the large embankments at Mt. Tomah and Mt. Bell for the drainage of surface water from springs.

Work on formation and sub-base was completed to 26 miles east of Mt. Victoria by October, 1948.

4. *Post-war Phase: Bilpin-Kurrajong Section.*—During the construction of the Mt. Tomah section, surveys and investigations were continued on the section between Bilpin and Kurrajong and a short deviation at Kurrajong was completed in 1947, involving the construction of a concrete bridge over Little Wheeney Creek and the construction of approximately 1½ miles of new road.

In addition, work was continued east of Bilpin as far as Cut Rock. The sandstone formation at Cut Rock contains a fault in the strata cutting across the road, and in order to make certain that drainage and foundation conditions would be satisfactory, a geological survey of the area was made in August, 1947, from which construction procedure was developed.

The actual construction of the section between Cut Rock and Kurrajong Heights entailed two major problems:—

(1) that of maintaining traffic on the existing road or over a suitable detour; and

(2) excavating and blasting so as not to damage retaining walls supporting the existing formation.

The geological report was invaluable in respect of the latter problem, and it was decided that so far as possible the existing road should be kept open to traffic during construction of the new road, and that when traffic had to be blocked, it would be directed on to an old formation over Kurrajong Heights abandoned many years previously. The old road had to be reconditioned for this service, and the arrangement worked with minimum of inconvenience to traffic which was allowed to use the existing road during hours of darkness.

The new road was open to all traffic early in 1949, and the temporary pavement was completed in June of that year.

Materials for Pavement.—It was known even before the war that difficulty would be met in obtaining local pavement materials for this reconstruction. The local sandstone is mainly soft, such isolated hard deposits as existed being small and costly to work.

Isolated deposits of suitable gravels were located between Bell and Mt. Tomah, but in insufficient quantities for the whole length of road. After tests had been conducted it was finally decided to sheet the pavement between Mt. Victoria and a point 12 miles east with chocolate shale from an outcrop on Mt. York, and from the 12 mile peg to 16½ miles to use the small available quantity of ridge gravel. The work has been completed and a bituminous surface provided.

Between 16½ miles and 36 miles the surrounding country was explored for materials, with little success, and after further tests it was decided to place first a base course of sandstone which, based on tests of subsoils, varies from 8 inches to 15 inches in depth. This pavement material has carried light traffic fairly satisfactorily, but it has not sufficient durability for a permanent pavement, nor is it suitable for sealing. A surface course is, therefore, to be constructed of crushed stone penetrated or otherwise treated with bitumen.

Plant Employed.—In the post-war phases of this construction, the work was fully mechanised. Compressors and jackhammers were used in the rock cuttings. After shooting down, earth and rock were then moved by the following methods: Short leads were dozed by two heavy and two medium bulldozers, on medium leads earth and stone were scooped and drawn by tractors—one 12-cubic yard, one 8-cubic yard, and two 6-cubic yard scoops being employed. For long leads the material was loaded by mechanical shovel into lorries, after it had been dozed to the shovel, or loaded into lorries by dozer from side loaders. Trimming was carried out with heavy auto-patrol grader and by two drawn graders.

The maintenance of the plant and the keeping of the plant moving under such particularly heavy service, at a period when spare parts were frequently unobtainable, was no inconsiderable task, with continued wet weather playing havoc with full efficiency.

Quantities of Work (including Deviation at Kurrajong).—

Earthworks.—Sandy loam, 263,500 cubic yards; sandstone requiring drilling and blasting, 492,200 cubic yards. Total, 755,700 cubic yards (solid measurement).

Trimming and consolidating subgrade and shoulders—195,000 l. ft.

Concrete pipe culverts—sizes 12 in. to 48 in. diameter—10,502 l. ft.

Subsoil drains—98,703 l. ft.

Catch drains—94,965 l. ft.

Pavement—Shale, sandstone and local gravel of variable thickness—433,600 square yards.

Two coat bitumen seal with tar primer—183,800 square yards.

Retaining walls (stone)—360 cubic yards.

Unit Costs for Main Items of Work.—(Direct costs only exclusive of Workers' Compensation Insurance, Pay Roll Tax, Holidays, Camp, Depot, Engineering Supervision and Clerical Costs. Deviation at Kurrajong is included.)

Earthworks—Average cost for Earth and Rock, 6s. 1d. per cubic yard (solid measurement)—includes Unemployment Relief Work carried out with minimum mechanisation.

Trimming and consolidating subgrade and shoulders—£5 19s. 2d. per 100 lineal feet.

Concrete pipe culverts—Average for all sizes, £1 0s. 11d. per l. ft.

Pavement—Shale, sandstone and local gravel of variable thickness—3s. 10d. square yard.
Two coats bitumen seal with tar primer including preparation pavement—2s. 5d. square yard.

Supervision.—This work was carried out under the supervision of the Department's Divisional Office at Chatswood.

The general supervision of the construction was carried out from August, 1939, to December, 1941, and from December, 1943, to August, 1948, by Mr. C. Binns, Divisional Engineer, from December, 1941, to December, 1943, by Mr. E. J. Constable, Acting-Divisional Engineer, and from August, 1948, to the completion of the work by Mr. T. A. Donaldson, Divisional Engineer.

The engineers directly in charge of the work were, in succession: Messrs. L. W. Burgess, H. W. Cover, R. O. Smee, F. A. Relf and J. L. Allan.

PAYMENTS FROM THE ROAD FUNDS FOR PERIOD 1st JULY, 1949 to 30th JUNE, 1950.

	Amount Paid.
COUNTY OF CUMBERLAND MAIN ROADS FUND:	£
Construction of Roads and Bridges	750,314
Acquisition of Land and Buildings for Road Widening	35,153
Maintenance of Roads and Bridges	521,041
Interest, Exchange and Repayment of Loans	79,397
Other Expenditure	139,496
Total	*£1,525,401

* Excludes £500,000 transferred as temporary loan to Country Main Roads Fund under Section 2 of the Main Roads (Finances Adjustment) Act, 1949.

COUNTRY MAIN ROADS FUND:	£
Construction of Roads and Bridges	1,347,377
Acquisition of Land and Buildings for Road Widening	23,233
Maintenance of Roads and Bridges	2,332,324
Interest, Exchange and Repayment of Loans	157,044
Purchase and Repair of Plant and Motor Vehicles	472,768
Other Expenditure	198,677
Total	£4,531,423

DEVELOPMENTAL ROADS FUND:	
Construction of Roads and Bridges	149,608
Other Expenditure	1,058
Total	£150,666

SUMMARY OF ALL FUNDS:	
Construction of Roads and Bridges	2,247,299
Acquisition of Land and Buildings for Road Widening	58,386
Maintenance of Roads and Bridges	2,853,365
Interest, Exchange and Repayment of Loans	236,441
Purchase and Repair of Plant and Motor Vehicles	472,768
Other Expenditure	339,231
Total	£6,207,490

NOTE.—The figures in the above Statement are subject to slight adjustment upon completion of accounts for the year.

Railings for Bridges

Factors Affecting Design. Types of Railing Used.

From the earliest times, bridge building has been a source of public interest and pride. The skill displayed in the design and construction of bridges has fired public imagination, and the upkeep of bridges has been regarded as an honoured task. The standard of the roads and bridges of a country, together with its buildings and towns, has often reflected, fairly accurately, the standard of civilisation attained.

Bridges vary greatly in size and type, from the spectacular structure of large dimensions to the modest single beam span. Regardless of size, all bridges have this in common, that the railing is the part which is most closely observed by users of the bridge, and which most directly protects both pedestrians and vehicles. For these reasons, the design of the railing of a bridge merits special attention, regardless of whether it takes the form of posts and rails, or of a parapet, or of whether the parapet is a solid wall or a balustrade.

Requirements to be Met.—In designing a bridge railing, the basic requirements may be set down as follows:—

(1) To be capable of withstanding a reasonable impact from collision. To resist the pressure of crowds of pedestrians. To be safe for children.

(2) To give a feeling of security to users of the bridge, whether in vehicles or on foot.

(3) To be so situated and shaped as to reduce risk of impact with vehicles proceeding in a normal manner or with any projecting load. In the event of a collision, to minimise damage to the vehicle or bridge.

(4) To have aesthetic value in itself, but to be in harmony with the remainder of the bridge and with the surroundings.

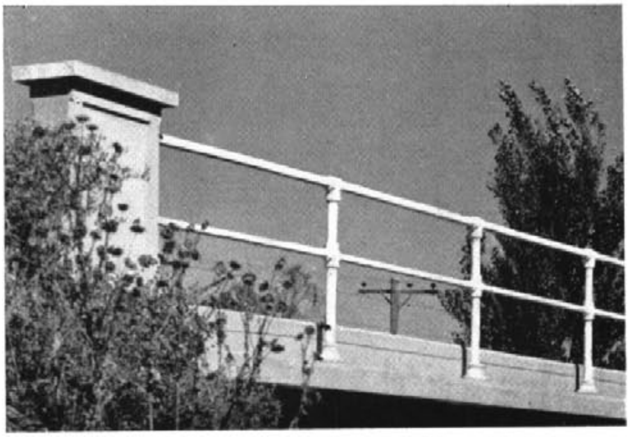


Fig. 1. Pipe railing with concrete end posts.

(5) To prevent animals such as sheep and lambs from being forced over the side when crossing in a mob. This applies only in certain areas.

(6) In the case of high bridges, especially in towns, to prevent or deter persons from climbing over the railing.

Some of these requirements may be conflicting, and the weight attached to each varies according to the type of bridge and its location. Usually some compromise is required. No standard type of railing will suit all cases.

Regarding strength of handrail to resist impact, it is clearly impracticable to provide a railing which will hold a large vehicle in the event of a major direct collision. The Department's present practice is to design the railing or parapet, together with connections to the structure, for loads equivalent to 150 lb. per linear foot applied in any direction.

Fig. 2. Reinforced concrete posts and rails.

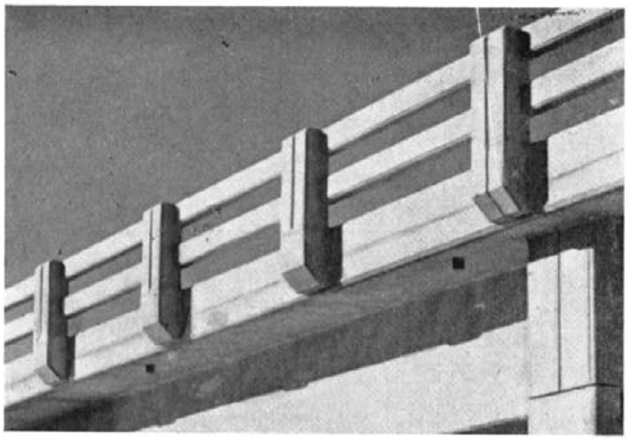


Fig. 3. Recent design of rail with flush surfaces to traffic.

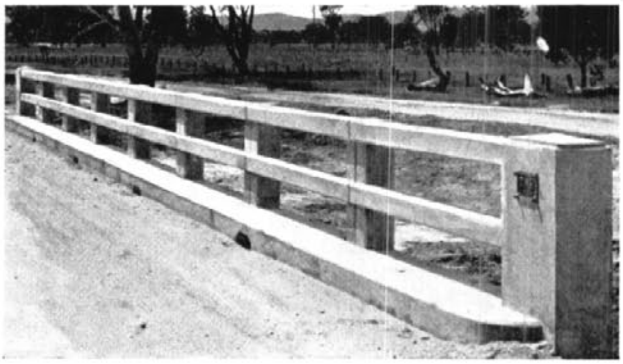
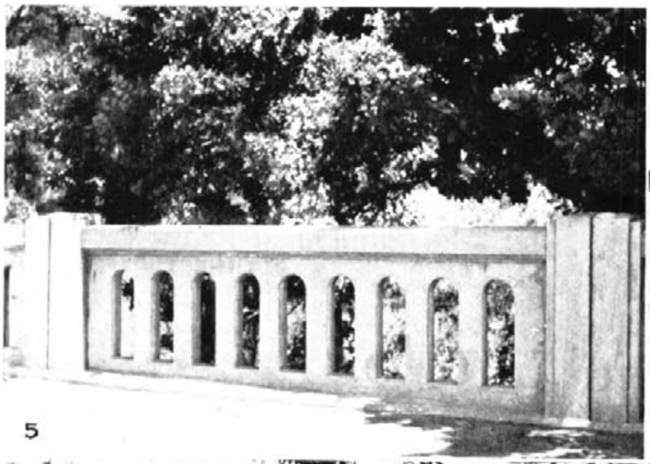


Fig. 4. Recent design of rail with flush surfaces to traffic.

Where there is considerable pedestrian traffic and a footway is provided, railings should not have gaps wide enough for a small child to climb through. This usually limits openings to about 6 inches, horizontally or vertically.

To give a feeling of security, it is necessary to have a railing which has the appearance of strength and solidity. Without this appearance there may be some feeling of insecurity, although the actual strength may be adequate for the usual slanting type of collision. It is generally agreed that height of railing should be between 3 feet and 3 feet 6 inches, except in the case of high bridges where 4 feet is desirable. There is a tendency in the United States to use low railings, sometimes with only one rail, in cases where there is little pedestrian traffic.



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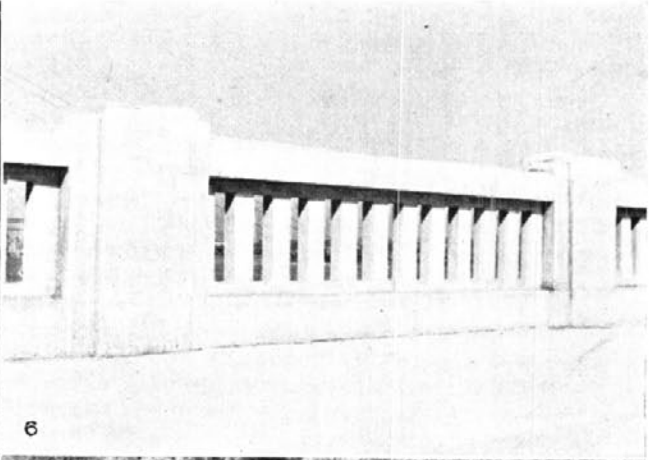

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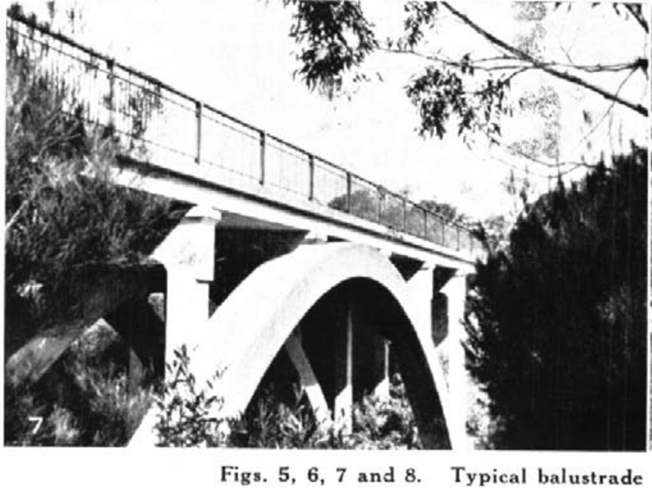

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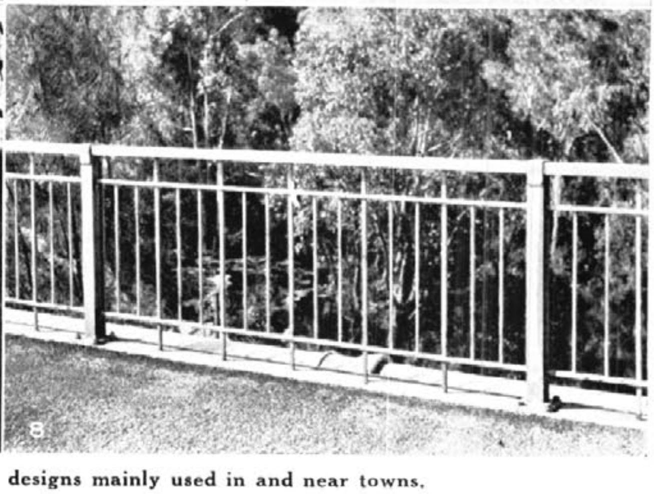

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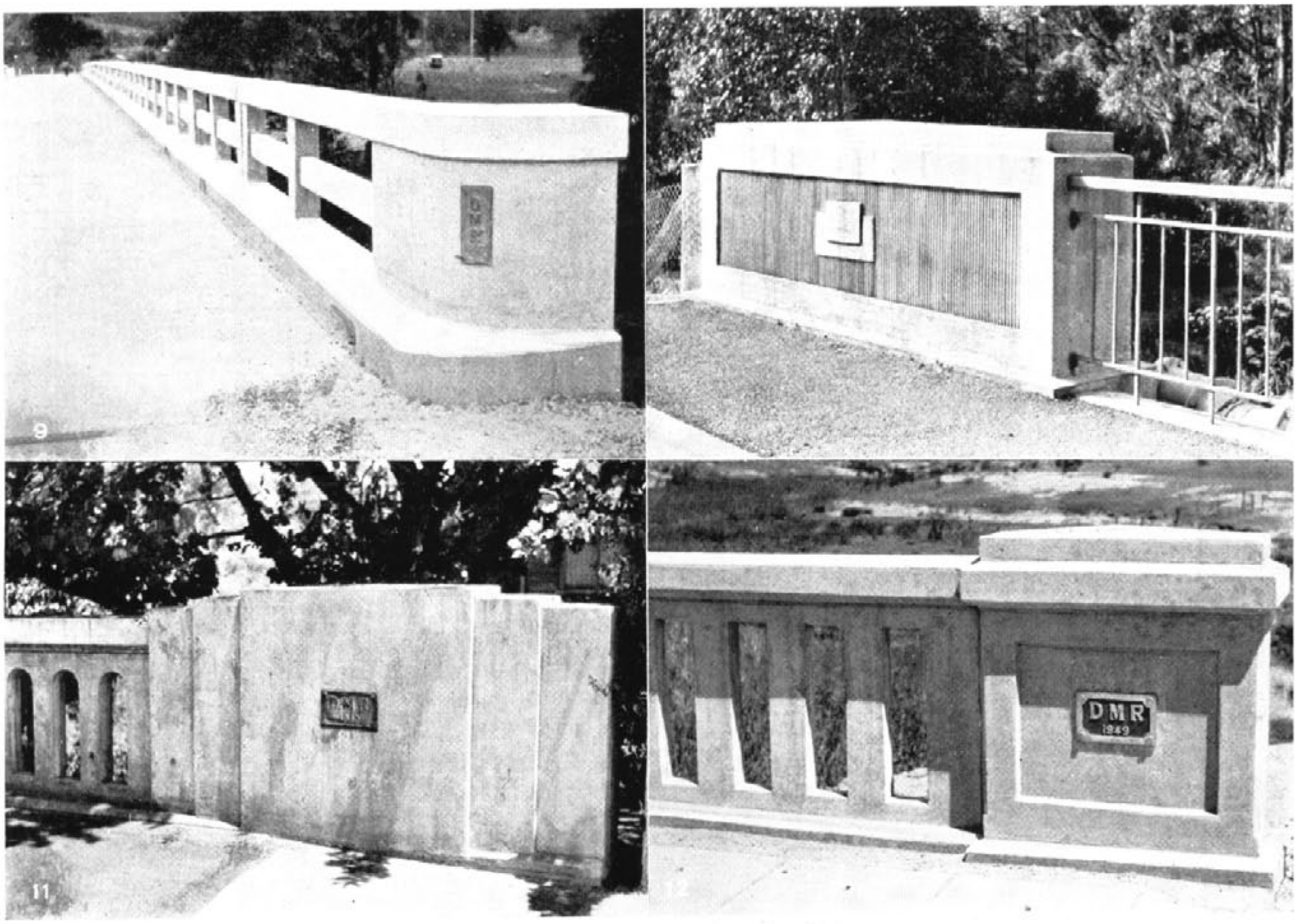
Figs. 5, 6, 7 and 8. Typical balustrade designs mainly used in and near towns.



Figs. 9, 10, 11 and 12. Typical end posts.

Modern vehicles and speeds demand a larger lateral clearance than has been used in the past If the railing is placed close to the inner face of the kerb, vehicles tend to veer away from the kerb and some of the available roadway width is virtually wasted. For this reason, posts should be kept back from the face of the kerb.

Railings with posts projecting above or in front of the rails may tend to catch passing vehicles and loads, especially if a vehicle is out of control as in the case of a skid. Consequently, it is desirable to design the railing with a smooth face towards the traffic. Further, there is a tendency on the part of drivers to keep well clear of projecting or apparently projecting posts, which leads to waste of road space.

Regarding aesthetic aspects, the railing should harmonise with the structure, and the bridge as a whole, including the railing, must be in keeping with its surroundings. This does not mean that only one type of railing will suit a particular type of bridge design under all conditions. A simple pipe railing may be eminently suitable on structures of simple functional design set in rural surroundings. A bridge of similar type in a city may require a parapet not only to make it safe for pedestrians, but better to fit it to the formality of the town.

Design of railing may be varied to create a particular effect. For example, an open pipe railing or a balustrade makes a structure look lighter than would a parapet consisting of a continuous wall. By emphasising either horizontal or vertical lines in the railing design, the elements of either length or height in the bridge design may be strengthened. A degree of variety in the design of railings adds interest to the appearance of structures, and provided it does not materially add to the cost, is considered preferable to the invariable adoption of standard designs.

Flocks of travelling stock are common on the country main roads of many parts of New South Wales, and require special consideration. Lambs have a tendency to walk along the kerbs and are likely to be forced off the bridge by other sheep. Protection at a suitable level is therefore necessary and has been provided in the past by the use of a wire or by an additional rail. Recent designs of railing embodying the kerb extended to the edge of the bridge, and a heavy and deep lower rail, adequately protect travelling stock.

Fig. 13. Pipe railing on a steel truss bridge.

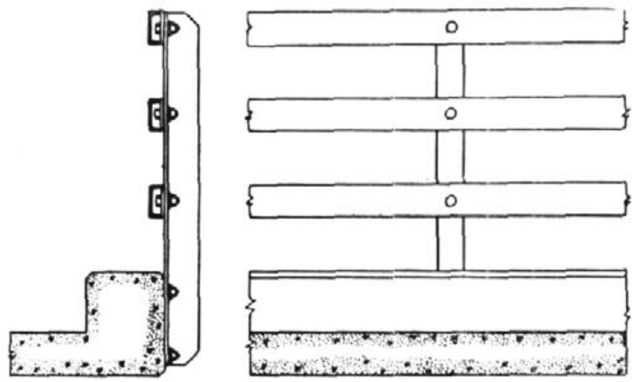


Fig. 15. Steel section railing presenting flush surface to traffic.

In the case of bridges of considerable height, especially in or near larger towns, railings should provide absolute security for pedestrians, and a fence of more than average height is desirable, so designed as to be difficult to climb.

Types of Railing in Use.—Broadly, there are three main types of bridge railing, as follows: (a) with horizontal rails and vertical posts; (b) parapet with perforated panels, i.e., a balustrade; and (c) a continuous wall parapet without openings. Each of these types may be further subdivided according to the material of which the bridge is made, i.e., concrete, steel or timber.

The main trend in the design of railings has been in the direction of making them less liable to be damaged by, or to cause damage to, vehicles or loads on vehicles. Increased durability and improved strength and appearance have also been aimed at.

Early concrete bridges built by the Department of Main Roads usually had pipe rails and intermediate posts, and small concrete end posts. Later, the size of end posts was increased for greater strength and better appearance. A typical design of this type is shown in Fig. 1. Pipe railing is simple, strong and cheap, and gives an effect of lightness which can be obtained in no other way. It was used on some of the famous concrete bridges built by the Swiss engineer Maillart in situations of great natural beauty. During recent years, pipe for railings has been difficult to obtain in New South Wales, and has been little used on this account.

An alternative type of railing which has been much used on concrete main roads bridges in the country is the reinforced concrete post and rail, the rails usually being pre-cast. This type of railing has also been extensively used in the United States. The design originally used in New South Wales is shown in Fig. 2. Modifications have been made from time to time to improve strength and durability, and so that the railing presents a flush surface to traffic throughout its length. Recent designs are illustrated in Figs. 3 and 4. Each post is double, and the railing consists of a series of separated panels or units, each comprising two strong rails with posts at each end. The double posts automatically provide for expansion. The rails project in front of the posts, presenting a smooth face along which a vehicle out of control may slide without undue damage.

Fig. 14. Timber posts and rails on typical timber beam bridge.

Bridges in or near important towns have usually been provided with a balustrade. During recent years, improved designs have been prepared as a result of experience with the earlier designs, the main defects in which related to inadequate provision for expansion, and insufficient cross-section of verticals in panels. Recent designs are illustrated in Figs. 5 and 6.

A form of balustrade which combines lightness in appearance with strength and safety is the welded steel grille type illustrated in Figs. 7 and 8. This design is suitable in towns in any case where it is desired to lighten the appearance of a bridge while yet conveying a formal appearance. The balustrade illustrated in Figs. 7 and 8 consists of a top rail channel, 4 inches by 2 inches, posts of joists 4 inches by 3 inches and a grille of square steel ¾ inch by ¾ inch and ½ inch by ½ inch with horizontal stiffening rails 1½ inches by ¾ inch. The steel-work may be galvanised.

End posts for reinforced concrete bridges may take a variety of forms, or may be omitted altogether as in some German designs. Typical end posts on main road bridges in New South Wales are illustrated in Figs. 9, 10, 11 and 12. Figure 9 shows a recent simple design appropriate to the flush type of railing now generally used.

Steel beam bridges or steel "deck" truss bridges with reinforced concrete deck are provided with railings similar to those used on reinforced concrete bridges.

Steel "through" truss bridges were usually in the past provided with pipe railings. (See Fig. 13.) Pipe posts were replaced by steel angle iron posts bolted to back face of kerb in later designs, this providing a somewhat cheaper and equally effective arrangement. Designs now being prepared provide a railing of smooth face consisting of 5 inches by 2½ inches steel channel rails bolted to 5 inches by 4 inches steel angle posts. The height of the railing is 4 feet. (See Fig. 15). Wire mesh panels are introduced into hand-railing on steel through truss bridges where required for the protection of children or of travelling stock.

In the case of timber beam bridges, conventional timber posts and rails are used. (See Fig. 14). Slight modifications have been made recently to the design of end posts to ensure that the hand-rail presents throughout a smooth, unbroken face to traffic.

The kerb is the first line of defence in the case of a vehicle out of control, and it protects the railing. A maximum kerb height of nine to eleven inches is found satisfactory, any greater height being liable to damage running-boards and mudguards of cars.

Kerbs are usually made wider than in the past, and the Department of Main Roads standard horizontal clearance from face of kerb is in general 12 inches for reinforced concrete and steel beam spans, but may be reduced to 9½ inches to 10 inches from face of rail. A wide kerb keeps the handrail well away from the carriageway, and thus reduces the likelihood of damage by vehicles or loads. It may also serve as a sufficient refuge to pedestrians in emergency.

In the case of steel through truss spans, the minimum lateral clearance from face of kerb to face of rail is 9½ inches. For timber bridges, the kerb is now made 10 inches wide, giving a lateral clearance from face of kerb to face of rails of 7½ inches.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the respective Councils during the period 1st April to 30th June, 1950:—

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Bland Shire ...	57	Gravel resheeting 4.1 m. to 7.1 m. and 13.5 m. to 18.4 m.	F. A. Lewington ...	1,616 0 0
Boolooroo Shire ...	12 16 17	Supply and delivery 4,800 cub. yds. gravel	Muggleton Bros. ...	3,420 0 0
Boomi Shire ...	12	Supply and spreading 3,900 cub. yds. gravel	Kratz and Hansen ...	2,248 11 8
Boree Shire ...	238	Construction of R.C. box culvert and R.C. pipe culvert between 11 m. 4,200 ft. and 11 m. 4,800 ft.	M. Kallas	1,352 8 0
Concord Municipality.	200	Construction of extra lanes between Mary and Killoola streets.	J. Cassidy & Sons ...	12,117 11 11
Gilgandra Shire ...	205	Supply and delivery of gravel at various locations ...	E. W. Hall	1,012 4 0
Holbrook Shire ...	331	Supply and delivery 9,000 cub. yds. gravel	F. Carstens and Sons ...	1,653 6 8
Illabo Shire ...	57	Construction of box culvert at Mattishaw's Creek 25.85 m. from Wagga.	J. H. Galvin	2,148 12 3
Kyeamba Shire ...	57	Supply, delivery and spreading 9,360 cub. yds. gravel ...	R. G. Johnston ...	1,691 0 0
Macintyre Shire ...	12	Resheeting with gravel on T.R. 73 and Main Roads Nos. 134, 135, 136, 137 and 187.	L. W. Keft	5,565 9 0
Do ...	12	Supply and delivery 2,405 cub. yds. gravel	Frost and Spriggs ...	2,886 0 0
Severn Shire ...	9 12	Supply, delivery and spreading 1,875 cub. yds. gravel ...	Frost and Spriggs ...	1,031 5 0
Do ...	9	Construction of road with culverts and subsidiary works...	Frost and Spriggs ...	4,324 7 6

Tenders Accepted—*continued.*

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Shoalhaven Shire	267	Resealing with bitumen	B.H.P. By-Products Pty. Ltd.	2,429 9 0
Do ...	267 312	Supply and delivery 1,285 cub. yds. aggregate	Blue Metal and Gravel Pty. Ltd.	1,729 6 0
Do ...	267	Supply, delivery and spreading 4,195 cub. yds. gravel between 18 m. and 24 m.	F. Matthews	1,783 0 0
Do ...	1196	Construction from 5 m. 2,700 ft. to 6 m. 4,700 ft. ...	J. Cater...	2,711 15 0
Stroud Shire ...	...	Operation of Karuah ferry	W. K. Buie	1,800 0 0
Do ...	110 506	Haulage of 4,538 cub. yds. crushed slag	G. A. Tillitzki	3,991 16 6
Tomki Shire ...	83	Supply of aggregate	Scoope and Co. ...	1,326 15 0
Do ...	83	Surfacing 1.1 m. to 5.57 m.	B.H.P. By-Products Pty. Ltd.	2,206 4 11
Do ...	16	Supply of aggregate 31.62 m. to 35.6 m.	Scoope and Co. ...	2,725 4 6
Tumut Shire ...	278 297	Supply, delivery and spreading 6,400 cub. yds. gravel ...	K. Kennedy	1,440 0 0
Upper Hunter Shire.	62 105	Supply, delivery and spreading 3,400 cub. yds. gravel ...	W. Shearer	1,524 10 0
Uralla Shire ...	63	Construction of R.C. bridge over Cash's Creek	J. Gabauer	5,312 7 0
Wallarobba Shire	101 289 301	Bituminous Works	B.H.P. By-Products Pty. Ltd.	1,902 7 6
Weddin Shire ...	398	Supply, delivery and spreading gravel between 2 m. and 8.1 m., 8.1 m. to 19 m., and 19 m. to 25.9 m.	C. J. Gavin	1,434 0 0

"Stripping" of Aggregate in Bituminous Work

Use of Magnesium Stearate

The past few wet seasons have brought into prominence in New South Wales the danger of water displacing bitumen films from aggregate particles in bituminous road pavements. This is generally known as "stripping" of aggregate. Several failures of pavements have resulted in New South Wales from this action.

The Department has been conducting in its laboratory a series of experiments designed to determine the extent of the danger of "stripping" failures and investigate possible remedies. The most common type of remedy has been the incorporation in the bitumen of some "additive" intended to increase the adhesion of the bitumen. These experiments have shown:—

1. That an unexpectedly high proportion of New South Wales aggregates are liable to stripping.
2. That, contrary to the widely held belief, many "basic" rocks (basalts, dolerites, etc.), are liable to stripping and some "acid" rocks (quartzite, etc.), are not.
3. That certain commercial additives which are available in New South Wales prevent stripping with many aggregates, but are ineffective with other dangerous aggregates. (They are in general effective with "acid" aggregates only.)
4. That sodium and calcium salts of phenolic acids, also suggested as possible additives, are inferior to the commercial additives.
5. That magnesium stearate added to the bitumen (approximately 1½ per cent.) is the most promising additive yet tested. For quite a wide range of aggregates, both acid and basic, it produces a substantial improvement in the adhesion of bitumen in the presence of water. This improvement seems to be sufficient to prevent dangerous stripping with all aggregates tested.

Magnesium stearate was suggested by the Department's chemists. Subsequent to the suggestion and to the work that followed and led to (5) above, British publications have been received showing that road research authorities in Britain have found similar promising results with other heavy metal soaps. Magnesium stearate is, however, preferred as in New South Wales it is the most readily commercially available material of this type.

Actual field works conducted with the recommended addition of magnesium stearate to the binder have demonstrated that the process is simple, free from difficulty, and reasonably economical. The actual cost of the material amounts to about 2d. per gallon of binder. Laboratory work is being extended to verify that the new "additive" is effective with all aggregates, or to ascertain what type or types of aggregate fail to respond.

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, April, 1939.)

24B General Conditions of Contract, Council Contract. (Revised, December, 1949.)

64 Schedule of Quantities.

39 Bulk Sum Tender Form, Council Contract. (Revised, August, 1946.)

38 Bulk Sum Contract Form, Council Contract.

121 Provision for Traffic (Revised, June, 1947) with general arrangement, A 1323 and details A 1325 of temporary signs. (Revised January, 1947.)

A 1342 Warning Signs, Details of Construction.

A 1346 Iron Trestles for Road Barriers.

A 1341 Timber Trestle and Barrier.

A 1824 Light Broom Drag. (1941.

A 1924 Pipe Frame Drag.

A 178 Mould for Concrete Test Cylinder.

A 1381–3, A 1452–5 } Tree Guards, Types A, B, C, D, E, F, and G.

197 Hire of Council's Plant. (Revised, April, 1937.)

A 478 Specimen Drawings, Rural Road Design, with drawings A478A and A 478B.

A 478C Specimen Drawing, Flat Country Road Design.

A 1113 Rural Road Plan and Longitudinal Section Form (tracing cloth).

A 1114 Rural Road Cross-section Form (tracing cloth).

A 1115 Urban Road Plan Forms (tracing cloth).

193 Duties of Superintending Officer (instructions). (Revised, July, 1938.)

314 Standard Regulations for Running of Ferries. (Revised, December, 1948.)

A 1645 Stadia Reduction Diagram. (1939.)

355 Instructions for Design of Two-lane Rural Highways (1937).

A 1487 Horizontal Curve Transitions (diagrams).

A 1488, A 1488A, A 1488B, and A 1488C.—Horizontal Curve Transitions (tables for speeds of 30, 40, 50, and 60 miles per hour).

A 1614 Widening of Shoulders on Crests.

369 Instructions for Design of Urban Roads (1939).

288 Instructions for Design of Intersections (Revised, January, 1948.)

402 Instructions for Design of Rural Intersections (acceleration and deceleration lanes). (1941.)

Form No.

KERBS, GUTTERS, AND GULLY PITS.

243 Integral Concrete Kerb and Gutter and Vehicle and Dish Crossing. (Revised, July, 1939) and Drawing. (A134A.)

245 Gully Pit (Revised, May, 1939) and Drawings (*a*) with grating (A 1042); (*b*) Kerb inlet only (A 1043); (*c*) with grating and extended kerb inlet (A 1352); (*d*) extended kerb inlet (A 1353).

A 190 Gully Grating. (1933.)

A 1418 Concrete Converter. (1936.)

FENCING.

142 Split Post and Rail Fencing and Drawing (A 43).

141 Post and Wire Fencing (Revised, December, 1947) and Drawings (a) Plain (A 494); (*b*) Rabbit-proof (A 498); (*c*) Flood gate (A 316).

143 Ordnance Fencing (Revised, February 1934) and Drawing A 7. (Revised, November, 1939.)

144 Chain Wire Protection Fencing and Drawing (A 140).

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, $3\frac{1}{2}$ 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.

State Highway System
of the
State of New South Wales

Area of New South Wales, 309,433 square miles.
Length of public roads within New South Wales, 126,058 miles.

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