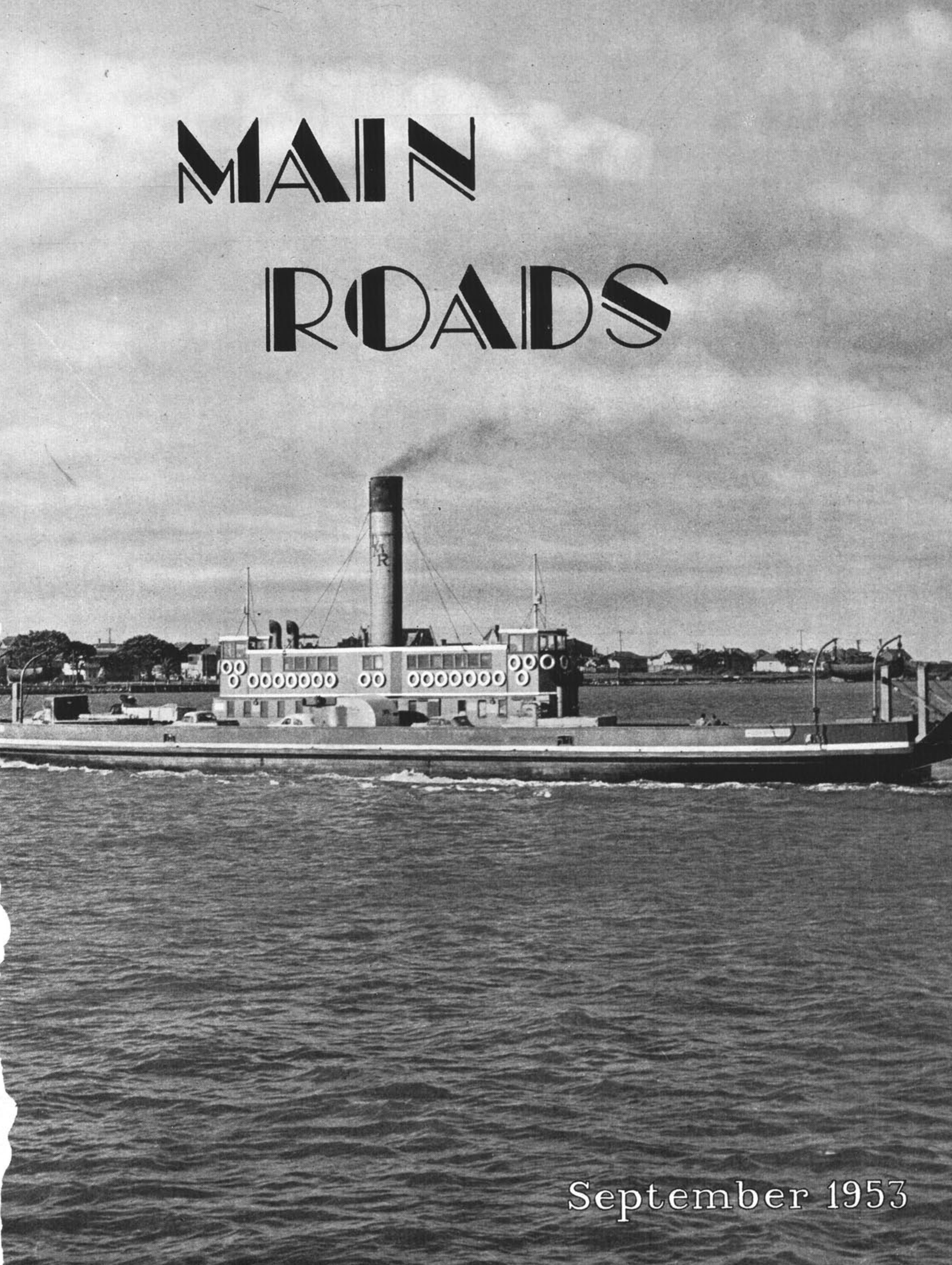
MAIN ROADS



September 1953

MAIN ROADS.

Issued Quarterly by and with the Authority of the Commissioner for Main Roads.

Vol. XIX, No. 1. *Sydney, September, 1953.* *Price: Two Shillings.*

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Additional copies of this journal obtainable from the—

Department of Main Roads,

309 Castlereagh Street, Sydney, New South Wales, Australia.

Box 3903 G.P.O. Telephone: M 6231. Telegrams: "Mainroads" Sydney.

Annual Subscription, 8/- ; Post Free.

Cover Page.

S.S. "Koondooloo," which was added to the Newcastle-Stockton Ferry Service early this year. (Carrying capacity 57 cars).

Next Issue: December, 1953.

*16294

The Late

Alfred Edward Toyer

B.E., M.I.E.Aust., M.Inst.T.

Commissioner for Main Roads

2nd August 1946 to 18th August 1953.

Mr. Alfred Edward Toyer, Commissioner for Main Roads, New South Wales, died suddenly on the afternoon of Tuesday, 18th August, 1953, bringing to a close a life spent in service to his country both as a soldier and a civilian. Never sparing himself in his devotion to his duties, Mr. Toyer collapsed while carrying out an inspection of bridgeworks at Blandford, near Murrurundi on the New England Highway.

It was Mr. Toyer's onerous responsibility to direct the activities of the Department of Main Roads during the post-war years—a difficult period of conversion of the Department's resources from war-time to peacetime accentuated by deteriorated road pavements and structures due to the impact of the war.

A man of outstanding organising ability, he gave of his best and infected those who worked under him with his own enthusiasm. Ever ready to meet his staff, the Councils or the public, his office was an "open door" and he was held in high regard and esteem by all with whom he was associated.

By his death at the commencement of a further seven years term of office, the State has lost a valuable servant of undoubted engineering and administrative ability; one who, since the formation of the Main Roads Board in 1925, has played a big part in the development and improvement of the Main Roads System of the State.

Mr. Toyer was born in Sydney, New South Wales, on 24th January, 1896, and was educated at Cleveland Street School and the University of Sydney, where he graduated Bachelor of Engineering with honours in 1924.

Entering the State Public Service in 1912, Mr. Toyer enlisted in the First Australian Imperial Forces and saw active service overseas. On his return to Australia and discharge from the Military Forces he was appointed to the Department of Public Works, where he was employed on engineering work from 1920 until 1925.

Mr. Toyer was transferred to the staff of the newly established Main Roads Board in June, 1925, as Assistant Engineer, being one of the first two engineers appointed to the Board's service. He subsequently became Designing Engineer, Metropolitan Construction Engineer, and when the Metropolitan Division was constituted in 1928, Engineer-in-Charge of that Division. He became Chief Engineer (Metropolitan) in 1932 and Chief Engineer of the Department in 1937.

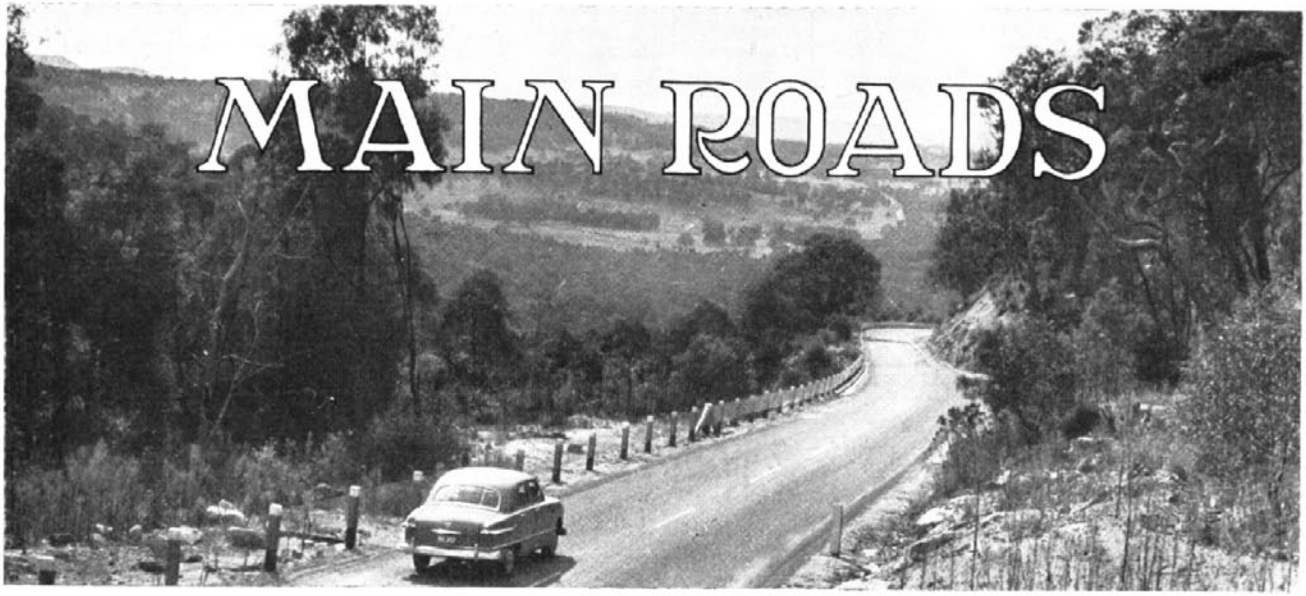
In 1939, Mr. Toyer was sent to Great Britain and the United States of America to study and report on the latest developments in highway work.

In 1941 he was appointed Assistant Commissioner for Main Roads, and in 1946 Commissioner for Main Roads.

Mr. Toyer enlisted in the Second Australian Imperial Forces in 1941, in which he served with the Engineers until 1945. He attained the rank of Colonel. He served during 1942-43 in the Northern Territory as Chief Engineer of the Northern Territory Force, responsible for co-ordinating and supervising most of the work on the North-South road, aerodrome construction, and other works by service and civilian organisations. He and his units were later in New Guinea, Morotai and Borneo. Mr. Toyer was mentioned in despatches for service in the South-West Pacific Area.

The late Alfred Edward Toyer.

Mr. Toyer was a Member of the Institution of Engineers, Australia; a Member of the Institute of Transport, London, and a Vice-Chairman of the New South Wales Section; a Fellow of the Australian Planning Institute, a Fellow of the Institute of Public Administration and a Member of the Council of Management of the Road Safety Council of New South Wales.



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Gates and Grids on Main Roads

ENQUIRIES are made from time to time as to the respective responsibilities of the landholder, the Council and the Department of Main Roads in the control, provision and maintenance of gates and vehicle-grids on Main Roads. It is considered appropriate therefore to set out the general position and to re-state the Department's policy.

It is the Department's objective so far as practicable to secure the ultimate elimination of both gates and grids on Main Roads. In considering the elimination of gates and grids regard has to be paid both to the importance of the road and to the volume of traffic. Complete elimination of both gates and grids is both practicable and desirable and has been largely accomplished in closely-settled areas and on Main Roads carrying a substantial volume of traffic. This applies generally over the eastern half of the State, other than on certain Main Roads carrying little traffic and passing through sparsely-settled districts. In the western part of the State there is a somewhat lesser percentage of Main Roads where complete elimination of gates and grids is justified, but in all cases where gates must remain, they should be supplemented by grids.

Councils are asked to review periodically the gates and grids on Main Roads in their areas, with a view to securing the removal of these where warranted in the public interest. Where it is considered that a gate must remain, and no grid has been provided, arrangements should be made for a grid to be installed in place of the gate and the gate moved to one side. Where it is considered that a grid must remain, and it is not in the centre of the road, arrangements should be made for it to be centralised.

Under section 39 of the Main Roads Act all proposals for the erection of gates and vehicle-grids on main roads need to be approved by the Department prior to establishment. On important Main Roads, the Department considers that grids should be made of sufficient width to carry safely two lanes of traffic, i.e., not less than 20 feet. The Department has available standard drawings giving full details of 10 feet, 12 feet and 20 feet wide grids. There is no obligation on any landholder to use one of these designs, but he should be required to see that the grid conforms with the strength, safety, width and general arrangement of a standard design.

The Department is not agreeable to the erection on main roads of gates or grids in fences built to divide stock reserves under lease.

The Department does not contribute towards the cost of the erection and maintenance of a grid, and the landholder is required to meet the full cost and to make arrangements for its erection and subsequent maintenance. When a grid is to be erected, the Department will assist the Council in constructing and maintaining the approaches to the grid, and also to the gate in its new position, on the same basis as that applying generally to works on the road.

If a grid is not being maintained in a safe condition or at the level at which it was originally constructed, it is for the road authority to direct the attention of the landholder to this. In the event of dangerous conditions arising at a grid at short notice on a Main Road controlled by a Council, and which can readily be remedied by action by the Council, the landholder being absent or at a distance, then remedial action may be taken, but the Council should communicate immediately with the landholder requesting completion of the necessary repairs. The landholder should be charged with the cost of any repairs carried out by the Council.

Landholders' gates on Main Roads are the responsibility of the landholder and are to be painted white or striped and provided with red triangles studded with reflectors or white painted metal sheets triangular in shape, with sides 2 feet 6 inches long. The standard warning sign with the legend "Gate" or "Grid and Gate" is to be erected in advance of vehicle-grids and/or gates. The Department will provide these standard warning signs. The landholder is entirely responsible for the provision and maintenance at his own cost of the further notice boards prescribed by section 251A (5) of the Local Government Act, 1919.

Miscellaneous Activities Bulletin

A bulletin relating to miscellaneous activities on main roads, first issued by the Department of Main Roads in 1937, has been revised and reprinted. It sets out the responsibilities and policies of the Department of Main Roads pursuant to the Main Roads Act and the procedure to be followed by Councils and other public bodies and by persons in respect of miscellaneous activities within the boundaries of proclaimed main roads.

The bulletin is divided into three parts. The first part deals with those activities connected with the use of main roads for vehicular and pedestrian purposes and covers such matters as signposts, mileposts, drainage, footpaths, kerbing and guttering, traffic lines and the planting and preservation of roadside trees. The second part deals with the arrangement of utility services within main road boundaries and the opening of roads for underground services. The third part deals with activities connected with the use of main roads for private purposes, such as advertising, kerbside petrol pumps, gates and grids and the control of the weights of loads on vehicles using main roads.

Copies of the bulletin have been distributed to Municipal and Shire Councils.

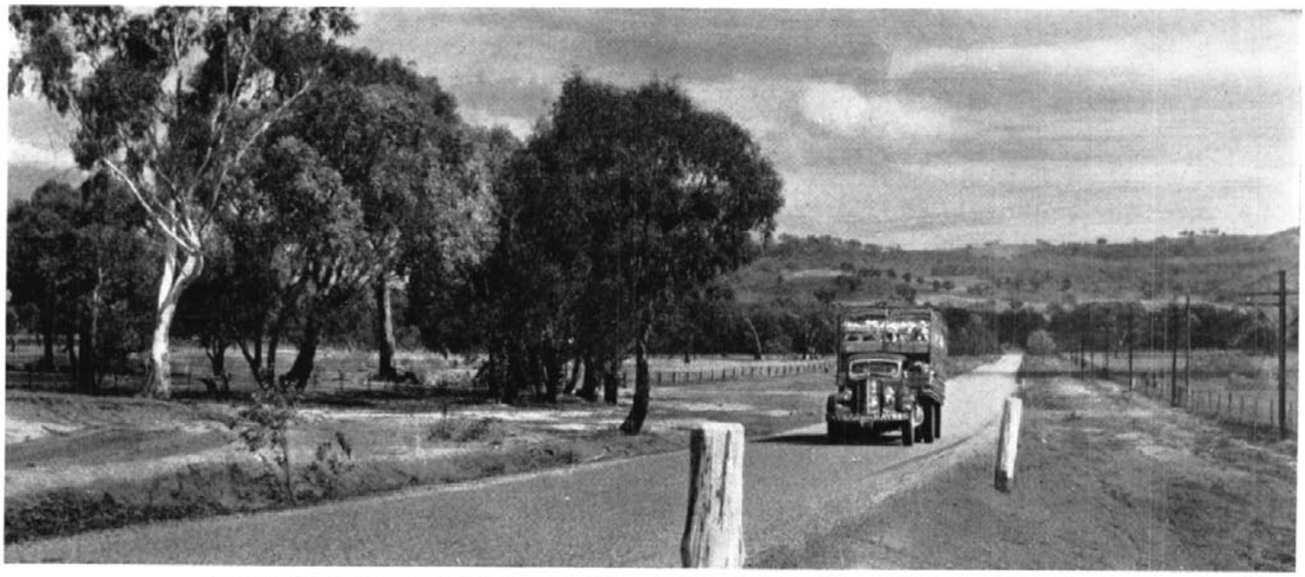
SYDNEY HARBOUR BRIDGE ACCOUNT

Income and Expenditure for period 1st July, 1952 to 30th June, 1953

Income.	£
Road Tolls	595,371
Contributions—	
Railway Passengers	135,969
Tramway and Omnibus Passengers	25,899
Rent from Properties	14,262
Miscellaneous	52
	£771,553

Expenditure.	£	£
Cost of Collecting Road Tolls		61,029
Provision for Traffic Facilities		7,550
Alterations to Archways		21,464
Maintenance and Minor Improvements		100,862
Administrative Expenses		3,076
Loan Charges—		
Interest	220,243	
Exchange	21,089	
Sinking Fund	65,577	
		306,909
Miscellaneous		2,184
		£503,074

NOTE: The figures in the above statement are subject to adjustment upon completion of accounts for the year.



A typical bitumen surfaced Main Road. A section of the Hume Highway 20 miles north of Holbrook.

Bituminous Surfacing Work

Theory and Practice

by

J. H. MOULD, B.E., A.M.I.E. AUST., Executive Engineer

Many miles of initial bituminous surface coats are laid each year in New South Wales and old bituminous surface pavements regularly require resurfacing. Bituminous surfacing work is therefore one of the most important phases of road engineering practice. The following article discusses briefly the theoretical background to the work and describes how the theoretical requirements may be achieved in practice.

A bituminous surface coat is essentially a layer of mineral aggregate put down on a prepared pavement of gravel, or crushed rock or similar material, the aggregate being held in position partly by the mechanical interlocking of the stones comprising the aggregate but principally by an adhesive coat of bituminous binder. A bituminous surface coat does not add any appreciable strength to the pavement: it serves rather to protect the pavement from wind and water erosion and from surface disturbance by wheel loads; at the same time it provides a smooth-riding but non-skid, dustless, running surface for traffic. If a pavement is too thin, wheel loading will cause the subgrade beneath the pavement to distort, the pavement will lose its shape and the surface coat will be destroyed. Likewise, if the material comprising the pavement itself lacks stability it will distort under wheel loads and the surface coat will craze and crack. This may not always be apparent during dry weather but, if distortion and cracking of the pavement has occurred, then wet weather will inevitably be followed by pot-holes after periods of rain. The smooth riding qualities of the finished pavement are dependent entirely upon the care and attention given to the preparation of the pavement prior to the application of the surface coat. An article by H. C. Macready on the preparation for bitumen surfacing of pavements was published in "Main Roads" for December, 1952, and the importance of this phase cannot be overstressed. Inadequate compaction of a pavement will lead to early failure. Inequalities in the surface of the pavement will not be removed by the surface coat and, apart from this undesirable feature may also lead to early pavement failure. Some of the hot binder sprayed on the road will flow from the high spots into the depressions, and so there may be insufficient binder at high spots to hold the cover stone in position. We may expect the high spots to be the first parts of the pavement to show signs of ravelling and pot-holing under traffic. On the other hand, excess binder in the depressions will be squeezed to the surface, causing fatty or slick patches and very often bumps in the pavement. This is particularly so when tar is used as a binder since tar develops a tough skin on the surface by combination with oxygen from the air. Under

Sprayer taking delivery of hot binder from bank of oil fired kettles at Depot.

the kneading action of the traffic, surplus live tar in the pavement breaks through weak spots in the surface skin, erupts over the surface and builds up into bumps as the binder accumulates debris and grit.

The life of a surface coat will depend on two factors, namely, the rate of wear of the stone by attrition under traffic and the period over which the binder will retain its adhesive properties. For the commercial aggregates normally used,—crushed basalts, limestones, river gravels, etc., with French coefficient of wear not less than 10—it can usually be assumed under local traffic conditions that the stone will outlast the binder. The life of the binder is therefore the governing factor, and as the surface coat is a "protective" coat and does not add any appreciable strength to the pavement, there is no overall economic advantage to the gained in laying thick coats of aggregate which add considerably to the initial cost of the work. The objective of the work should therefore be to lay a coat of aggregrate one stone thick with just sufficient binder to coat the stone and hold it firmly in position. Too little binder will lead to early failure of the surface coat by ravelling; too much binder will result in a slick surface coat hazardous to traffic.

It is important to note that the amount of aggregate required to cover the pavement one stone thick will vary with the grading of the aggregate. The larger the size of aggregate, the less road area will it cover per unit volume and the greater the quantity of binder required to hold it in position. This point is sometimes overlooked in preparing estimates and in planning work. A successful surface coat can be laid with any aggregate graded below a limit of 1 in. maximum size provided a careful assessment is made of the coverage of the aggregate and the correct amount of binder. The following table giving the rate of application of crushed stone aggregate for the various grades commercially obtainable and the corresponding rate of application of binder has proved to be a fairly reliable guide. However, some minor variations would be required, particularly for aggregates from $\frac{3}{4}$ in. to $\frac{1}{2}$ in., to suit variations in grading. Aggregates with a large preponderance of coarser sizes would cover less area than that given in the table and *vice versa*. The shape of the individual stones comprising the aggregate is also a factor influencing its covering capacity.

It is worth noting also that some aggregates, particularly some classes of crushed slags and quartz aggregates, have a tendency to shatter under the impact of rollers and heavy traffic wheels. Although the shattered pieces may remain incorporated in the pavement, the degradation of the aggregate results in the binder becoming excessive, which can give rise in time to a slick surface. Where aggregate suspected of having this property is used, the binder should be reduced to the absolute minimum required to hold the stone in position during the setting-up period.

In practice it is found that best results are obtained with aggregates of maximum size of $\frac{3}{4}$ in. for initial surfacing coats and a maximum size of $\frac{1}{2}$ in. for resurfacing coats, although the larger size may be advisable for resurfacing work in certain circumstances, particularly where the existing surface is slick due to excess binder. In this case the larger size aggregate will provide a greater volume of voids to absorb the surplus binder. However, resurfacing is at best a temporary remedy only for slick pavements, and it will eventually be necessary to remove the excess binder

TABLE.

Rate of application of crushed stone aggregate.			Rate of application of binder—cold gallons per square yard.			
			No primer.		On primer or as reseal.	
Nominal gauge.	Limit of grading.	Square yards per cubic yard.	Bitumen.	Tar.	Bitumen.	Tar.
$\frac{3}{4}$ in.	$\frac{3}{4}$ in.–$\frac{3}{8}$ in.	1/65	·32	...	·27	...
$\frac{5}{8}$ in.	$\frac{5}{8}$ in. –$\frac{3}{8}$ in.	1/75	·29	·31	·24	·26
$\frac{1}{2}$ in.	$\frac{1}{2}$ in.–$\frac{3}{8}$ in.	1/90	·27	·29	·22	·24
$\frac{1}{2}$ in.	$\frac{1}{2}$ in.–$\frac{3}{16}$ in.	1/95	·26	·28	·21	·23
$\frac{3}{8}$ in.	$\frac{3}{8}$ in.–$\frac{3}{16}$ in.	1/120	·22	·24	·17	·19

Note: The above figures are for single applications of graded aggregate. For two coat work, the separate applications of aggregate would be lighter, but the total application heavier than the rates listed. Reduce up to 0.05 galls. on very slick surfaces. Increase up to 0.05 galls. on very rough and/or absorbent surfaces.

Laying paper mat for start of full width spray run. Note guide bar on sprayer.

by burning it off the surface or covering it by the application of an open graded bituminous macadam. Aggregate larger than ½ in. gauge should not be used for resurfacing with tar as difficulty will be experienced in holding the larger stone in position during the setting up of the tar. Moreover, tar has a shorter life than bitumen and the use of the small gauge will give a better economic balance of the life of the binder and wear of the stone.

Experience has also shown that where aggregate graded from coarse to fine is cast, either by hand or by mechanical means, upon the pavement, inevitably some of the fines reach the pavement first so that a proportion of the larger size stones rest on finer particles. This results in a rather rough open surface finish of varying thickness and, due to the poor interlocking and binding of the stone, there is a tendency for the larger projecting stones to be dislodged by traffic. Loss of aggregate can be serious if it is poorly graded with a preponderance of fines or if the quantity of binder has not been sprayed with a high degree of accuracy, and, apart from wastage of stone, a slick pavement will result. If a more or less "one size" aggregate cannot be obtained, best results are obtained when the aggregate is divided into two separate gradings, the coarse grading being spread first one stone thick and rolled; the finer grade then being spread to fill the surface voids and rolling repeated. A fine textured non-skid surface of uniform thickness is thus obtained without any loss of aggregate.

The following gradings will meet these requirements and at the same time be within the practicability of supply from normal crushing and screening plants:—

Percentage passing British Standard Sieves.

Material.	1 in.	¾ in.	½ in.	⅜ in.	¼ in.	3/16 in.	No. 14.
¾-in. Gauge—Double Application—							
A—Coarse ..	100	95–100	0–20	0–15	...	0–2	...
B—Fine ...	...	...	100	95–100	...	10–35	0–3
½-in. Gauge Single Application ...	...	100	95–100	45–70	...	10–25	0–2
½-in. Gauge—Double Application—							
A—Coarse ...	...	100	95–100	0–30	...	0–5	...
B—Fine ...	...	...	...	100	95–100	30–65	0–5

It is important that the aggregate be roughly cuboidal in shape and free from elongated and flakey particles. It is also important that the coarse grade approximate as far as is practicable to one size, i.e., coarse aggregate graded between ¾ in. and ⅝ in., would be preferable to aggregate graded from ¾ to 3/16 in. It is sometimes necessary to accept a finer aggregate in order to make the most economical use of the full range of materials produced by certain screening or crushing plants. In view of the high cost of bituminous surfacing work, however, use of second class aggregate cannot be justified unless the resultant saving in cost of the completed work is commensurate with the estimated reduction in the life of the surface coat.

Typical jobs with double applications of aggregate are as follows:—

Initial Surface Coat—	
Coarse aggregate—$\frac{3}{4}$ in. to $\frac{3}{8}$ in. ...	1 c. yd. to 70 sq. yds.
Fine aggregate—$\frac{3}{8}$ in. to $\frac{3}{16}$ in. ...	1 c. yd. to 240 sq. yds.
Total	1 c. yd. aggregate to 55 sq. yds.
Binder (Bitumen)—	
On primer	·27 gallons to sq. yd.
Without primer	·32 gallons per sq. yd.
Resurface Coat—	
Coarse aggregate—$\frac{1}{2}$ in. to $\frac{3}{8}$ in. ...	1 c. yd. to 100 sq. yds.
Fine aggregate—$\frac{3}{8}$ in. to $\frac{3}{16}$ in. ...	1 c. yd. to 300 sq. yds.
Total	1 c. yd. to 75 sq. yds.
Binder (Bitumen)	·22 gallons per sq. yd.

Where large gauge aggregate ($\frac{3}{4}$ in. to $\frac{1}{2}$ in.) is used with tar as binder, it is advantageous to spray the tar in two applications—a first coat prior to the spreading of the coarse aggregate, and a second, lighter coat prior to the final application of fine aggregate. The total amount of aggregate and binder should not be increased but the double application of binder allows for its better distribution, and this assists in holding the stone in position during the setting-up period. The same technique is adopted when it is desired, owing to special conditions of heavy traffic, to lay a heavier "armour" coat to protect the pavement.

Priming Coats.

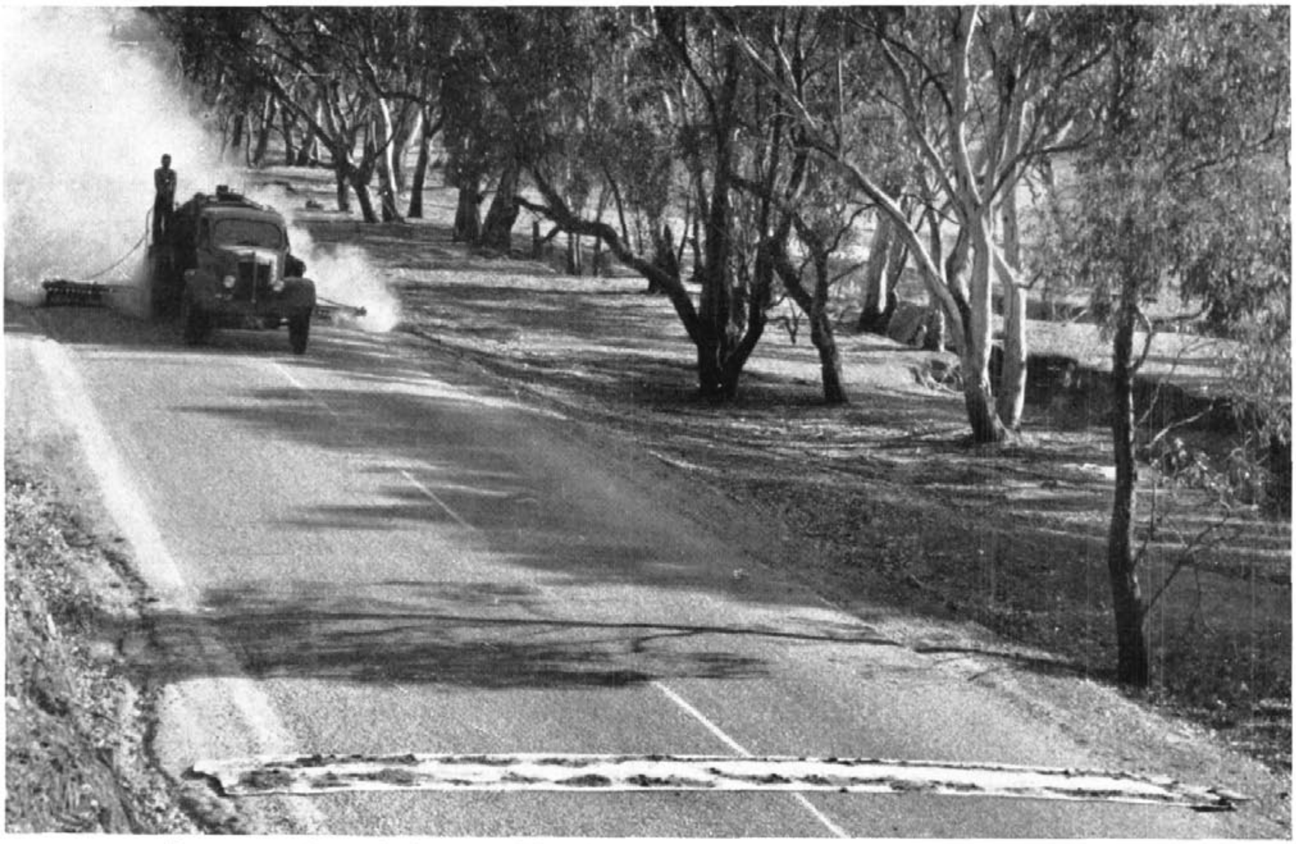
Experience has shown that the spraying of priming coats of light tar as a preliminary to new bituminous surfacing work, as was almost invariably adopted in earlier works, is not generally necessary. The priming coat itself adds little value to the surface coat—although adding to the cost—and in some cases it has a deleterious effect as it tends to destroy the binding qualities of the gravel pavement it penetrates. There are some gravels, particularly those of the more open or freer type which may absorb a high proportion of the surface coat binder which require a priming coat but, in general, any pavement that can be compacted and swept to give a clean hard surface showing a mosaic of stone can be surfaced without a priming coat. The particular advantage of a priming coat lies in the fact that it allows the pavement, once it has been prepared in readiness for the surface coat, to be held in this condition under traffic for some time until the surface coat is applied. This has some importance where a specially trained mobile surfacing organisation, as employed by the Department, is moving from job to job. Any delays due to the pavement not being prepared in advance, or to repairs being necessary as a result of damage by traffic during wet weather following final preparation, upset schedules and add to costs.

Where priming coats were used, best results have been obtained by applying a crude gas tar or a refined heavy priming tar to the pavement and allowing it to soak in. At a rate of application of approximately 0.18 gallons to a square yard, absorption may take from 12 to 24 hours. Pavements primed in this way have stood up under reasonably heavy traffic for long periods. However, where traffic is so heavy that it cannot be deviated or denied the use of half width of the pavement for the period required for priming, the priming tar can be covered with sand or grit and opened immediately to traffic. A heavier application of priming tar will be necessary in this case, the cost will be increased and generally the life of the priming coat under traffic will be reduced.

Fluxing.

When hot binder is sprayed on a road it must be fluid enough to coat thoroughly the surface of the stone that will be embedded in the binder. It must also have sufficient tenacity when cooled to road temperature to hold the aggregate firmly in position. The viscosity of the binder, which is a measure of its fluidity, varies with its temperature, and the viscosity of the binder at any temperature will also be dependent upon the properties of the particular grade of binder used—that is, upon the original viscosity at standard temperature (77°F.). When sprayed the binder soon cools to the temperature of the road. The road temperature not only varies from season to season and from locality to

Commencement of spray run. Aggregate spreading trucks and roller in position to follow immediately spraying starts.



Sprayer nearing end of measured length. Paper mat in position for clean finish to run.

locality but from hour to hour due to chilling winds, clouding over of the sun, shadows cast by roadside trees, etc. Road surface temperatures may be as high as 40°F. above air temperatures.

To take account of these factors, it is customary in New South Wales to (a) confine bituminous surfacing work to the late spring, summer and early autumn months when the range of air temperatures is limited and very low temperatures are not experienced and (b) increase the fluidity of the binder by adding flux oil. Grades of binder (80/100 penetration bitumen or either H100, H48 or H16 grade tar), which will have viscosities a little above that desirable over the range of temperatures likely to be experienced during the work, are used. Sufficient volatile fluxing oil, which will more or less evaporate during the setting up of the bituminous surface, is then added to the binder immediately prior to spraying on the road to increase its fluidity (by lowering the viscosity) to that desirable at the road temperature at which the spraying is to be carried out but with due regard to changing weather conditions over the next few hours. Road temperatures are measured by placing a black bulb thermometer on the road and covering the bulb with sufficient roadside grit to protect it from the wind.

Charts are available giving the correct percentage of flux oil to add to each grade of binder for a given road temperature, and these were described in detail in an article on the fluxing of binders in the issue of "Main Roads" for March, 1947.

Organisation.

From the considerations discussed above it will be seen that for first-class work the following requirements must be met:—

(a) The binder must be heated and fluxed to give the right consistency for the road temperature when sprayed.

(b) The binder must be sprayed at the correct gallonage per square yard and with a close degree of accuracy.

(c) The aggregate must be accurately spread at the designed rate per square yard of road and rolled immediately after the binder is sprayed.

The principal item of plant used to achieve this end is the bitumen pressure sprayer. This consists essentially of a tank of approximately 800 gallons capacity to carry the hot binder, mounted on a motor truck chassis, and connected to a spray bar at the rear of the truck. An auxiliary engine is also mounted on the truck to drive a pump which is fitted with a three-way valve to allow the hot binder to be pumped into the tank or to be circulated in the tank and spray-bar manifold or to be sprayed on to the road. A platform to accommodate the sprayer operator is fitted to the rear of the truck from which the operator can manipulate the valve controlling the pumping system and vary the speed of the auxiliary engine to give constant pressure from the pump as measured by a pressure gauge. The binder tank is usually lagged and fitted with a blow torch to enable the binder to be kept hot in transit to a job. A special tachometer is mounted in the driving cabin; this is operated by a light wheel which can be lowered to make contact with the road when required and is capable of accurately registering slow speeds. The spray bar is adjustable so that varying widths up 20 or 22 ft. can be sprayed in one operation and is fitted with removable jets so adjusted that at road surface the spray from each overlaps the spray on each side. At the ends of the spray bar, where overlapping is not possible, the jet nipples are specially designed to deliver the correct proportion of binder to the outer half of the spray. "Thin" edges to the pavement and fatty streaks can often be attributed to the fact that the end jets have been misplaced during adjustment of the spray bar or when the jets have been removed for cleaning. To assist the driver in accurately placing the surface coat, a projecting pole with a length of chain hanging from the end is often fitted to the front of the sprayer truck so that it can be accurately steered by passing the chain over marks placed to define the edge of the pavement. This is important when, to avoid the complete closing of the road traffic, spraying is carried out in half road widths, as it permits a clean joint to be obtained at the centre without a gap between, or an overlap of, the two half width sprays.

With constant pressure along the spray bar, the rate of spraying of binder is dependent only upon the speed of the sprayer which is accurately registered by the tachometer in the cab. The sprayer can therefore be calibrated to give spraying rates against speed, and with an experienced driver and operator accuracies of spraying up to 5 per cent. can be obtained.

As the controlling valve allows a quick cut-off of the binder, a sharply defined end of each spray run can generally be obtained provided the binder tank is not allowed to empty to the stage when blowing-out occurs due to air entering the manifold. However, it takes some time for the pressure to build up for even distribution through the spray bar when starting the run and to overcome this the run is generally started over a strip of heavy paper placed with its leading edge co-linear with the transverse edge of the previous run. The paper is subsequently removed and an accurate joint obtained.

The spreading of the aggregate is carried out with tipping trucks generally of 5 cub. yd. capacity fitted with a special tail gate and "fan-tail spreaders" (see illustration). The rate of spreading is dependent upon the opening of the tail gate and the speed of the truck. While at first glance this might appear to give rather inadequate control over the rate of spreading, with experienced drivers and tail gate operators under or over spread does not exceed 5 per cent. In practice a slight under spreading should be aimed at, and any areas of thin spread are made up by hand spotting.

Where the work is close to a railway siding the binder can sometimes be supplied advantageously in special rail tank waggons capable of being steam heated from portable boilers. Generally, however, for country work the binder is supplied in drums, heating being carried out in a bank of portable bitumen kettles fitted

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Spreading aggregate through truck tail gate and fantail spreader.

with oil-fired burners. A heating and fluxing site is selected in advance of the arrival of the bituminous surfacing organisation and should be central to the job to reduce the haul for the sprayer to a minimum. The aggregate is also delivered in advance to the job and is stock-piled at the side of the road at sites chosen to reduce the haul of the spreading trucks so as not to exceed about 3 miles. The aggregate is loaded into trucks by mechanical means, sometimes by scoop loaders fitted to the trucks, but more often by self-propelled mechanical loaders of the elevating bucket type, which move with the surfacing gang from job to job. As the supply of the aggregate is a major item in the cost of the work, wastage of the aggregate by contamination with the ground should be avoided by choosing clean level sites for the stock-pile. A stock-pile should have a firm base from which the loader can operate and should be built up in two or three lifts by supplying timber bearers of old railway sleepers or bridge decking for the delivery trucks to mount the rising pile of aggregate. Where the ground has poor bearing value, a firm floor of gravel should first be laid and an all-weather access track provided from the pavement to the stock-pile. If this is overlooked delays may be experienced after wet weather owing to inaccessibility of the stock-pile.

In addition to the sprayer, loading equipment, and heating kettles, a bituminous surfacing organisation should be equipped with two fast medium weight rollers (6-8-ton tandem rollers are suitable); a mechanical broom to sweep the pavement prior to surfacing; a light broom drag for distributing the light screenings applied in the second application of screenings; four or five cub. yard trucks fitted with tail gates and fantail spreaders; and an additional light truck for subsidiary haulage work, including the towing of the broom drag.

Description of Work.

The spraying of binder may be carried out in one operation for the full width of a 20-22 ft. wide pavement or in half widths of pavement. Full width spraying is preferable in many instances as it avoids the necessity for a centre joint and it allows the sprayer to be discharged in one run, thus reducing its waiting time. This is important when the sprayer has a long lead from the heating depot and its output is the controlling factor in the daily progress of the work. Disadvantages are: (a) possible reduction in pressure towards the end of the spray bar so that the binder may not be evenly distributed; (b) the road has to be totally closed to traffic during the spraying, spreading and setting-up period; and (c) due to the hold-up of traffic there may be a tendency to "hurry" the work. Additional trucks with fantail spreaders and extra road rollers are generally required for quick coverage of the binder with aggregate and for rolling, thereby adding to the size and cost of a mobile organisation moving through a country area from job to job.

Spraying over half widths by lengths of 500 to 600 yards can be adopted with advantage on country work where traffic is relatively light and can be allowed the use of the remaining half width of pavement during the spreading, rolling and setting-up period. With experienced sprayer-drivers overlapping of, or gaps between, the half width sprays at the centre of the road can be avoided and, generally, half width spraying will permit the use of a more compact organisation and better control of the work. Where traffic is predominately heavy in one direction the side carrying the lighter traffic should be sprayed first.

The cycle of operations in carrying out the work can best be described starting from the commencement of the spray run. The loaded sprayer is standing right at the end of the previous run behind the strip of paper laid at the joint. The first truck of coarse aggregate is standing by and the road roller is working at the end of the previous run in readiness to move on to the new strip. As the sprayer passes over the paper at the joint, spraying is commenced. The paper, with surplus binder, is immediately removed—and subsequently destroyed—and the truck of aggregate follows closely behind the sprayer backing over the pavement and spreading the aggregate through the fantails so that the wheels do not come in contact with the hot binder. The aggregate truck is immediately followed by the roller. As each truck empties its load the next truck, which is standing by, cuts in and continues the spreading so that the whole of the hot binder is covered immediately after it has been sprayed. Where half width spraying is adopted the length of the spray run is fixed so that the four (or five) spreading trucks will have sufficient coarse aggregate to cover the binder with a surplus in the last truck to make up any undercovered spots. As soon as they are emptied the trucks return to the stock pile to be refilled with coarse aggregate, and the sprayer moves into position for the adjacent half width run which is started immediately the truck returns to the job. The first two trucks emptied on this run return to the stock pile for fine aggregate which is spread as soon as the coarse aggregate has had an initial rolling.

When the sprayer completes this run it returns to the heating depot to be recharged, carrying written instructions from the road foreman in regard to the amount of flux oil to be added to the binder. This amount has been ascertained from the fluxing chart after reading the actual road temperature. By the

Rolling first application of coarse aggregate.

time the recharged sprayer returns to the road the trucks are again standing by with coarse aggregate and the whole cycle of operations is repeated. After the spreading of the fine aggregate rolling is continued and when the binder has set up sufficiently, generally the next day, any fine aggregate that has not at that stage been held by the binder is evenly distributed by a light broom drag drawn behind a truck.

A complete record is kept of each spray run including its exact location in the pavement, the amount of binder, flux oil and aggregate used and the road temperature and weather conditions.

On country roads, where traffic does not exceed 300 vehicles per day, the finished surface coat may be opened to traffic, without risk of damage to the surface as soon as the final application of fine aggregate has been well rolled and initial setting-up taken place—generally within two to four hours, depending upon weather conditions, and other factors. However, adequate measures such as the erection of suitable barriers, employment of flagmen to control traffic, etc., must be taken to ensure that traffic does not use the treated pavement during the initial setting up period. Where traffic is heavy the period of closure should be considerably extended, and in urban and city areas carrying heavy industrial traffic bituminous surfacing work of this type should not be carried out unless the road can be totally closed for at least twenty-four hours.

Conclusion.

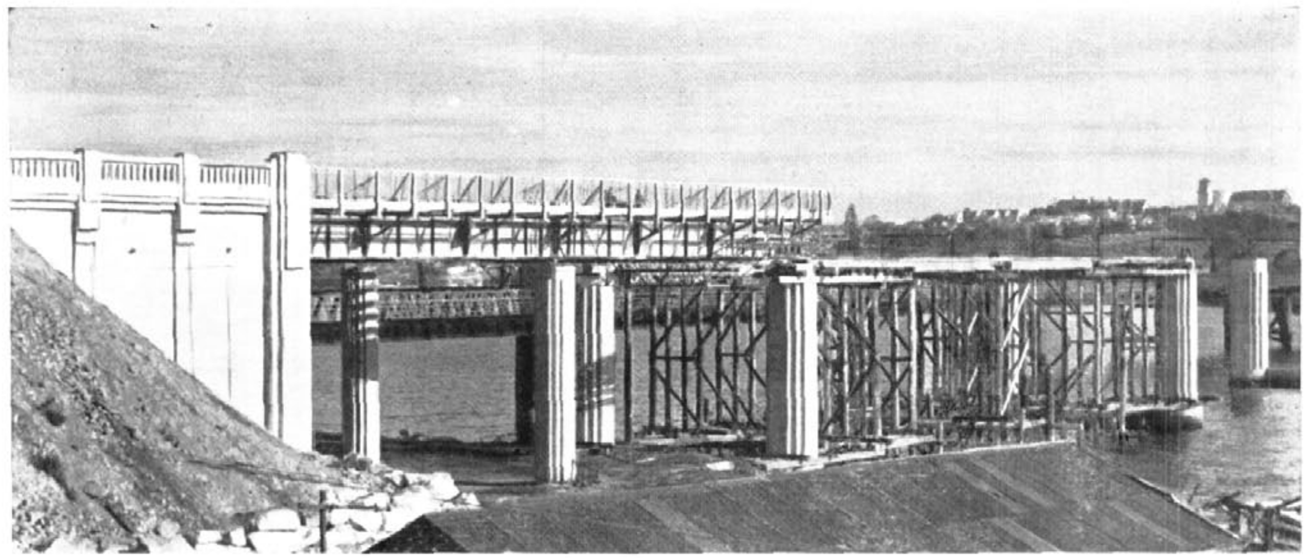
Bituminous surfacing work is expensive. It makes use of a technique that has been evolved after many years of experience and allows for many critical factors upon which depends the success of the work and the future life of the surfacing. Careful selection and proportioning of the binder and aggregate and close supervision of details are essential for first-class work, and these are more than justified on economic grounds. Provided adequate attention is given to details, a pavement with excellent riding qualities, protected by a dense even mat of stone, with an even textured non-skid surface will be obtained.

A large measure of the engineering success of the job will be apparent within a week of completion of the work. If it has been properly designed and carefully carried out there should then be no signs of binder working to the surface and no loose stones upon the pavement or aggregate whipped off by traffic lying at the sides of the road.

Tenders accepted by Councils

The following Tenders (exceeding £1,000) were accepted by the respective Councils during the months of April, May and June, 1953 :—

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Bland S. ...	57	Gravel resheeting. Supply, spreading and consolidating 10,800 cu. yds.	A. G. Neal	3,216 0 0
Bogan S. ...	7	Supply, delivery and spreading 3,000 cu. yds. sandy loam and 750 cu. yds. sand between 347·3 m. and 361·1 m. Average haul loam 5 m.; sand 20 m.	L. G. Randall	1,425 0 0
Do ...	1,163	Construction R.C. box culvert, causeways and gravelling 8 m. 1,200 ft.–9 m. 760 ft.	W. A. Rowley	2,562 12 3
Coonamble S. ...	18	Supply and delivery 8,160 cu. yds. sandy loam between 8·5 m. and 13·6 m.	Construction Services Pty. Ltd.	1,847 0 0
Gilgandra S. ...	11 } 18 }	Supply and delivery of 5,628 cu. yds. gravel on S.H. 11 and S.H. 18 between 324·8 m. and 366·5 m. and 47·55 m. and 56 m.	J. A. Moses	1,881 17 3
Hay M.	14	Re-shaping and re-loaming existing formation between 0·9 m. and 4·4 m.	Jackson and Hurst ...	1,365 0 0
Jemalong S. ...	1,199	Supply, delivery and spreading 5,940 cu. yds. gravel between 5·48 m. and 9·19 m.	Town and Country Roadworks.	3,539 5 0
Jerilderie S. ...	1,211	Supply and delivery of 3,456 cu. yds. of sand clay between 3·35 m. and 5·15 m.	K. Tatnell	1,026 16 0
Do ...	323	Supply, delivery and spreading gravel between 6·85 m. and 7·10 m.; 8·65 m. and 9·65 m.; 18·10 m. and 18·50 m.	do	1,141 16 0
Do ...	59	Supply and delivery of 6,610 cu. yds. of loam between 0 m. and 6·5 m.	D. D. McCallum	1,308 3 10
Liverpool Plains S.	1,112	Construction of 4,314·3 lin. ft. of D.R. 1,112 and 200 lin. ft. of side road.	Clifford Bros.	2,346 19 3
Do ...	1,112	Clearing, forming and gravelling from 20 m. to 24 m. from Trunk Road 72.	H. T. Roach	8,545 17 0
Murrumbidgee S.	14	Supply and delivery of 13,200 cu. yds. of loam... ...	A. Hunter-Boyd	2,733 0 0
Snowy River S....	286	Construction of R.C. box culvert	G. Flamia	2,670 10 0



Iron Cove Bridge showing first two plate girder spans in position on the piers. Another two plate girder spans have since been erected.

Progress with Construction of some Large Bridges

SINCE the end of the war the Department has put in hand the construction of seven large bridges, namely:—

1. Bridge over Hunter River at Hexham.
2. Bridge over diversion of Cook's River at Kingsford Smith Aerodrome.
3. Bridge over Iron Cove, an arm of Sydney Harbour.
4. Bridge over entrance to Lake Macquarie at Swansea.
5. Bridge over Clyde River at Bateman's Bay.
6. Bridge over Middle Harbour, Sydney, at The Spit.
7. Bridge over Cockfighter Creek at Warkworth.

The bridges over the Hunter River and over the Cook's River diversion, which have been opened to traffic, were referred to in the issues of "Main Roads" of December, 1946, September, 1949, December, 1950, and March, 1953. Construction of the other bridges is still in progress.

Iron Cove Bridge.

The new bridge over Iron Cove, the design of which was referred to in the March, 1947, issue of "Main Roads", will replace the old iron bridge, built in 1884, which is now obsolete and inadequate for traffic requirements. The new bridge will provide for four lanes of traffic and carry two footways; the old bridge provides for two lanes of vehicles and carries one footway. The new bridge consists of two steel plate girder spans at each end, and seven steel truss spans. A contract was let to Messrs. Hornibrook, McKenzie, Clark and Co. on 12th June, 1945, for the construction of the piers and abutments; construction under this contract commenced in February, 1946, and was completed in November, 1950.

In May, 1946, a contract was let to the Clyde Engineering Co. for the fabrication of the steelwork. Shortage of steel in the middle of 1948 prevented progress being made with this, and work was suspended until towards the end of 1952. The four plate girder spans have since been delivered and it is anticipated that the whole of the steelwork will shortly become available.

A third contract was let in June, 1948, to Messrs. Hornibrook, McKenzie, Clark and Co., for the erection of steelwork, the construction of the deck and the completion of the structure. This contract was affected by the delay in the steelwork contract and was not commenced. A fresh contract was negotiated in July, 1952, and work was commenced towards the end of 1952. The four plate girders spans have now been placed in position on the piers, and assembly of the first truss span has been commenced. It is anticipated that this contract will be completed towards the latter half of 1954.

The approaches will be constructed by the Department of Main Roads by day labour to coincide with the completion of the bridge.

Swansea Bridge.

The new bridge over the entrance to Lake Macquarie at Swansea, the design of which was referred to in the March, 1948, issue of "Main Roads", will replace a timber beam bridge built in 1910, which is now worn out. The old bridge, which has a carriageway of 15 feet, has no footway, but has pedestrian refuges at intervals along each side. The new bridge comprises twelve 40-feet rolled steel joist spans with concrete deck, and an electrically operated double-leaf bascule opening span with a steel open-grid deck. The total length of the bridge will be 570 feet and it will have a 5-feet footway on the downstream side. The roadway width will be 22 feet.

A contract for the manufacture, supply and delivery of the steel work and machinery for the new bridge was let in Germany, and this has been delivered to the bridge site.

Although tenders for the erection of the bridge were invited on several occasions, both in the Sydney and Interstate press, no tenders were received, and the Department of Main Roads then undertook the construction of the bridge by day labour, and work commenced in February, 1952.

Swansea Bridge showing falsework and concrete piles for driving.

Work carried out to date comprises the construction of all falsework and the completion of one abutment and two piers at the Sydney end, and steel girders have been placed in position ready for pouring of the concrete deck in the first two spans at that end. Three reinforced concrete piles have been driven in the second abutment and test piles have been driven in three piers. Fabrication of sheet piling for piers 3 and 4 (opening span) is proceeding and one-third of this work has been completed. In addition to work of actual construction, all piles have been poured for abutment B and piers 10, 11 and 12.

The approaches will be constructed by the Department of Main Roads.

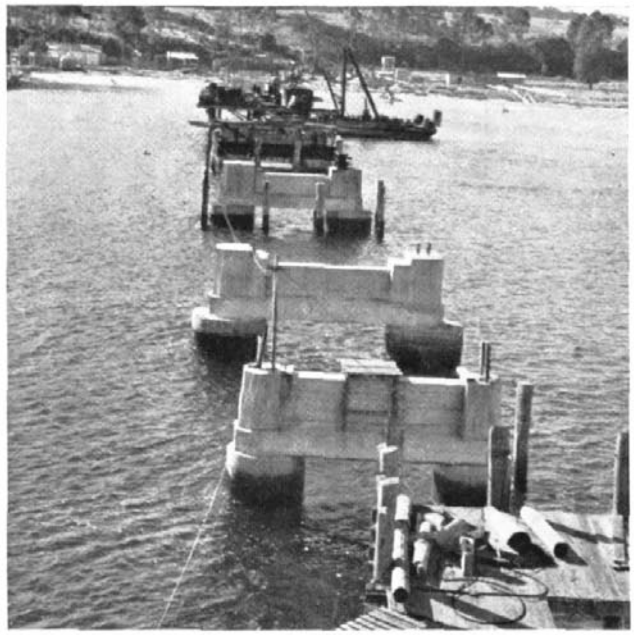
The bridge is expected to be opened to traffic late in 1954.

Bridge over Clyde River at Bateman's Bay.

The new bridge over the Clyde River at Bateman's Bay, 177 miles south of Sydney on the Prince's Highway, the design of which referred to in the March, 1948, issue of "Main Roads", will replace a ferry service. The new bridge will consist of five 120-feet steel truss spans, a 90-feet vertical-lift opening span, and four steel girder approach spans. It will have a reinforced concrete roadway 22 feet wide and a 5-feet wide footway on the downstream side. The total length of the bridge will be 1,008 feet.

A contract for the erection of the bridge was entered into with Balgue Constructions Pty. Ltd. in December, 1947, and work commenced soon after that date. A contract for the manufacture, supply and delivery of metalwork and machinery was entered into with the Clyde Engineering Co. Ltd. in March, 1948.

In 1951, Balgue Constructions Pty. Ltd. asked to be relieved of their contract. The Department of Main



Bridge over Clyde River at Bateman's Bay showing some of the completed piers.

Roads agreed to this, and in May, 1951, the work was taken over from the contractors and was put in hand by day labour. Work carried out to date, including that done by the contractor before relinquishing his contract, is as follows:—The cylinders for all piers, except pier No. 4, have been taken down to rock foundation, in some cases more than 60 feet below high water level and sealed, and headstocks have been constructed on piers 1, 2, 6, 7, 8 and 9 ready for the erection of structural steel.

The original contract for the supply of structural steel and machinery, which was placed with the Clyde

Engineering Co., was subsequently cancelled owing to Clyde Engineering Company's other commitments, and arrangements were made with the State Dockyard, Newcastle, whereby the structural steelwork will be fabricated at the Dockyard. The Clyde Engineering will construct the machinery for the opening span.

The approaches work will be carried out by the Department by day labour, and it is expected that the bridge will be opened to traffic in 1955.

Bridge over Middle Harbour at The Spit.

Details of the design of this structure were described in the December, 1949 issue of "Main Roads".

The new bridge is to replace a bridge built in 1924 by the Sydney Harbour Trust on behalf of the Manly Municipal Council and which for some years past has been unable to carry peak-hour traffic without delay and which is now approaching the end of its useful life.

The new structure will provide a carriageway 44-feet wide for four lanes of vehicles and will also carry two five-feet footways for pedestrians. The bridge will consist of seven 100-feet spans of plate girder type supported by concrete piers. Piers 3, 4, 5 and 6 will be supported on cylinders founded on rock at depths varying up to 100 feet below water level; the other piers will be on driven concrete piles. Marine traffic will be provided for by an opening span of the single-leaf bascule type, electrically operated, with 80 feet horizontal clearance.

Contracts for the construction of the bridge and also for the supply and delivery of metalwork and machinery were entered into with the Cleveland Bridge and Engineering Co. Ltd., England, in March, 1951, and work commenced in September, 1951. Work has progressed to the stage where abutment "B" is about one-third complete, at abutment "A" a crane is being erected prior to work on the abutment being put in hand, driving of sheet piling is almost complete at pier 2, and 65/35-feet and 8/40-feet reinforced concrete piles have been cast. The first shipment of steelwork for the superstructure, being prefabricated in England by Cleveland Bridge and Engineering Co., is expected to arrive in Australia shortly.

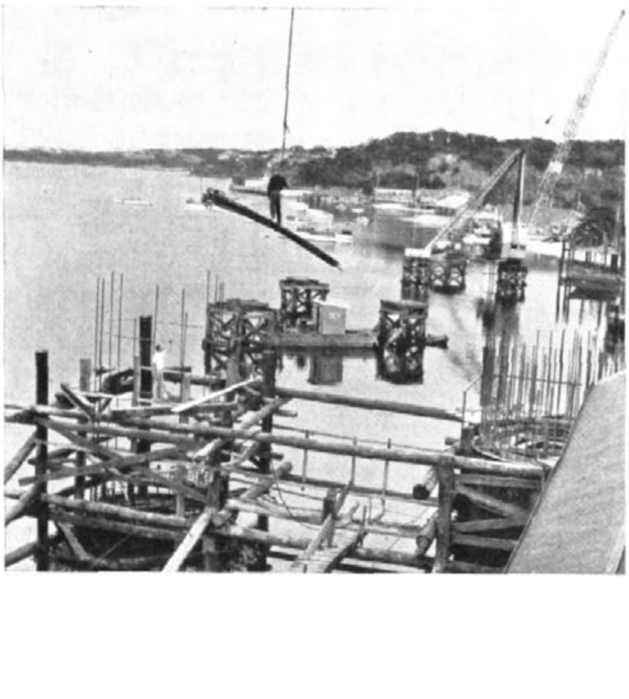
The approaches will be carried out by the Department of Main Roads by day labour, and will be put in hand concurrently with the erection of the bridge. It is expected that the bridge and approaches work will have advanced sufficiently to allow the bridge to be opened in 1956-57.

Warkworth Bridge.

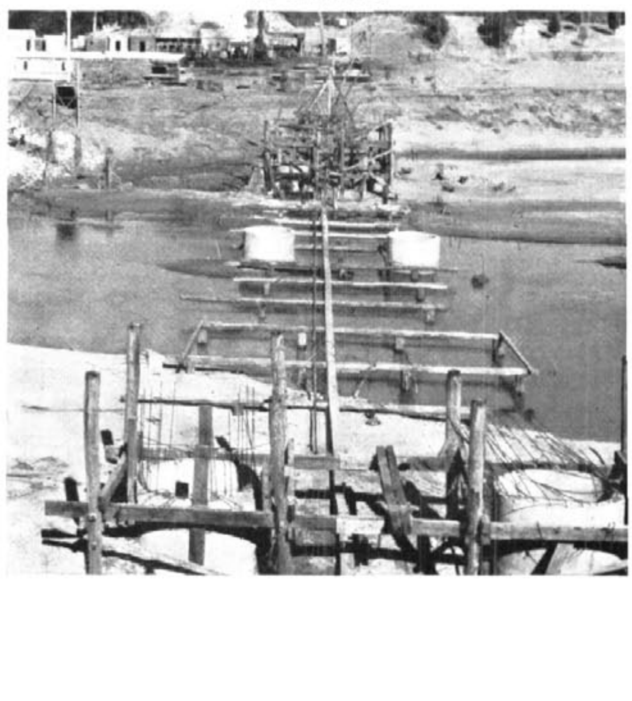
The old bridge over Cockfighter Creek at Warkworth was built in 1871-72 at a total cost of £3,000. It was of timber truss construction comprising three truss spans and two approach spans, the total length being 320 feet. It was completely rebuilt by the Public Works Department in 1925-26. Between 1926 and 1949, the bridge was severely damaged on several occasions by floods, but each time it was restored to use. In addition to repairs following flood damage, extensive work had to be carried out on the foundations, this being due to scour occurring around the piles.

In July, 1949, the truss spans of the bridge were completly washed away by flood and deposited some distance downstream of the bridge site. As the area served by the bridge is a rich dairying district and there was no other local means of crossing Cockfighter Creek, emergency arrangements had to be made in order that farm produce, etc., could be taken over the creek. A light temporary crossing was provided in the first place, following on which a low-level bridge was built. This comprised four 30-feet spans, founded on reinforced concrete cylinders, 16 feet between kerbs and with an overall length of 120 feet, and was completed in May, 1950. In order to provide facilities for the transport of goods across the creek when flood-waters were too deep to allow the low-level bridge to

Spit Bridge Middle Harbour showing one of the piers under construction.



Warkworth Bridge showing work in progress on the cylinders.



be used, a flying fox was erected and put into operation in September, 1950.

As a result of subsequent silting of the stream bed it has been found necessary to raise the level of the low-level bridge three times, a total height of about 7 feet. The last raising was completed in June, 1953.

The construction of a new high-level bridge was put in hand by the Department by day labour in September, 1951.

The new bridge will have six 40-feet and four 50-feet reinforced concrete girder spans and three 66-feet plate girder spans. The substructure consists of five piers founded on pile foundations and seven piers founded on cylinders taken to rock foundations. The bridge will have a carriageway width of 22 feet.

The original design of this structure was for six 40-feet reinforced concrete approach spans, three 66-feet steel plate girder spans, and three 40-feet reinforced concrete approach spans, the total overall length of the bridge being 584 feet. Floods which occurred in August, 1952, severely damaged work which had already been completed on the new bridge and at the same time scoured the banks of the stream to such an extent that the stream bed was approximately 100 feet wider than before the floods. This necessitated the re-design of the structure to allow for an additional 80 feet length of bridge. This was arranged by the lengthening of three 40-feet spans by 10 feet each and the addition of another 50-feet span.

Work on the new bridge was retarded by the floods of August, 1952, as a result of which a large amount of rehabilitation work had to be undertaken. Further flooding in May, 1953, again damaged the work which had been done. Work so far has been confined to the substructure, and to date one cylinder has been sunk to full depth but has not been sealed, four cylinders have been sunk to rock level, but have still to be sunk a further 6 feet into solid rock. In addition, four cylinders that were in position prior to the May, 1953, floods, and were moved out of position, have again been set up ready for sinking.

The approaches to the bridge will involve a deviation of approximately one mile in length.

It is anticipated that the bridge will be opened to traffic in 1955.

PAYMENTS FROM THE ROAD FUNDS

For period 1st July, 1952 to 30th June, 1953

	Amount Paid.
	£
County of Cumberland Main Roads Fund:	
Construction and Reconstruction of Roads and Bridges	1,240,914
Acquisition of Land and Buildings for Road Widening	71,841
Maintenance and Minor Improvements of Roads and Bridges	933,758
Interest, Exchange and Repayment of Loans	82,792
Other Expenditure	165,046
Total	£2,494,351
Country Main Roads Fund:	
Construction and Reconstruction of Roads and Bridges	2,787,708
Acquisition of Land and Buildings for Road Widening	29,321
Maintenance and Minor Improvements of Roads and Bridges	3,539,629
Interest, Exchange and Repayment of Loans	152,123
Purchase and Repair of Plant, Motor Vehicles and Other Assets	1,018,625
Other Expenditure	716,132
Total	£8,243,538
Developmental Roads Fund:	
Construction and Reconstruction of Roads and Bridges	£316,183
Summary All Funds:	
Construction and Reconstruction of Roads and Bridges	4,344,805
Acquisition of Land and Buildings for Road Widening	101,162
Maintenance and Minor Improvements of Roads and Bridges	4,473,387
Interest, Exchange and Repayment of Loans	234,915
Purchase and Repair of Plant and Motor Vehicles	1,018,625
Other Expenditure	881,178
Total	£11,054,072

NOTE: The figures in the above statement are subject to adjustment upon completion of accounts for the year.

New Concrete Pavement at Bexley

CEMENT concrete pavement construction over a length of 5,863 feet has recently been completed in Forest Road (Main Road No. 168), Bexley.

Forest Road extends from the Prince's Highway, Arncliffe, to the Lugarno Ferry over George's River and passess through important shopping centres of Bexley and Hurstville as well as serving old established and still expanding residential areas. The more heavily trafficked section is that between Arncliffe and King George's Road (Main Road No. 315), a short distance south of the Hurstville shopping centre. Improvement and reconstruction of this section of road has been progressive over the years, and by the end of 1950, the road had been paved full width between Arncliffe and Hurstville with the exception of the length between Dunmore-street, Bexley, and Croydon-road, Hurstville. Between Wollongong-road and Dunmore-street a full width of concrete pavement existed and elsewhere the pavement was of bituminous construction.

A tender by J. Cassidy & Sons was accepted by the Rockdale Council in February, 1951, for the reconstruction in cement concrete of the section Dunmore-street to Croydon Road to a width of 42 feet between kerbs, but excluding a short length between Queen Victoria Street and Besborough Avenue which has yet to be realigned.

Considerable adjustments were necessary to the utility mains and delays arising from shortage, of materials and labour in the early stages, together with much rain, handicapped the contractor in the commencement and execution of the work.

The first concrete was poured on the 22nd January, 1952, and the pavement work was completed in April, 1953.

Shortage of pipe made it impossible to arrange for the adjustment of all water mains, and the abandonment of an old 18-inch main in the carriageway was deferred temporarily, provision being made for surface boxes to be set in the concrete over all main cocks to services.

Minor irregularities in alignment which were adjusted in conjunction with the work, involved some setting back of properties and in places the footway was widened. Council will loam and plant the new areas with grass. Alteration to levels involved considerable adjustment to footpaving and kerbing.

The major items of the work comprised cement concrete pavement 28,500 square yards; excavation 12,940 cubic yards; subsoil drains 11,700 linear feet; concrete kerbing 8,625 linear feet. The completed cost was approximately £90,000.

Ready-mixed concrete was used throughout from the plant of Bankstown Concrete, an Associate Company of J. Cassidy & Sons. Materials were batched by weight, and hauled in transit mix trucks.

The contract was supervised by Mr. J. Carson, Chief Engineer, Rockdale Municipal Council, who was assisted by a superintending officer supplied by the Department.

The Use of Explosives in Roadwork

This article is an outline only of the method of handling and use of explosives in general use for roadwork. *It is intended primarily for the information of those not experienced in blasting practice.*

SAFETY PRECAUTIONS.

The basic safety precautions to be followed in the use of explosives are laid down in the Standards Association of Australia Explosives Code No. CA.23-1949. Transport and storage are covered by Regulations under the New South Wales Explosives Act, 1905. The Department of Main Roads Manual No. 5, "Explosives", incorporates all information and regulations from these two sources relevant to its work. As this article does *NOT* cover all safety precautions, reference should be made to these publications for all matters concerning safe practice.

COMMERCIAL EXPLOSIVES.

The essential characteristics of an explosive for rock excavation are:—

(i) Capable of very rapid conversion into gas occupying many times its original volume.

(ii) Reasonable safety in handling.

The explosives in common use are solids requiring heat or shock to fire them, and the chemical change which then takes place is propagated either by deflagration or detonation.

The difference between detonation and deflagration (fast combustion) may be explained as follows—An unconfined piece of explosive, if ignited, will commence to burn and will continue to burn steadily (if insufficient heat is generated to detonate it) at a rate not exceeding a few hundred feet per second, the combustion being continued from layer to layer as a result of the heat generated. On the other hand, if a piece of explosive is detonated either by the application of sufficient heat and/or by sudden shock, an explosion proceeds at the rate of thousands of feet per second. In this case, the chemical change is propagated by pressure, although it is possible that the change is actually caused through the rise in temperature resulting from the wave of increased pressure.

In a detonating explosive each molecule contains the combustible element and the oxidising element and the molecule is in a state of unstable equilibrium.

Variations in the work done by different explosives arise from the following:—(i) the amount of gas evolved per unit volume of the explosive, and its temperature and pressure, and (ii) the time taken in the evolution of gas.

TYPES OF EXPLOSIVES.

(*a*) *Blasting Powder (Gun Powder).* Blasting powder is a mechanical mixture of potassium nitrate with charcoal and sulphur in the approximate proportions of 75, 15 and 10 parts by weight. It will not detonate, as the chemical change will take place only *at those points where the oxidiser and combustible are* in actual contact. However intimate the mixture, the rate of combustion (by deflagration) will not exceed about 1,000 ft. per second.

Blasting powder is manufactured in grains of various sizes and also in compressed cartridges.

(*b*) *Nitro-glycerine explosives.* The principal active constituents are nitro-glycerine and ammonium nitrate. They are either gelatinous or granular. All are fired by detonation. Those in common use for roadwork are:—

Gelatinous.

A.N. Gelatine Dynamite 75

A.N. Gelignite 60

A.N. Gelignite 50

Non-Gelatinous.

Quarry Monobel

A.N. Ligdyn 40

In the "A.N." explosives, portion of the nitro-glycerine has been replaced with ammonium nitrate, and the suffix "50" or "60" indicates that the energy is equivalent to one containing 50%, or 60% of nitro-glycerine.

Blasting gelatine is the most powerful explosive produced for blasting but in roadwork its use is rarely called for. The name "dynamite" is applied to nitro-glycerine explosives by manufacturers in the United States.

A point to be remembered in connection with nitro-glycerine is that age affects:—

Speed of detonation,

Energy, and

Sensitiveness,

and that the value of the first two are reduced, whilst sensitiveness may be increased. When delivered, these explosives will generally not be more than three to four weeks old, and it should be seen that they are used strictly in rotation, that is, the last of the previous packet, case or consignment should be used before a new packet, case, or consignment is opened. In addition, such explosives should be stored so that the cartridges lie on their sides, as if they stand on end for any length of time, especially in a warm or damp climate, the nitro-glycerine may gravitate to the bottom end and exude.

CHARACTERISTICS OF EXPLOSIVES.

The characteristics of some explosives are shown in Table I.

TABLE I.

Explosive.	Velocity of detonation, Metres/sec.	Use.	Packaging, etc., (See note (*a*) below).
Blasting powder	300 (deflagration).	Soft solid rock, dimension stone	Grains of various sizes, and compressed cartridges. Non-resistant to water.
Blasting gelatine	7,000	Very hard rock. Very high shattering effect. Rarely used in roadwork.	Cartridges usually 1⅛ in. dia. Available for sale only on special order. Water resistant.
A.N. Gelatine Dynamite	3,800	Very hard rock. High shattering effect......	As for blasting gelatine. Available for sale only on special order.
Gelignites	4,000 to 3,400	Hard rock. High to medium shattering ...	Cartridges 1 in. and 1⅛ in. dia. usually 8 in. long.
Ligdyn	2,900 to 2,500	Intermediate between gelignites and Quarry Monobel.	Cartridges 1⅛ in. dia., 4 in. or 8 in. long.
Quarry Monobel	2,700	Medium hard rock. Medium shattering......	Cartridges 1⅛ in. dia., 8½ ins. long. Of greater bulk than Gelignite and Ligdyn

NOTE: (*a*) For special work cartridges of N.G. explosives up to 5in. diameter can be obtained.
(*b*) The A.N. nitro-glycerines, and Quarry Monobel are affected by water and should be exposed to moist conditions (as in damp holes) for short periods only.

FIRING OF EXPLOSIVES.

All firing should be done electrically except where only isolated shots are involved or where the charges are very small. Electrical firing of blasting powder is carried out by an electric powder fuse or by an electric detonator inserted in a stick of gelignite (or similar) included in the charge. Nitro-glycerine explosives are fired electrically by an electric detonator inserted in a stick of the explosive.

Non-electrical firing is done in the case of blasting powder by safety fuse inserted in the powder, and in the case of nitro-glycerine explosives by means of safety fuse and a detonator inserted in a stick of the explosive. (See illustration).

Explosive cartridge primed with plain detonator and safety fuse.

BLASTING ACCESSORIES.

Safety Fuse consists of a core of combustible powder covered with cotton thread or tape and other substances to render it more or less waterproof. The usual rate of burning is 1-yard in 90 plus or minus 10 secs., but this rate will hold good only if the fuse is without twists or sharp bends and is not coiled. Fuse should be tested as detailed in Section 8 of Manual No. 5. Close coiling has a very marked effect as a result of the opening of the threads and of the liability of the burning powder to spit through the covering to adjacent coils. Increases of up to 100 per cent. in the burning rate have resulted from this cause. Very close confinement of fuse may also double the burning rate, on account of the temperature produced being much higher than when burned in an unconfined space. Fuse should be handled with reasonable care and any which has been made use of as rope, or is dented or kinked, or has been lying in a very hot sun, or has had oil spilt on it, or is damaged in any way, should not be used, as all these eventualities are liable to injure the powder core and either interrupt the burning or alter its rate. If burning of the core is interrupted the covering may go on smouldering and refire the powder after some minutes causing a "hang-fire". Fuse is usually bought in coils of 24-ft., but may also be obtained, if required, in lengths of up to 1,800 ft. wound on reels. Fuse is likely to deteriorate if stored too long where the temperature is too high or the atmosphere damp. Re-drying fuse after it has been wet is not permissible as the burning speed is likely to become slow or irregular.

When cutting for insertion into a detonator, the end should be cut square, preferably with special fuse cutters, and it should be made sure that no particles of dirt or sand are adhering to the end to be inserted. After shaking out the sawdust, the detonator should be placed over the clean, square cut fuse, and gently pushed on without any twisting movement until the fuse end just touches the detonating compound. The detonator should then be crimped on firmly (near its *open end*) with a pair of crimpers. In the past, the practice of crimping on with the teeth was extensively followed but it is exceedingly dangerous and, in addition, makes a very inefficient crimp. Where large numbers of detonators are being used, the most efficient and safest method is to have a bench crimping machine located in a small shed set apart for the purpose.

Blasting powder, both in the form of grains and compressed cartridges, can be fired directly by safety fuse, but it is advisable in order to obtain sureness of results, to leave an ample length of fuse actually in contact with the powder and to nick this length with a knife in order to provide several openings through which the spit can make contact with the powder.

Crimpers.—As stated above, the most efficient and the safest method of attaching safety fuse to detonators is with crimpers manufactured for the purpose. These are so made as to obviate any danger of injuring the powder core by too tight squeezing, while giving, at the same time, a crimp sufficiently tight to keep out damp. The handles of hand-crimpers are generally shaped so as to be convenient for forming a hole in a gelatinous high explosive cartridge for the insertion of the detonator when making up a primer.

If a bench crimper is used all crimping is done at a central crimping station from where all fuse with the detonators attached is obtained by the powderman. Central crimping has the following advantages:—

(1) Loose detonators do not leave the crimping shed and are, therefore, not likely to get into the hands of children and others;

(2) The safety fuse can be kept clean and its end free from grit;

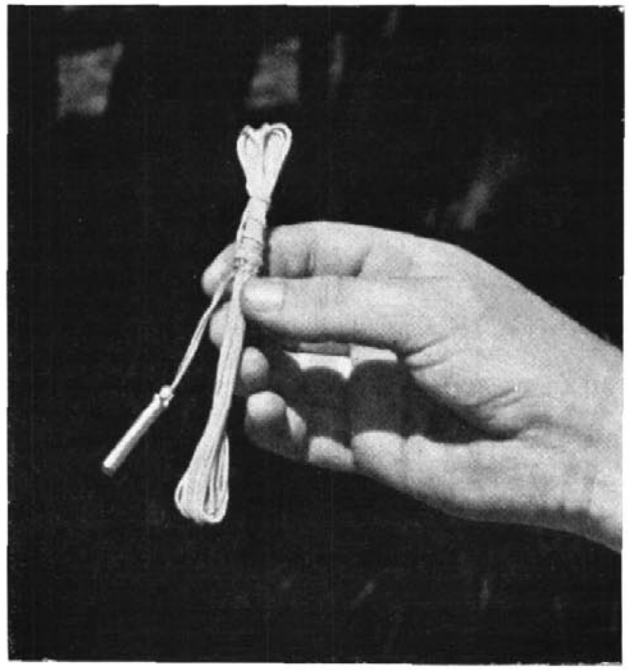
(3) The detonator is enclosed in the machine when the safety fuse is inserted and the crimp applied, thereby protecting the operator from an accidental explosion;

(4) The crimp is so tight as to be practically waterproof.

Detonators.—For use with safety fuse detonators are formed of small aluminium tubular capsules partially filled with a sensitive detonating explosive mixture of high velocity. For safety in transit, the open end of the tube is filled with sawdust which has to be shaken out before inserting the safety fuse.

Detonators are made in various sizes but the one normally used is No. 6 which is about 1½ inches long and ¼-in. dia. Present day detonating mixtures are not so sensitive as fulminate of mercury which was formerly in use. Nevertheless detonators must always be handled with care and treated with respect.

Electric Detonators.—These are used in cases where shots are fired electrically (see illustration). They may be either low tension or high tension but the former is much more common and is in almost universal use on main roads in New South Wales. Two insulated wires pass into the detonator and, in the case of the low



Electric detonator with 6 ft. lead wires.

tension, the ends are connected by a very fine wire (known as the bridge-wire) which fuses when a current of the required amperage passes through, igniting a combustible mixture encasing the bridge-wire; this in turn fires the detonating substance. The lead-in wires are held in place by a rubber washer over which the metal case is crimped. Although all electric detonators are waterproofed to resist moisture, they cannot be used after prolonged immersion. Electric detonators may be obtained in similar sizes to the ordinary type, and with various lengths of insulated copper lead wires ranging from 4 feet to 40 feet. Detonators with copper wires (25 S.W.G.) 4 feet long have a resistance of 1.25 ohms approximately and, when single shots are being fired, 0.4 amperes is sufficient current. However, the time of ignition of the detonator flashing mixtures may vary on account of variations in thickness of the bridge-wires and on this account it is advisable when firing two or more detonators in series to allow for currents up to 1.5 amperes.

When such an allowance is made there will be practical certainty that the heavier bridge-wires and those in the flashing mixtures with the longer time of ignition will be heated sufficiently to cause ignition before the circuit is broken by the fusing of the thinner bridge-wires.

Electric Delay Detonators.—For certain work, such as tunnelling, it is necessary at times to arrange the shots so that those in certain positions will fire before the others. Such consecutive firing can be arranged with delay action detonators. In these, ignition takes place as usual by the fusing of a fine bridge-wire which ignites a match head and this ignites a fuse attached to the detonator, the length of the fuse determining the period of delay. These detonators are obtainable with delays from 0 to 12, each unit being ½ sec.

Milli-second delay action detonators are now also obtainable having delay intervals of approximately 1/40 sec. and are applicable in general blasting practice. The advantages claimed from milli-second delay firing are:—

(i) Greater shattering effect; (ii) Reduction in vibration.

Detonating Fuse.—This so-called fuse consists of a plastic tube approximately 0.23 in. in diameter containing penta-era-thritol-tetra-nitrate (P.E.T.N.) or similar detonant having a velocity of detonation of about 5,200 metres/second. For ordinary purposes, it can therefore be taken that all shots connected will be fired simultaneously. It is bought by the foot in spools containing lengths up to 1,500 feet. A detonator is necessary to fire this fuse as it is unaffected by ordinary shock, flame or friction.

It is not of common use except in large or deck loaded blasts or where extra assurance as to certainty of action is required. (Note—to deck-load means to divide the charge into sections, with stemming between. It is done where there are alternate hard and soft strata, the charge being placed in the hard strata.)

Electric Powder Fuses.—If blasting powder is the explosive in use, and it is desired to fire it electrically, a detonator should not be used alone as the heat generated may not be sufficient to ignite the powder. There are two alternative methods as follows:—

(*a*) By using an ordinary electric detonator in a cartridge of high explosive to act as a primer; or

(*b*) By using an electric powder fuse.

Electric powder fuses are of somewhat similar construction to detonators. The compound contained in them, however, results in a minor shock only, but the evolution of heat is sufficient to ignite the powder with certainty.

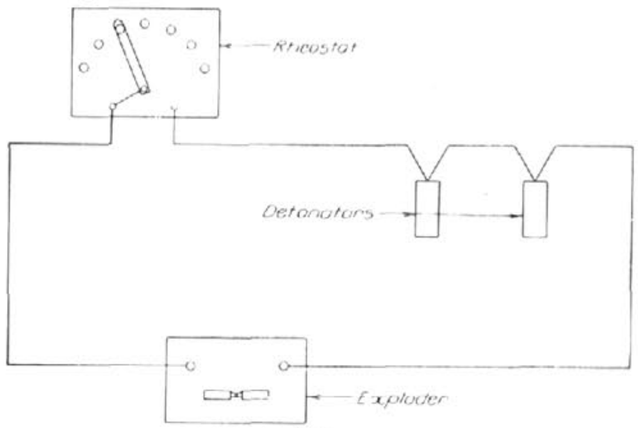
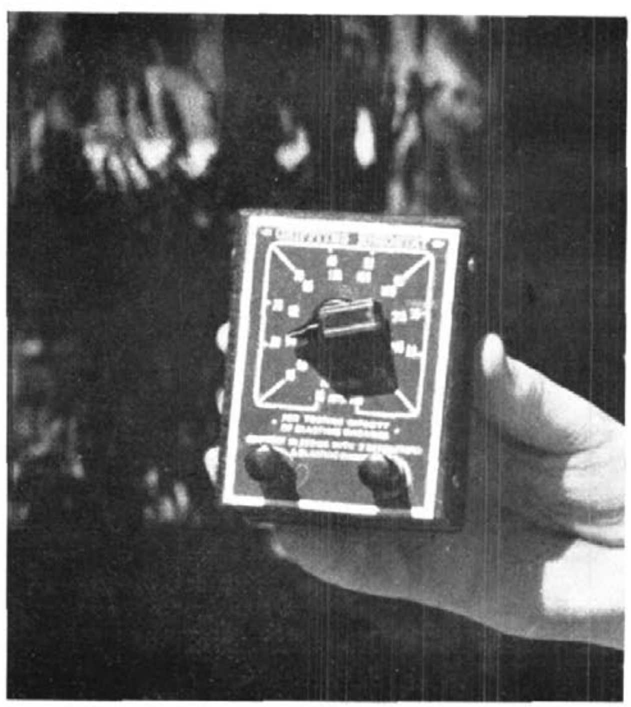


FIG 1.

Exploders for low tension electric firing are obtainable in sizes for firing a number of shots varying from one to one hundred simultaneously (see illustration). These machines contain small dynamos or magnetos which are actuated by the downward thrust of a rack bar or by twisting a handle (in the small types); the circuit being closed at the end of the stroke or twist

Exploder for low tension electric firing.

Rheostat for testing blasting machines.

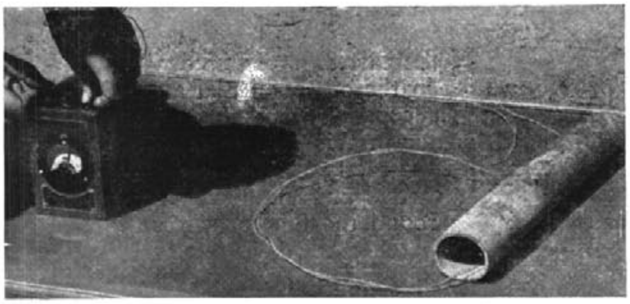


when the electrical potential is of sufficient magnitude. When operating a push down machine, it should be set squarely on a firm dry level place and the handle thrust down hard.

Rheostat.—Rheostats are used for testing blasting machines (see illustration). Usually the rheostats are so marked that varying resistances equivalent to numbers of detonators plus necessary lead wires and cable may be applied across the blasting machines in series with two detonators for testing purposes. The circuit is shown in Figure I.

The testing procedure is described in the Department's Manual No. 5, "Explosives".

Ohmmeter.—An ohmmeter is used to measure electric resistance in checking detonators, cables, and complete circuits before firing (see illustration). Usually



Testing an electric detonator with an ohmmeter.

the ohmmeter has two scales, one reading up to 10 ohms for testing detonators and the other reading up to 300 ohms for testing cables and complete circuits. Although a small current flows in a circuit when an ohmmeter is connected into that circuit, this current is not large enough to explode a detonator.

The procedures for testing detonators before use, and cables and circuits after wiring up is complete, are described in the Department's Manual No. 5, "Explosives".

Shotfiring Cable.—The usual type of cable consists of two copper wire conductors insulated from each other and from the ground with rubber and tape, and bound together with cotton braiding.

For firing, the ends of the wires at one end of the dual cable are connected to the two terminals of the blasting machine, and the other two ends are connected to the detonator lead wires.

Stemming.—Stemming is the material used to fill the portions of the bore hole not occupied by the explosive. It is preferably a mixture of moist fine sand and clay in the proportions of 2 to 1.

Tamping Rods.—Tamping or stemming rods of wood only may be used and they must not be provided with a metal ferrule. When used for inserting the charge the rod must be free from any adhering grit and the end must be kept clean and flat.

BLASTING PRACTICE.

Choice of Explosive.—The determination of the quantity of rock which will be broken out by a certain quantity of a given explosive is complex, owing to the number of factors, such as toughness, homogeneity and stratification, which must be taken into account. This particularly applies to roadwork where the line and grade are frequently laid out without much reference to the dip and strike of the strata and the bedding planes. Also much excavation in roadwork is carried out in side hill cuts so that the depth, and frequently also the character, of the material varies considerably from one side of the road to the other. Blasting in roadwork is frequently further complicated by limitation of the size of the shots owing to the proximity of buildings and the necessity to avoid the scattering of stone on adjacent pastures and crops. However, the following points may be accepted as a guide in the selection of explosives:—

(*a*) For very hard rock use explosives of high energy where hard shooting is permissible.

(*b*) In medium to hard rocks a high velocity of detonation will give a shattering effect.

(*c*) The lower the velocity of detonation the less the shattering effect. Powder is generally the most suitable explosive where it is not desired to break up the rock, as in quarrying dimension stone.

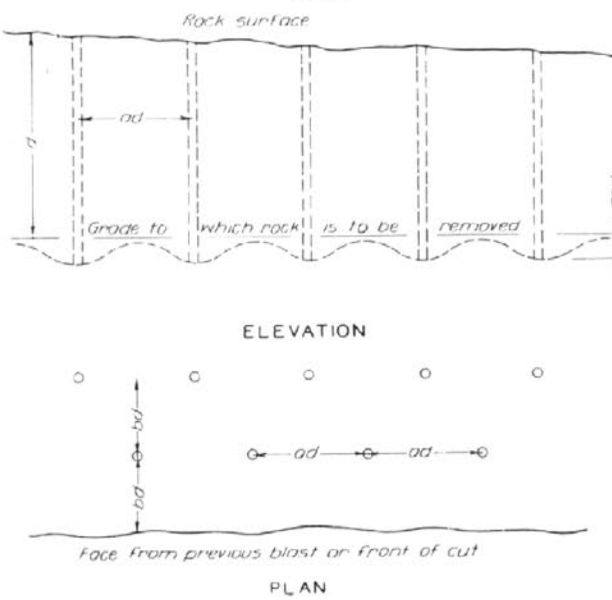
(*d*) In medium to hard laminated rock or in similar rock where fissures exist medium to high velocity explosives will be most economical.

(*e*) In shooting semi-plastic materials like gravel or hard clay, medium to high velocity explosives are ineffective as the energy is dissipated in compressing the material in the immediate vicinity of the charge.

(*f*) In bulling or chambering medium to high velocity of detonation is required in order to obtain a localised shattering effect. Bulling or chambering is the enlargement of the hole at the bottom to provide additional space for explosive.

(*g*) In solid soft and medium rock the greatest efficiency i.e. the most rock moved and broken to a convenient size for handling, will be obtained if a fairly

FIG. 2.



bulky explosive is used, which will occupy the hole for about two-thirds its depth, as if the charge is concentrated too much, its effect tends to become too localised.

(*h*) In plastering, i.e. breaking boulders by firing a charge fixed to the surface of the rock, the higher the velocity the greater the effect.

LOCATION OF BORE HOLES.

The best spacing for bore holes should be determined by trial, as it is not possible to lay down hard and fast rules on account of the number of factors involved.

A suggested location of holes for trial shots is given in Table II below. This table has been adapted from information published by the U.S. Bureau of Public Roads, (*Public Roads* Vol. 12, No. 12). The relation between the spacing and burden of holes, depth of cut, and depth of drill holes below the grade line (see Figure 2) is expressed as follows:—

a = ratio of depth of cut to spacing of holes across cut.

b = ratio of depth of cut to burden.

c = coefficient of depth of drill hole below grade.

d = depth of cut at drill hole.

ad = distance between holes across cut.

bd = burden.

cad = depth of drill hole below grade to which rock is to be removed.

d+cad = total of drill hole.

TABLE II.

Type of Material.	a.	b.	c.	Pounds of Australian explosive per cu. yd. of burden.
Any rock exceptionally difficult to shatter	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0·75
Most hard, dense, unweathered rock	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{1}{3}$	0·5—0·75
All medium hard, weathered or partly disintegrated rock, those which shatter readily and very hard shales	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{1}{3}$	0·5—0·75
Ordinary shales and similar materials	$1\frac{1}{4}$	1	$\frac{1}{4}$	0·3—0·5

With the above table the deeper the hole, the greater the diameter of hole required to accommodate the necessary volume of explosive which generally should be placed in the lower two-thirds of the hole.

The table applies to conditions where fairly hard shooting is permissible. Where this is not so, closer spacing of holes will need to be adopted in order to obtain proper fragmentation. However, in view of the cost of drilling, the spacing should be the greatest at which suffiicent fragmentation can be achieved to give easy loading within the limits of the heaviest permissible shooting.

Drilling below the grade line is necessary as otherwise the floor of the cut will be above the grade line between drill holes, and expensive secondary shooting will be required.

Where there are alternating strata of hard and soft material spacing of holes closer than normal will be required and an attempt should be made to deck-load the charge, i.e. to place the charge only in the hard strata and place stemming across fissures or soft strata. All portions of the charges or sections should be fired simultaneously by means of independent detonators wired on to the same circuit or with detonating fuse.

TESTING OF DETONATORS.

Electric detonators should be checked for resistance with an ohmmeter before use. Instructions for carrying out this test are contained in Manual No. 5.

PRIMING OF CHARGES.

Priming is the process of attaching a detonator or detonating fuse to the explosive.

The procedure with a detonator is as follows:—Open the wrapping of the cartridge of explosive at one end and make a hole in the centre of and axially with the cartridge with a copper, wooden or bone pricker. Insert the detonator in this hole to such a depth that its junction with the safety fuse or wires is flush with the end of the cartridge. Tie the wrapping of the cartridge tightly round the fuse or wires.

With electric detonators, the wires are in addition frequently threaded double through a diagonal hole in the cartridge and the end of the cartridge passed through the loop. The wires are then drawn tight.

The method of attaching detonating fuse to a cartridge is illustrated in Figure 3.

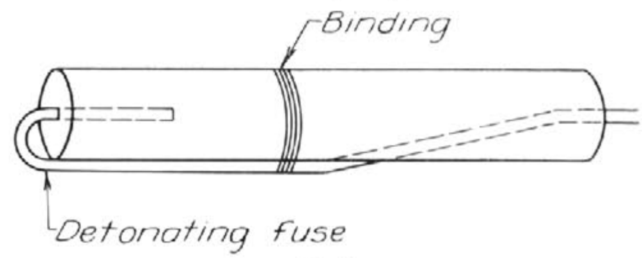


FIG. 3.

CHARGING.

The explosive cartridges to be used shall be at least $\frac{1}{4}$-in. less diameter than the bottom of the holes in which they are to be placed.

Before charging, the hole should be cleaned and emptied of water as far as possible, and all tools and equipment not required by the powderman are to be removed from the vicinity. No drilling is to be carried out within 20 feet of a hole being charged.

Holes should not be charged unless they can be fired the same day. Where holes are cleaned out for charging, some means such as plugging, must be taken to keep them clean if charging does not proceed straight away.

When using detonators, the priming cartridge is the last to be placed in the hole. The only exception to this practice is in such work as tunnelling where delay action detonators are being used in closely spaced rounds and there is the possibility of an earlier round breaking out the top portion of a later round. In all cases, the closed end of the detonator should point towards the body of the charge in order to gain the maximum effect from the wave of detonation.

With detonating fuse, the priming cartridge is placed first in the hole in order to bring the fuse into contact with the full length of the charge. Care must be taken when placing succeeding cartridges that the detonating fuse is kept straight and free from kinks.

When a detonator is used, tamping shall not begin until at least 6 inches of stemming has been put in. The tamping shall be light but may be gradually increased in force until the hole is filled.

Connecting and Firing Charged Holes.

(*a*) Holes to be fired by using safety fuse are usually ignited individually with a safety fuse igniter. Where holes are close together a multiple safety fuse igniter may be used to ignite a number of fuses at the one time.

Methods other than these two should not be used when more than one fuse is to be ignited.

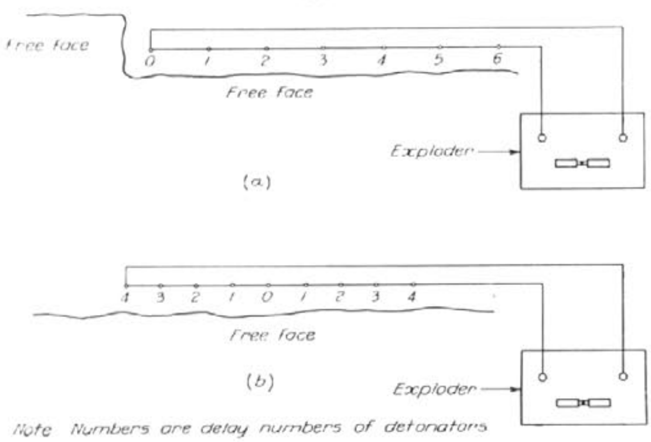
(*b*) Holes to be fired electrically with ordinary electric detonators are wired up in series as shown in the diagram on page 35 of Manual No. 5. After wiring up, the circuit is checked with an ohmmeter from the firing position after the required safety precautions have been taken. The firing is then carried out using a blasting machine of sufficient capacity.

(*c*) Holes to be fired by electric milli-second delay detonators are usually primed and wired up in a manner which particularly suits the use of these detonators for the work being carried out.

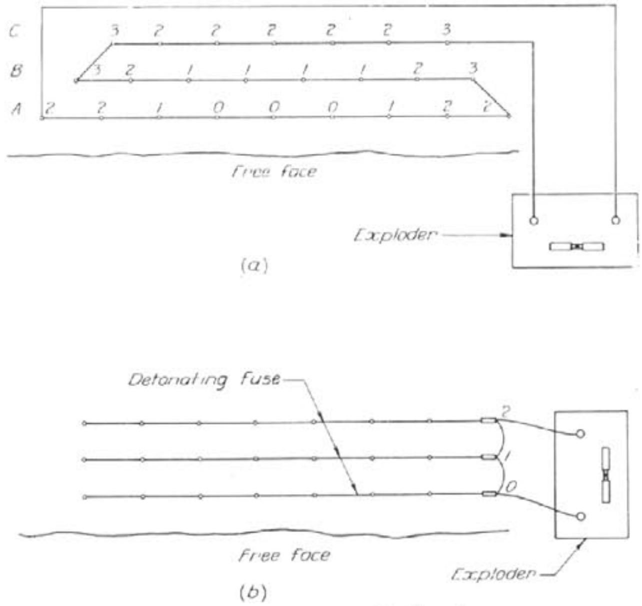
For firing a single row of holes with one or more free faces to the rock, the arrangement of delays is usually of the form shown in Figure 4.

The use of delay action detonators permits the explosive to exert a peeling effect on the stone, thus providing a free face for each succeeding blast.

FIG. 4.



Note. Numbers are delay numbers of detonators



Note. Numbers are delay numbers of detonators

FIG. (5a) and FIG. (5b).

For firing multiple rows the delays may be arranged to coincide with the rows. Thus the row nearest the free face is fired first, and then rows are fired in subsequent order back from the face, as shown in Figure 5 (a).

This gives two theoretical advantages. Firstly, each row of shots is fired when it is adjacent to a free face. Secondly, the material in strip B is blown against the strip A, and strip C against strip B, etc. after the stone in the outer strip has been freed, but has not had time to fall to earth. Thus better fragmentation is obtained throughout.

The fact that the explosion when using milli-second delay detonators, is really made up of a number (one for each delay) of separate smaller explositions has a marked effect in reducing ground vibration.

(*d*) When using detonating fuse the fuse from the individual holes should project at least four inches above the surface, and to these fuse ends is attached the trunk line of detonating fuse.

Figure 5 (b) shows the use of milli-second delay action detonators with detonating fuse for multiple row firing.

Detonating fuse is always exploded by means of a detonator attached to one end.

Procedure after firing.—The precautions for safety which must be taken after firing are set out in Clause 10 of the Department's Manual No. 5, "Explosives".

In the event of misfires, the procedure which must be adopted is set out under Clause 11 of that Manual.

Fifty-six Miles of New Road Formation

NEW LINK BETWEEN BOURKE AND LOUTH.

A NEW road link has recently been constructed and put into use between Bourke and Louth, involving fifty-six miles of new formation.

The town of Bourke, 491 miles from Sydney by road, is situated on the Darling River and at railhead. Bourke serves as a business, social and stores centre for a vast pastoral area in the northern part of the Western Division of New South Wales. Nine main roads radiate from Bourke to provide connecting links with adjoining towns and the Queensland roads system, and access to many outlying properties.

In past years considerable main road improvement and reconstruction have been carried out in the Bourke district, to the extent that improved formations have been constructed between Bourke and Wanaaring, Hungerford and Barringun, also in the Walgett, Goodooga and Mungindi areas in the northern and eastern parts of the district, and towards Nyngan and Cobar in the southern part. Although much remains to be done to these roads to bring them to the stage that they are trafficable under all weather conditions, they do under normal conditions provide much safer, smoother and more economical and direct travelling than previously existed.

Louth is linked to Bourke by two roads generally parallel with the Darling River, Trunk Road No. 68 on the eastern bank, and Main Road No. 406 on the western bank. Both roads traversed considerable lengths of black soil river flats and crossed numerous watercourses flowing into the river. They became impassable in times of flood and, in moderate rainy periods, only the road on the eastern bank was usable. This road, Trunk Road No. 68, had been provided with raised formation from Bourke to Louth with the exception of about 10 miles over sound red soil country, the major creeks were bridged, and some sections of the black soil had been gravelled.

The route on the western bank, Main Road No. 406, was an unformed track between Bourke and Louth, and also farther south. There was an open crossing of the Warrego River north of Louth, only trafficable under dry river conditions.

During flood and wet periods, traffic had developed a well defined track away from the river, mainly, on higher sound red soil, which in turn linked up with the Bourke—Wanaaring Road (Main Road No. 405). This track was in parts narrow and winding because of the heavy timber growth, and as a result difficult to negotiate by semi-trailer vehicles of the type used extensively in the area for wool and stores haulage. The deep wheel tracks which had developed also made car travel hazardous.

Requests had been received by the Department of Main Roads from the settlers on the western side of the Darling River for improvement to this track. With closer settlement imminent, and a more frequent high level in the Darling River, it was considered necessary, not only to improve this route between Bourke and Louth, but to plan for an improved road linking Bourke and Wilcannia.

After investigation, both on the ground and by aerial survey, it was determined that the route between Bourke and Louth west of the Darling River which would serve the greatest number of settlers, provide connection with existing mail and wool haulage routes, and provide the most suitable ground for construction and avoidance of flood effects, was that commencing at Paka Tank, on Main Road No. 405, 20 miles west of Bourke, thence via Nulty and Toorale to Louth (see map). The length from Paka Tank to Bourke had previously been constructed.

The route presented no abnormal construction difficulties, although crossings of the Warrego River and its overflow channel were necessary.

Nature of Country.

The country through which the new road passes is mainly flat and of red sandy loam and claypan until the Warrego River is reached at Dick's Dam, just south of Toorale. Further south the country is predominantly black soil, although two hills, Mt. Burry Curry and Mt. Talowla, are skirted. There are no villages or settlements on the road and only four homesteads in close proximity. Other than the sections near the Warrego River and its flood overflow channel, where timber growth of the eucalypt family is large, the timber is mostly of the low Wilga and Gidgee variety. The growth is particularly dense between Paka Tank and Toorale. The timber is light on the claypan plains north of the Warrego, and of moderate density from the Warrego to Louth.

The Road Work.

The work, which was commenced in early 1951, was carried out by the Department of Main Roads, and despite frequent interruptions because of the effect of rain resulting in local flooding, has been substantially completed to Louth, although some further work remains to be done.

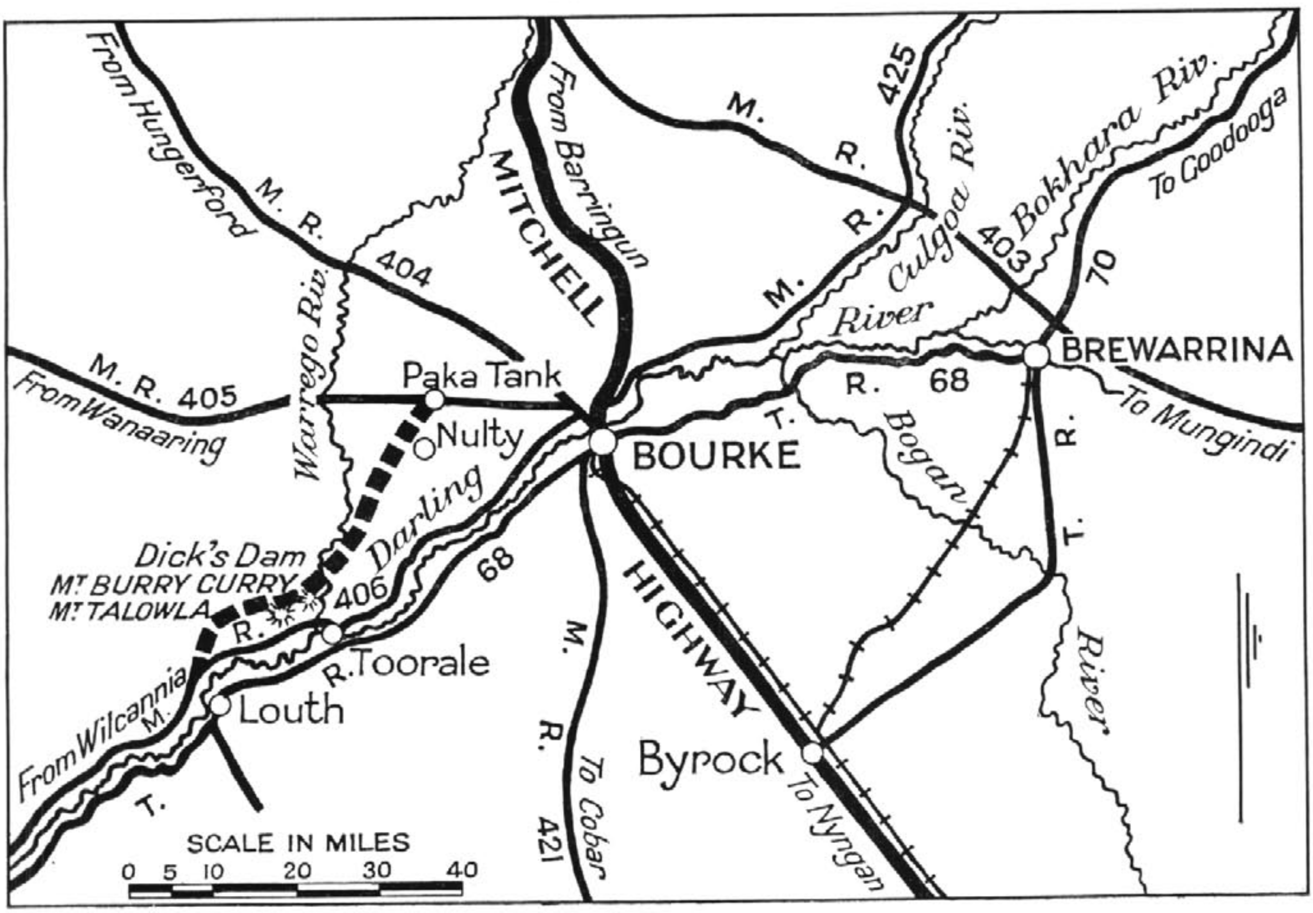
Features of the work were the following:—

(1) Clearing of trees and scrub for a length of $56\frac{1}{2}$ miles was carried out by bulldozers and by the use of a steel wire cable strung between two tractors.

(2) Construction of $56\frac{1}{2}$ miles of new formation of which $48\frac{1}{2}$ miles was raised to a height of about 18 inches above natural surface by an elevating grader, and $7\frac{1}{4}$ miles was formed by power-grader preparatory to gravelling. Approximately 363,000 cubic yards of soil were excavated and deposited to make these formations, which were compacted immediately by sheeps-foot and pneumatic-tyred rollers to take advantage of the natural ground moisture.

(3) Stabilizing with sand of $2\frac{3}{4}$ miles of black soil formation south of Dick's Dam to prevent slippery conditions when wet.

LOCALITY MAP.



Causeway across Warrego River flood channel.

(4) Crossing of the main channel of the Warrego River at 30.7 miles by the restoration of Dick's Dam and the construction of a large causeway at the nearby flood channel. The greater part of this dam had been washed away during a major flood many years ago, and it was restored by the placing of some 9,000 cubic yards of filling topped with a gravel pavement 14 feet wide, which is two feet above the highest known Darling River flood. The causeway at the flood channel, which was constructed with concrete cut-off walls and a packed stone base topped with gravel, is 800 feet long and was built at a level within two feet of the highest known Warrego River flood and within four feet of the highest known Darling River flood. It will thus serve traffic excepting at times of extreme flood, which only occur at long intervals. When the Warrego River is in high flood some of the flood waters flow through an overflow channel 14 miles south of Dick's Dam, and provision for traffic to cross this channel during these abnormal conditions will be made by the construction of a gravel causeway 3,000 feet long at natural surface level.

(5) Provision of numerous grids at intersecting fences, and guide posting at curves.

No gravelling of formation on black soil has yet been carried out, but the 7¼ miles of low formation on black soil approaching Louth will be gravelled later.

Costs and Results.

To date the work on this road has cost in the region of £38,500, and it is estimated that a further £9,000 will be required to complete the work. Travelling time for traffic on the western side of the Darling River has now been considerably reduced, the through journey time from Louth to Bourke being in the vicinity of two hours or an improvement of an hour or more on the previous travelling time. Considerable benefit, particularly during the 1952 flood, has already been felt by the settlers along the route, who now have a speedy and trouble free route for their stores, mail and wool haulage needs.

The preservation of the asset now established can be greatly aided by the exercise of restraint by road users during wet periods, particularly drivers of four-wheel drive vehicles.

Supervision.

The work on the Paka Tank—Louth Road was carried out under the general supervision of the Department's Assistant Maintenance Engineer, Mr. F. I. Peterson, the District Engineer, Bourke, Mr. T. A. Mackintosh being in immediate charge of the construction.

Reproduction of Plans, etc.

Methods used by the Department of Main Roads

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THIS article describes *the photographic methods* used by the Department of Main Roads for the reproduction, reduction and enlargement of plans; reproduction of forms, standard *specifications*, *standard drawings*, plant instruction sheets, etc.; and associated work.

Most of the work described, on account of *its specialised nature*, is *concentrated* at the Department's Head Office; however, plan printing is also carried out in Divisional Offices, and in some cases at Local Offices, where *blue prints* and *dyeline copies are* made by hand using a sun frame.

PLAN PRINTING.

Where no change in scale is required, plan printing is carried out in a fully automatic plan reproduction unit, which can use both ammonia-type papers and foils. (See illustration.) Originals and sensitised paper are fed into the machine together and carried around a revolving printing cylinder containing a special mercury vapour lamp. They are then separated, the original returning to the operator and the print passing to the synchronised developing section of the machine. The finished prints are then stacked at the front or rear of the machine as desired. After an initial setting has been made to control exposure, all the above operations are automatic, and ammonia prints in either black, blue or maroon are produced at speeds up to thirty feet per minute without distortion in scale.

Plan printing machine (feeding end).

The ammonia process is "positive" in that the sensitised material which is protected from ultra violet light by the opaque portions of the original is changed into a dye when developed by heated ammonia fumes, whilst the exposed portions are converted into an invisible compound, thus giving a replica of the original.

When a change of scale is required between the original and finished prints, a photographic "intermediate" to the required scale is first made on photocopying equipment from the original, and contact prints are then made in the plan reproduction unit.

The machine is also used to expose blueprint, "helio", dyeline and sepia papers which are then developed by hand according to their individual processes. The uses and treatment of these papers were described in detail in an article which appeared in the November, 1939 number of this journal (Vol. XI, No. 1).

PHOTO-COPYING.

Photo-copying equipment, operated in a dark room, is used for the following processes:—

1. The production of reduced size negatives of plans for use in the printing of small scale copies of plans.

2. The copying of opaque originals when only a limited number is required, such as old mounted plans, documents, abstracts from technical journals, etc.

3. The preparation of offset printing sheets, when large numbers of copies are required from an original.

4. The enlargement of either prints or negatives of aerial photographs.

5. The preparation of film negatives either larger or smaller than the original.

6. The copying of originals when a change of scale is required.

In making reproductions, the photo-copying equipment is normally used with a prism, the original being placed on a horizontal copy board illuminated by mercury vapour lights. (See illustration.) The object of using the prism is to produce a non-reversed copy. The range of work carried out by this machine has been extended by two means. The first is the addition of a vacuum back to the camera which, by ensuring that the film or paper is held flat during exposure makes it possible to use a wide range of photographic materials. The second change has been to mount the camera on a wheeled carriage thereby making it possible to enlarge or reduce up to a maximum of eight to one. In this case the prism is removed and the plan is held in the vertical position.

When film negatives, such as negatives of aerial photographs not exceeding 15 inches by 18 inches require to be enlarged, the vacuum back is replaced by a transparency attachment consisting of a bank of eleven twenty-watt fluorescent lamps behind the negative holder. The image is projected through the lens to a large vacuum paper holding frame 30 inches by 40 inches which permits enlargements up to these dimensions.

The vacuum frame is also used in photo-copying creased originals, and as a contact frame in preparing offset printing sheets. For these two processes illumination is provided by four arc lamps.

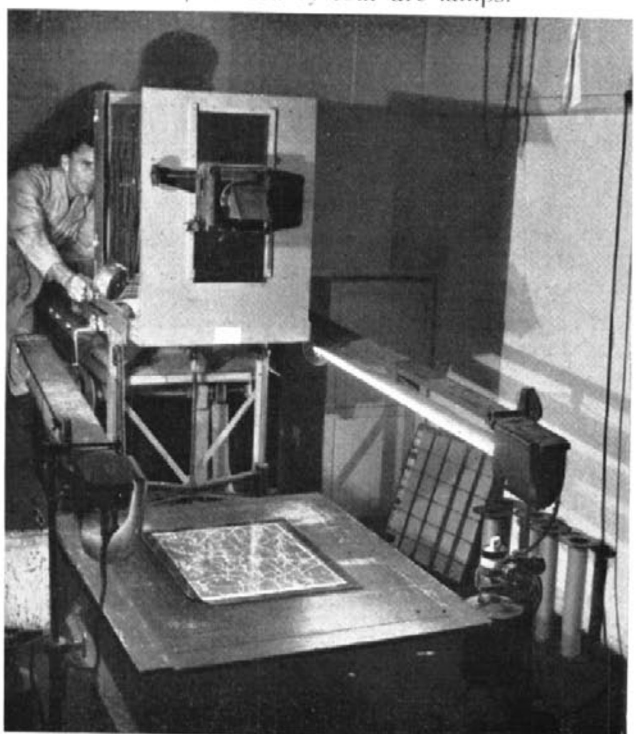


Photo copying, showing normal horizontal copy board.

Because of the higher cost of photographic paper used on this machine as compared to the material used in the plan printing machine, the printing of positive copies is, whenever possible, limited to a few prints from each original. Where a considerable number is required, a transparency only is made on the machine and further copies are then made on the continuous plan printing machine.

PRINTING AERIAL PHOTOGRAPHS.

The film negatives of aerial photographs often display considerable variation in exposure quality, and if printed in the ordinary way would give prints of uneven intensity. To overcome this, printing is carried out in a special contact printer fitted with twenty-four argon lamps with independent switches. (See illustration.) Prints of uniform quality are obtained by reducing the illumination of the under-exposed areas.

Contact printer for aerial photographs.

OFFSET PRINTING.

An electrically driven offset printing machine is used to reproduce forms, specifications, instruction sheets for plant operators, small drawings, typewritten manuscript, etc. (See illustration.)

The machine can reproduce any text or diagram photographed, drawn or typed on to a specially sur-

Offset printing machine (delivery end).

faced sheet which is chemically fixed to give an image similar to an offset lithographic plate. Photographic reproduction is mainly used, the sheets being prepared by the photo-copying equipment using the vacuum frame previously described. The "image" is direct reading, and, in order to make the final print the "same way round", a double reversal is necessary. The prepared sheet, therefore, prints on to a rubber blanket, which in turn transfers the reversed image on to the paper. The machine works on the rotary principle, three main cylinders being employed—the plate cylinder to which the plate is fastened, the "blanket" cylinder on which the rubber blanket is fixed, and the counter-pressure cylinder which applies the printing pressure on the paper passing between it and the rubber blanket.

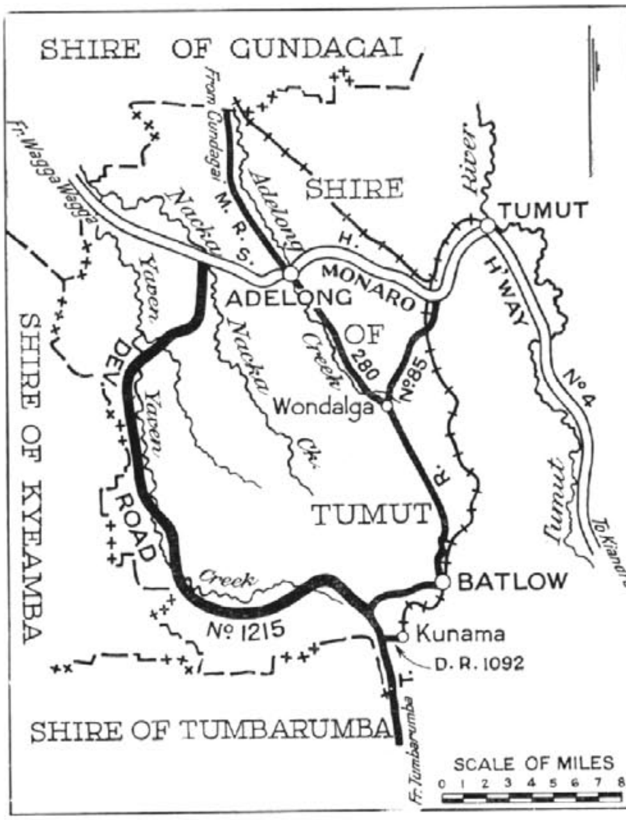
OTHER WORK.

Work carried out in association with reproduction includes single and double mounting of maps; binding books and material of permanent value; and photographic developing, enlarging and printing of photographs taken by the Department's officers for official purposes. Equipment includes a hand-operated guillotine for trimming paper and cardboard stock; a power stitching machine for binding multisheet publications reproduced by the offset printing process; and photographic dark room with developing tanks, enlarger, troughs, and drying racks.

The work referred to in this article is carried out under the supervision of the Department's Heliographer, Mr. R. L. Leonard.

Developmental Roadworks carried out by Councils

DEVELOPMENTAL ROAD No. 1215. MONARO HIGHWAY NEAR ADELONG TO TRUNK ROAD No. 85 NEAR BATLOW. SHIRE OF TUMUT.



Developmental Road No. 1215, which was proclaimed in 1950, commences from the Monaro Highway (State Highway No. 4) near Nacka Nacka Creek about five miles west of Adelong and passes generally southerly along Yaven Yaven Creek to the Jingellic-Tumut road (Trunk Road No. 85) about three miles south of Batlow. Its length of 28 miles is wholly within the Shire of Tumut.

The Yaven Creek valley south of the Monaro Highway runs between two parallel ranges of hills which lie in a north and south direction eight miles apart for a distance of approximately 20 miles to the head of Yaven Yaven Creek. The hill tops are steep and heavily timbered, but the foothills are cleared for grazing. There are a number of rich pockets of alluvial flats.

Abutting on the southern side of the Monaro Highway is Ellerslie Station, through which Developmental Road No. 1215 runs for the first five miles from its commencing point on the Highway. This station has recently been subdivided into soldier settlement blocks, accommodating twenty-nine settlers, of whom sixteen use this road for access to the Monaro Highway. Further south there are about twenty holdings for which this road provides the only means of access to the Highway.

The principal products are wool, sheep and cattle. During the war years the alluvial flats were used with success for vegetable growing.

The land served by Developmental Road No. 1215 is mainly of shale or granite formation with occasional intrusions of basalt. With a relatively high rainfall, which varies from 32 inches at the northern end of the valley to 45 inches at the southern end, the conditions are favourable for pasture improvement. Superphosphate for top-dressing is hauled by road from the railhead at Mount Horeb via Main Road No. 280 and State Highway No. 4 at the northern end of the Developmental Road.

The only access to this area is by Developmental Road No. 1215, which is at present a bush track of single-vehicle width with natural soil surface and some excessive grades.

New work 5 miles from Monaro Highway.

Construction has commenced at the northern end of Developmental Road No. 1215, at its junction with the Monaro Highway at Nacka Nacka Creek. This work comprises the construction of a 5 mile length with a formation width of 20 feet, a gravel pavement 12 feet wide and 6 inches thick and drainage structures. The work was being carried out by the Tumut Shire Council by contract, but owing to the slow progress made by the contractor, the Council has cancelled the contract and is completing the work by day labour.

A commencement has also been made on the construction by the Council by day labour of a further section of 2 miles between 17 miles and 19 miles from the Monaro Highway. This work comprises a formation 20 feet wide, a pavement 12 feet wide and 4 inches thick and drainage structures.

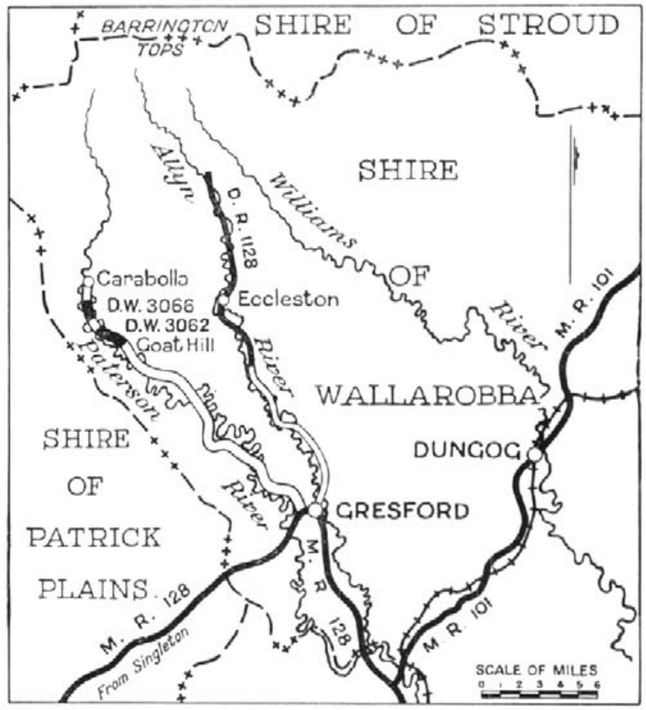
The total cost of these two works, approximately £17,500, is being met by the Department of Main Roads from Developmental Roads Funds.

The construction of Developmental Road No. 1215, by facilitating the improvement of further pasture areas, should result in increased productivity. When the road is completed, giving access to Batlow, with its food and fruit processing works, it is probable that new areas of fruit and vegetable growing will be established in the Yaven Yaven Creek Valley.

DEVELOPMENTAL WORK No. 3062 ON GRESFORD-UPPER PATERSON ROAD. SHIRE OF WALLAROBBA.

Developmental Work No. 3062, proclaimed in 1948, comprises the construction of four concrete causeways over the Paterson River, together with approaches and other road works on the Lostock-Carrabolla-Upper Paterson River Road in the Shire of Wallarobba.

The work forms an extension of a road system radiating from Gresford along the valleys of the Paterson and Allyn Rivers, which flow in a generally southerly direction through narrow, rugged but fertile valleys to their junction in the vicinity of Gresford. The work extends the road along the Paterson River towards settlements at the head of the valley. The



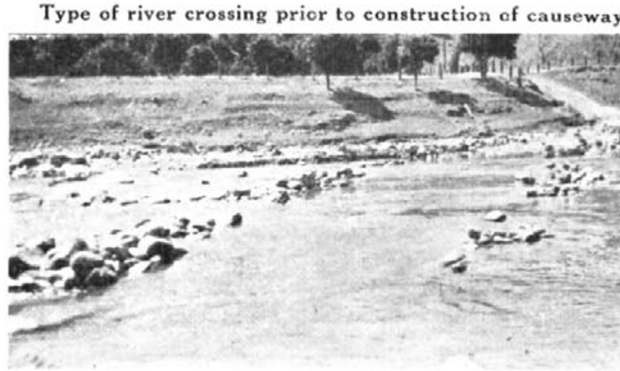
upper valley of the Allyn River is served in a similar manner by Developmental Road No. 1128.

The headwaters of the Paterson River rise in the Mt. Royal Range in the vicinity of the Barrington Tops, and the narrow valley along which the river flows contains areas suitable for cattle grazing, dairying and citrus fruit growing. Development of the upper reaches of this river has been retarded due to lack of satisfactory communications.

The gravel road from Gresford to Goat Hill has been in existence for some years, but beyond Goat Hill the route was untrafficable during wet weather. The numerous river crossings, consisting of rough shingle, became impassable after floods and freshes due to the presence of large boulders and loose shingle. In places the grades were 20 per cent. (1 in 5).

The work on Developmental Work No. 3062 involved the reconstruction and deviation of the existing track and the construction of 6,400 feet of road and four concrete causeways over the Paterson River. Work commenced at Goat Hill, approximately 24.5 miles north-west of Gresford.

Type of river crossing prior to construction of causeways.



Completed causeway.

The design provided a one-way feeder road with a formation width of 14 feet. The gravel pavement is 10 feet wide and four inches thick. The steepest grade constructed was 12 per cent.

The total length of the four reinforced concrete causeways constructed was 460 feet; they are 12 feet wide and provided with cut-off walls both on the up- and down-stream sides. In addition to the four causeways over the Paterson River, a similar crossing 80 feet in length was constructed over a small tributary. One reinforced concrete box culvert, 7 feet by 7 feet and 29 feet between kerbs, and numerous pipe culverts of various sizes were included in the work.

A trailbuilder and heavy grader were used on the construction of the earthworks and for the winning and spreading of the gravel pavement. It was necessary to drill and blast the small quantity of rock encountered in the deeper cuts. Gravel was loaded and hauled by lorries fitted with Berriman loaders and consolidated under traffic. Periods of wet weather necessitated the closing of the work from time to time. Additional work was involved in restoration following flood and storms.

The work which was carried out by the Wallarobba Shire Council by day labour was completed in 1951.

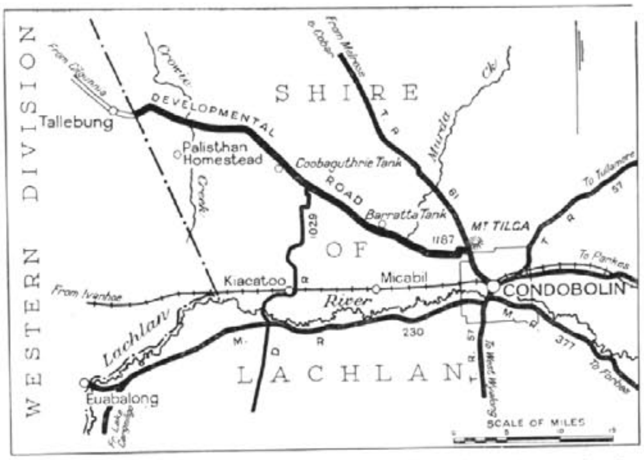
The total cost of the work was £6,125, and was financed by the Department of Main Roads from Developmental Roads Funds.

As an extension to the work described, the construction of a further 1,400 feet of road and an additional crossing of the Paterson River was completed in 1951 as Developmental Work No. 3066. The cost of £2,458 was also financed from Developmental Roads Funds.

With the completion of these two works, fertile areas of the upper reaches of the Paterson River have been provided with satisfactory access facilitating the transport of produce and enabling extension of the existing industries.

DEVELOPMENTAL ROAD No. 1187. CONDOBOLIN TO WESTERN DIVISION BOUNDARY. MUNICIPALITY OF CONDOBOLIN AND SHIRE OF LACHLAN.

Developmental Road No. 1187, commences at a point in the Municipality of Condobolin approximately three miles north of Condobolin on the Condobolin-Cobar road (Trunk Road No. 61), and extends for a distance



of 36.65 miles in a north westerly direction through the Shire of Lachlan to the boundary of the Western Division. A further length of 3.35 miles within the Western Division leads to the village of Tallebung. Developmental Road No. 1187 was proclaimed in 1941.

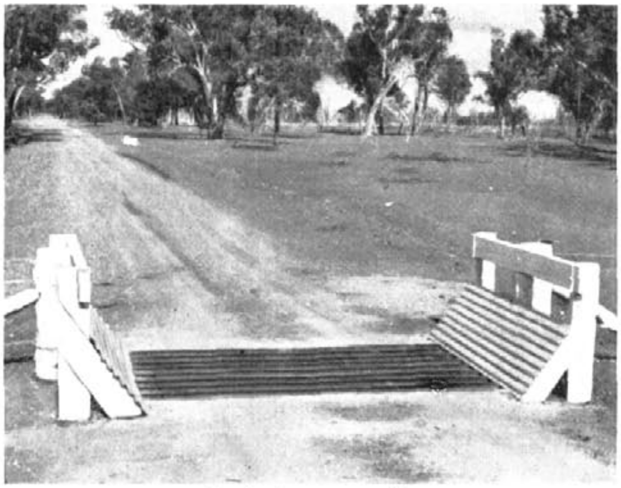
The road forms part of a system of roads radiating from a centre at Condobolin, and is the principal radial route in the area between the western and northern outlets provided respectively by Main Road No. 230 to Euabalong and Trunk Road No. 61 to Cobar.

For approximately 30 miles Developmental Road No. 1187 traverses flat to gently undulating country, with chiefly red sandy loam soil, timbered with cypress pine, gum and mallee. In the remaining distance there are several steep ridges, with some rocky outcrops. The country is used for wheat growing in the first 20 miles, and grazing. Towards the Western Division boundary a sawmill has been established in the vicinity.

Tallebung, some years ago, was a flourishing settlement where several tin and wolfram mines operated. Partly because of its isolation and associated transport difficulties, mining almost stopped. However, an extension of mining activities is now being planned, and it is expected that the village will regain its former position.

Developmental Road No. 1187 serves for the transport of wheat, stock, wool and other farm produce, sawn

Causeway constructed at Crowie Creek.



Typical motor grid.

timber and tin and wolfram from the mines at Tallebung.

Before construction commenced in 1947 the road was almost entirely unformed; traffic followed many tracks, making new tracks when ruts became too deep. Crowie Creek, situated 30 miles from Trunk Road No. 61, is the only major stream crossed. Though normally dry, it has always been a major obstacle to traffic during wet periods and the short causeway at this location was inadequate.

The construction has provided a well aligned road formation, 40 feet wide, with a gravel pavement, which is 12 feet wide and four inches thick except on sound loam where no gravel is provided. A total length of 23.5 miles has been gravelled and 13 miles formed. At Crowie Creek a causeway 350 feet long and 14 feet wide, with concrete side walls, rock filling and a reinforced concrete pavement, was constructed. Elsewhere, pipe culverts or gravel causeways were built.

The whole work has been carried out by the Councils concerned. Lachlan Shire Council constructed 24.7 miles in 1947-48, and 11.45 miles in 1952-53. The Condobolin Municipal Council constructed 0.5 miles in 1951-52. The clearing, forming and culvert or causeway work were done with the Council's plant, and the gravelling was done by contract.

The total cost of £17,594 was financed by the Department of Main Roads from Developmental Road Funds.

The section of 3.35 miles in the Western Division from the Lachlan Shire boundary to Tallebung was improved by the Department of Main Roads in 1946.

The construction carried out on Developmental Road No. 1187 has provided a sound road to assist the development of the agricultural, pastoral, timber and mining industries in the area.

The road is important also as part of a route leading from Condobolin into the Western Division to serve holdings between Palisthan and Gilgunnia some 60 miles to the west.

Tenders accepted by Department

The following Tenders (exceeding £1,000) were accepted by the Department during the months of April, May and June, 1953:—

Work or Service.	Name of accepted Tenderer.	Amount.
		£ s. d.
Construction and completion of Amenity Block for Departmental employees in basement of North Pylon, Sydney Harbour Bridge.	H. J. Abbey	6,987 10 0
Installation and maintenance of Lift in North Pylon, Sydney Harbour Bridge.	Hydraulic Power, Electric and Hydraulic Lifts Ltd.	5,070 0 0

MAIN ROADS STANDARD SPECIFICATIONS, DRAWINGS AND INSTRUCTIONS.

NOTE: Drawings are prefixed by letter "A", instructions are so described; all other items are specifications or forms. Year of revision, if within last 10 years, is shown in brackets.

Form No.

ROAD SURVEY AND DESIGN.

A 478, A 478A Specimen drawings, country road design.
A 478C Specimen drawing, flat country road design.
A 478B Specimen drawings, urban road design.
A 1645 Stadia reduction diagram.
355 Design of two-lane rural highways. (Instruction.)
369 Design of urban roads. (Instruction.)
288 Design of intersections. (Instruction,) (1952.)
402 Design of acceleration and deceleration lanes. (Instruction.)
499 Design of kerb-lines and splays at corners. (Instruction,) (1952.)
A 1614 Widening at points of "A" sight distance.
A 83 Earthwork quantity diagram.
Manual No. 2—Survey and design for main road works.
A 1640 Mould for permanent mark block.

STREET DRAINAGE.

243 Integral concrete kerb and gutter and vehicle and dish crossing, and drawing. (A 134A.)
245 Gully pit and drawings: with grating (A 1042); kerb inlet only (A 1043); with grating and extended kerb inlet (A 1352) extended kerb inlet (A 1353).
A 190 Gully grating.
A 1418 Concrete converter.
A 3491 Perambulator ramp.
A 3536 Mountable type kerb with reflectors.

CULVERTS.

138 Pre-cast concrete box culvert (1947) and drawing: 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 (1948) and instruction sheets. (A 304, A 305, A 306, A 359.)
A 1012–20 Single cell reinforced concrete box culvert: 6 in. to 1 ft. 3 in. (A 1012); 1 ft. 4 in. to 3 ft. (A 1013); 4ft. (A 1014); 5 ft. (A 1015); 6 ft. (A 1016); 7 ft. (A 1017); 8 ft. (A 1018); 9 ft. (A 1019); 10 ft. (A 1020).
A 1021–30 Two cell, reinforced concrete box culvert: 6 in. to 1 ft. 3 in. (A 1021); 1 ft. 4 in. to 3 ft. (A 1022); 4 ft. (A 1023); 5 ft. (A 1024); 6ft. (A 1025); 7 ft. (A 1026); 8 ft. (A 1027); 9 ft. (A 1028); 10 ft. (A 1029); and with concrete wearing surface–10 ft. (A 1030).
A 1031–41 Three cell, reinforced concrete box culvert: 6 in. to 1 ft. 3 in. (A-1031); 1 ft. 4 in. to 3 ft. (A 1032); 4 ft. (A 1033); 5 ft. (A 1034); 6 ft. (A 1035); 7 ft. (A 1036); 8 ft. (A 1038); 9 ft. (A 1040); and with concrete wearing surface–7 ft. (A 1037); 8 ft. (A 1039); 9 ft. (A 1041).
25 Pipe culverts and headwalls, and drawings: single rows of pipes: 15. in. to 21 in. dia. (A 143); 2 ft. to 3 ft. dia. (A 139); 3 ft. 6 in. dia. (A 172); 4 ft. dia. (A 173); 4 ft. 6 in. dia. (A 174); 5ft. dia. (A-175); 6 ft. dia. (A 177); Double rows of pipes :15 in. to 21 in. dia. (A 211); 2 ft. to 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 ft. to 3 ft. dia. (A 216). Straight headwalls for pipe culverts: 15 in. to 24 in. dia. (A 1153).
A 1 Joint for concrete pipes.
A 142 Inlet sump for pipe culvert 3 ft. dia. or less. (1947).
139 Timber culvert (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).
A 1223 Timber culvert 20 ft. roadway. (1949.)
A 3472 Timber culvert 22 ft. roadway. (1949.)
303 Supply and delivery of pre-cast reinforced concrete pipes.

BRIDGES AND FERRIES.

18 Data for bridge design. (1948.)
371 Waterway calculations. (Instruction.)
300 Pile driving frame, specification for 25 ft. and drawings for 50 ft. (A 209); 40 ft. (A 253); and 25 ft. portable (A 1148).
A 3693 Pontoon and pile driving equipment.
164 Timber beam bridge (1947) and instruction sheets, 12 ft. (A 3469); 20 ft. (A 70) (1949); and 22 ft. (A 1761) (1949).
326 Extermination of termites in timber bridges. (Instruction.)
350 Reinforced concrete bridge. (1949.)
495 Design of forms and falsework for concrete bridge construction. (Instruction.)
314 Regulations for running of ferries. (1948.)
A 4 Standard bridge loading. (Instruction, 1948.)
A 26 Waterway diagram. (1943.)
A 1886 Arrangement of bolting planks. (1948.)
A 45 Timber bridge, standard details. (1949.)
A 1791 Timber beam skew bridge details. (1949.)
A 3470, A 3471 Low level timber bridge, for 12 ft. and 20 ft. between kerb (Instruction.) (1949).
A 1216 Running planks.
A 1207 Reinforced concrete pile—25 tons. (1945.)
A 1208 Reinforced concrete pile—35 tons. (1945.)
A 1621 Reflector strip for bridges.

FORMATION.

70 Formation. (1949.)
513 Subsoil and subgrade drainage. (Instruction.
A 1532 Standard typical cross-section.
A 1149 Flat country cross-section, Type A.
A 1150 Flat country cross-section, Type B.
A 1151 Flat country cross-section, Type D1.
A 1152 Flat country cross-section, Type D2.
A 1476 Flat country cross-section, Type E1.
A 1101 Cross-section one-way feeder road.

Form No.

A 1102 Cross-section two-way feeder road.
A 114 Rubble retaining wall.

PAVEMENTS.

71 Gravel pavement. (1949.)
228 Reconstruction with gravel of existing pavement.
254A Supply and delivery of gravel.
72 Broken stone base course. (1947.)
216 Telford base course.
68 Reconstruction with broken stone of existing pavement to form a base course.
257 Haulage of materials.
65 Waterbound macadam surface course.
230 Tar or bitumen penetration macadam surface course, 2 in. thick.
66 Tar or bitumen penetration macadam surface course, 3 in. thick.
125 Cement concrete pavement, and plan and cross-section. (A 1147.)
A 380 Galvanised iron strip for deformed joint.
A 381 Bituminous filler strip for transverse expansion joint
493 Supply of ready mixed concrete.
266 Asphaltic concrete pavement.

SURFACE TREATMENT.

301 Supply and application of binder. (1950.)
122 Surfacing with tar. (1949.)
145 Surfacing with bitumen. (1949.)
93 Re-surfacing with tar. (1949.)
94 Re-surfacing with bitumen. (1952.)
466 Fluxing of binders for bituminous flush seals and reseals. (Instruction.)
351 Supply and delivery of aggregate.
354 Road-mix resealing. (1949.)
397 Fluxing for tar road-mix reseal. (Instruction and chart.)
A 1635 Fluxing chart for bitumen road-mix reseal.
167 Resheeting with plant-mixed bituminous macadam by drag spreader. (1951.)

FENCING AND GRIDS.

141 Post and wire fencing (1947) and drawings: plain (A 494); rabbit-proof (A 498); flood gate (A 316).
143 Ordnance fencing and drawing. (A 7.)
144 Chain wire protection fencing and drawing. (A 149.)
246 Location of protection fencing. (Instruction.)
224 Removal and re-erection of fencing.
A 1705 Plain wire fence for use in cattle country.
A 3598 Wire cable guard fence.
A 1301 Motor traffic by-pass 9 ft. wide.
A 1875 Motor traffic by-pass 20 ft. wide.

ROADSIDE.

A 1337 Concrete mile post, Type A.
A 1338 Concrete mile post, Type D.
A 1366 Standard lettering for mile posts
A 1367 Timber mile post, Type B1.
A 1368 Timber mile post, Type B2.
A 3497 Timber mile post, Type B3.
A 2815 Concrete kerb mile block.
A 1420 Steel mould for concrete mile posts.
A 1381–3, A 1452–5 Tree guards, Types A, B, C, D, E, F, and G.
Manual No. 4—Preservation of roadside trees.

MATERIALS.

296 Tar. (1949.)
337 Residual bitumen and fluxed native asphalt.
305 Bitumen emulsion. (1949.)
349 Light and medium oils for fluxing bitumen. (1948.)
A 27 Slump cone for concrete.
A 178 Mould for concrete test cylinder.
76 Design of non-rigid pavements. (Instruction.)
Manual No. 3—Materials.

TRAFFIC PROVISION AND PROTECTION.

121 Provision for traffic (1947) with general arrangement, (A 1323), and details (A 1325) of temporary signs. (1947.)
252 Supply and delivery of guide posts.
253 Erection of guide posts. (Instruction.)
A 1342 Temporary warning sign, details of construction.
A 1346 Iron trestle for road barrier.
A 1341 Timber trestle and barrier.

PLANT.

A 1414 Gate attachment for lorries with fantail spreader.
A 1450 Half-ton roller with pneumatic tyres for transport.
A 2814 Two-berth pneumatic tyred caravan.
A 2828 Multi-wheeled pneumatic tyred roller.
A 2976 Fantail aggregate spreader.
A 3530 Benders for steel reinforcement.
A 3547 Steel bar cutter.

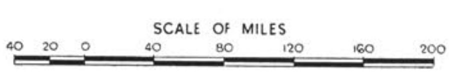
CONTRACTS.

24B General conditions of contract, Council contract. (1950.)
342 Cover sheet for specifications, Council contract. (1950.
64 Schedule of quanities form.
39 Bulk sum tender form, Council contract. (1946.)
38 Bulk sum contract form, Council contract.
193 Duties of superintending officer. (Instruction.)
498 Caretaking and operating ferry.

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

Sydney: A. H. Pettifer, Government Printer—1953.

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, 126,971 miles.

MILEAGE OF MAIN AND DEVELOPMENTAL ROADS, AS AT 30th JUNE, 1953.

State Highways	6,536
Trunk Roads	4,225
Main Roads	12,567
Secondary Roads (County of Cumberland only)	74
Developmental Roads	2,911
	26,313
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	2,620
TOTAL	28,933