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THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA

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7 MAY 1930

PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

REPORT

TOGETHER WITH

MINUTES OF EVIDENCE

RELATING TO THE PROPOSED CONSTRUCTION OF A

FEDERAL HIGHWAY

WITHIN THE

FEDERAL CAPITAL TERRITORY.

By Authority:
H. J. GREEN, GOVERNMENT PRINTER, CANBERRA.

F.3454.

MEMBERS OF THE PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

(Seventh Committee.)

ANDREW WILLIAM LACEY, ESQUIRE, M.P., CHAIRMAN.

Senate.	*House of Representatives.*
Senator John Braidwood Dooley	Malcolm Duncan Cameron, Esq., M.P.
Senator Matthew Reid	John Curtin, Esq., M.P.
Senator Burford Sampson	Hon. Henry Gregory, M.P.
	Edward James Holloway, Esq., M.P.
	William John Long, Esq., M.P.

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EXTRACT FROM THE VOTES AND PROCEEDINGS OF THE HOUSE OF REPRESENTATIVES, No. 6, DATED 28TH NOVEMBER, 1929.

4. PUBLIC WORKS COMMITTEE—REFERENCE OF WORK—CONSTRUCTION OF FEDERAL HIGHWAY WITHIN THE FEDERAL CAPITAL TERRITORY.—Mr. Lyons (Minister for Works and Railways) moved, pursuant to notice, That, in accordance with the provisions of the *Commonwealth Public Works Committee Act* 1913-1921, the following proposed work be referred to the Parliamentary Standing Committee on Public Works for investigation and report, viz. :—Construction of Federal Highway within the Federal Capital Territory.

Mr. Lyons having laid on the Table plans, &c., in connexion with the proposed work—

Debate ensued.

Question—put and passed.

LIST OF WITNESSES.

MAIL.

FEDERAL HIGHWAY.

REPORT.

The Parliamentary Standing Committee on Public Works to which the House of Representatives referred for investigation and report the question of the construction of a Federal Highway within the Federal Capital Territory has the honour to report as follows :—

INTRODUCTORY.

1. Canberra, until recently, was approached by two main roads—one from Sydney, via Goulburn and Queanbeyan, and the other from Melbourne, via Albury and Yass. The road from Goulburn to Canberra was about 68 miles in length, and that from Yass about 44 miles.

These were sufficient for the needs of Canberra until 1924, when the growing importance of the Federal Capital and the development of motor traffic rendered improved communication necessary.

2. Under the Federal Aids Road scheme a comprehensive view was taken of the matter so that all expenditure would form part of a definite plan which would embody in its main features access from Canberra to Sydney, to Melbourne via Albury, and to Melbourne via Cooma, Bombala and the Prince's Highway.

3. When the State of New South Wales, in 1927, decided to take advantage of the Federal road grant, this scheme of development was drawn up, the whole to be completed within ten years.

4. In considering the 68 miles of road from Goulburn via Bungendore and Queanbeyan to Canberra, it was recognized that 37 miles between Queanbeyan and Tarago was badly located with sharp curves and steep grades ; some of it was partly paved, and other portions were not paved at all. Another section of 21 miles between Goulburn and Collector was already in existence and was portion of a through road to be carried out with Federal aid over a period of ten years. After a conference between the then Treasurer (Dr. Earle Page) and the New South Wales authorities, it was decided that it would be better to construct the Goulburn-Collector road, rather than improve the old road, and an agreement was reached to proceed with the work as a special measure, rather than allow the usual development to take place over a period of ten years. Under this arrangement the State undertook to construct 22 miles of road from a point 5½ miles from Collector to the boundary of the Federal Territory, at an estimated cost of £200,000—two thirds of the money to be found by the Federal Government, and one third by the State over a period of two years. The Commonwealth undertook also to continue the road over a distance of approximately 6 miles from the boundary of the Federal Territory to the boundary of the City of Canberra. Under this proposal the total distance from Goulburn to Parliament House, Canberra, via Collector, will be 59½ miles, as against 68 miles via Queanbeyan and Bungendore.

5. The road from Goulburn to Collector, a distance of about 20 miles, is being dealt with by the State, and is not the subject of Federal aid. It is in good condition, well gravelled, and probably will be surfaced with bitumen. Over a distance of 3 miles 3,800 feet from Collector, the road is in very good condition and will not require further attention at the present ; from this point for a further 3 miles a contract has been let which will be met from Federal Aid funds. From 6 miles 3,800 feet south of Collector to the Federal Territory boundary is 21 miles 360 feet, and the cost of constructing this road is to be charged to the special grant of £200,000 set apart for this purpose, of which the Commonwealth is to pay two-thirds and the State one-third. The New South Wales Main Roads Board anticipates completing its section by the end of 1930.

PRESENT PROPOSAL.

6. The proposal submitted for the consideration of the Committee involves the continuation of the road above described from the boundary of the Federal Capital Territory to the City boundary of Canberra, a distance of 5 miles 3,438 feet.

DESCRIPTION OF THE ROAD PROPOSED.

7. Starting from Canberra, the road is located at first in the northerly prolongation of the constructed portion of the eastern roadway of Northbourne-avenue, and continues therein for about a mile. It then turns on a curve of 2,000-ft. radius to run in a north-easterly direction. The road runs parallel to, and distant about 700 feet westerly from the located route of the Canberra–Yass railway, but crosses the location of the railway about 1 mile 851 feet from the point of commencement. The road then continues in a general north-easterly direction crossing the lowest part of a low range at a point known as Ginn's Gap, elevation 2,263 feet, distant approximately 4 miles 3,880 feet from the point of commencement, and terminates at the New South Wales boundary, elevation 2,268 feet. The deepest cutting is to be 6 ft. 6 in., and the greatest filling is approximately 11 feet. The sharpest curves (500 and 900-ft. radius) occur at Ginn's Gap; all others being of 1,000 or 2,000-ft. radius. The maximum grade is 1 in 20 and the minimum is 1 in 300. The grading, curvature, &c., is held to conform to the best standards, and the road is properly designed for fast motor traffic. Outside the city area the work conforms with the details adopted by the Main Roads Board of New South Wales for the same highway in New South Wales.

8. The paved width will be 20 feet, the shoulders 4 feet wide, and the formation 28 feet wide. The formation width is measured between the tops of banks and the bottoms of cuttings. The clear width of bridges and culverts will be 20 feet between kerbs, excepting that pipe and box culverts will be made sufficiently wide to carry the full 28 feet of formation.

9. Surface water drainage will be collected by table and catch drains, and the water will be carried under the road by pipe and box culverts all constructed in reinforced concrete to designs standard for the whole of the highway. The pipe culverts will vary from 15 inches to 36 inches diameter; and box culverts range in size from one opening 6 feet by 3 feet to three openings 6 feet by 3 feet each. There will be one bridge opening of 30 feet span, so designed that it can be enlarged if later found necessary. The reservation for the road is 200 feet wide within the limits of the city plan, and 100 feet wide elsewhere. Provision is being made for an avenue of trees alongside the road.

ESTIMATED COST.

10. The estimated cost is set down at approximately £50,000.

COMMITTEE'S INVESTIGATIONS.

11. The Committee traversed the country through which the road is to pass, inspected various types of roads in the Federal Territory and elsewhere, and took evidence from the Director-General of Works, the Chief Engineer, Federal Capital Commission, and from road construction experts in Sydney, Melbourne and Adelaide.

Necessity for the Road.

12. With the growing importance of the Federal Capital City, it is generally recognized that direct road access should be available to the State capitals, and the increase of motor transport demands that such roads should be of a class capable of providing for fast traffic. The development of the road via Collector and Goulburn, rather than the existing road through Queanbeyan and Bungendore commends itself to the Committee which unanimously agrees with the location of the highway as proposed.

Method of Construction.

13. It was ascertained in evidence that the construction of this road will be proceeded with in stages. The first stage will comprise construction of culverts and the formation of earthworks; while these are consolidating it is proposed to spread a 7-in. layer of gravel and permit the passage of traffic until the road is thoroughly consolidated. Later, any weak spots discovered will be attended to and a surfacing put on. After a further twelve months' use an additional surfacing will be added and the road will be considered complete.

14. After hearing the opinions of various experts in the matter, the Committee is satisfied that the system of construction proposed is on the latest approved principles. Stress was laid on the importance of building roads from the bottom upwards with the various materials properly graded and worked into position before any surfacing is attempted. With careful attention to the drainage in addition, the Committee is convinced that the basis will be laid of a road that may be expected to give the best service for the longest period.

Surfacing.

15. The greatest road-making authorities assert that there is no "best road surface material" for all purposes. Every case must be dealt with on its merits, due regard being paid to sub-soil, climate, rainfall, and volume of traffic. It was stated in evidence that the traffic on this section will not at first be very heavy, and may be expected to average only 200 to 400 vehicles per day for some years, consequently nothing like the expenditure involved in city or suburban road construction need be considered. After the gravel of the first stage is consolidated, the Committee agrees that it be sprayed with tar or a bituminous material, and later, when traffic warrants it, further surfaced with penetration or mixed-in-place macadam. It is difficult to say what cannot be done with cheap construction in some cases, but the Committee has confidence in the Commonwealth officials in charge of this work, and is content to leave the actual details to them, only stressing the importance of thinking in terms of pence per super yard, as every penny so saved means many pounds per mile.

Use of Tar.

16. During the course of the inquiry representations were made to the Committee that an endeavour should be made in constructing roads to use as much Australian material as possible. Mention was made of Australian cement, but in a road of this class, the amount of traffic expected does not warrant a second thought being given to concrete, and, in any case, its cost would be prohibitive. It was stated in evidence, however, that considerable use might be made of Australian tar if greater attention were paid to it. The Committee ascertained that about 25 million gallons of tar is produced in Australia per annum as a by-product; about 4 million gallons by the Broken Hill Proprietary Company, and the remainder by the various gas companies. The Broken Hill Proprietary Company's tar, produced in coke ovens, and the tar produced by some of the gas companies in horizontal retorts is said to be of a superior quality to that produced in vertical retorts, and the former has been extensively and successfully used on various roads, especially for the primer coats. Experiments are now being conducted with a view to so treating tars as to admit of their more extensive use for all road-making purposes. It is the earnest hope of the Committee that these experiments will continue and may prove successful. At the same time it should be mentioned that, although tar is in most cases merely a by-product, and is frequently burned by the company producing it as fuel, and considered for that purpose to have a value of perhaps ¼d. a gallon, yet, when an endeavour is made to purchase it for road-making, 8d. a gallon is asked. It was pointed out in evidence that in many cases it is cheaper to import and use bitumen for road-making, than to utilize tar the local by-product. Although it is stated that the total production of tar is insufficient to meet the whole of the Australian requirements for roads, the Committee is desirous of recommending the use of Australian tar wherever it can be profitably used in road-making, but it is considered that the producers should do their part in reducing the price to a point which will make the use of that material more attractive than the imported bitumen.

Maintenance.

17. The cost of maintenance of roads is governed by the class of surface decided upon and the volume of traffic, and may range from £80 to £200 per mile. The type of road recommended, when completed with bitumen surfacing and seal coat is estimated to cost in maintenance approximately £200 per annum. This will provide for a renewal of the seal coat once every three years at a cost of £400 per mile equal to £133 per annum, while periodical attention by way of patrol, repairs to shoulders, and elimination of pot-holes is estimated to account for another £60.

CONCLUSION.

18. The Committee was impressed with the wealth of material contained in the very complete report on roads presented by the Director-General of Works, Mr. T. Hill, after his recent visit to England and America, which should be of considerable value to all road-makers. There is no regular publication of a Federal character at present on the subject of road engineering, but the Main Roads Board of New South Wales, realizing that something of that nature was needed, is publishing a monthly paper called *Main Roads*, in which are set out the results of their experiments and the need for testing materials. By this means it is hoped that local governing bodies will be kept in touch with the results of the Board's experiments, and, if Council and Shire Engineers can be induced to contribute to the journal letters or articles dealing with their problems, failures and successes, the result should be of considerable benefit to all.

A. A. LACEY,
Chairman.

Office of the Parliamentary Standing Committee on Public Works,
Parliament House, Canberra.
11th April, 1930.

MINUTES OF EVIDENCE.

(Taken at Canberra.)

THURSDAY, 5TH DECEMBER, 1929.

Present:

Mr. LACEY, Chairman;

Senator Dooley	Mr. Curtin
Senator Reid	Mr. Gregory
Senator Sampson	Mr. Holloway
Mr. M. Cameron	Mr. Long.

Thomas Hill, Director General of Works, Department of Works, Canberra, sworn and examined.

1. *To the Chairman.*—Canberra in its early days was approached by two roads—one from Sydney, via Goulburn and Queanbeyan, and the other from Melbourne, via Albury and Yass. The road from Goulburn to Canberra was about 68 miles in length and that from Yass to Canberra about 44 miles. They were sufficient for the needs of Canberra until about 1924, when the growing importance of the Federal Capital and the development of motor traffic rendered improved communication necessary. Whilst the respective *municipalities and shires had done excellent work in* maintaining the roads as well as their means permitted the lack of paving, gravelling, and culverts caused considerable interference with traffic in wet weather. Moreover, wear and tear of the roads became very heavy under the influence of the increasing traffic, and as they passed through only second-rate pastoral country the yield of rates did not provide much money for maintenance. The Federal Aids Road Scheme enabled us to take a comprehensive view of this matter, so that all expenditure would form part of a definite scheme which would embody as its main features access from Canberra to Sydney, to Melbourne via Albury, and also via Cooma, Bombala and the Prince's Highway, to Jervis Bay, and, finally, a westerly outlet *to Albury via Tumut to obviate the long detour via* Yass. When New South Wales belatedly decided in 1927 to take advantage of the federal road grants, this scheme of development was drawn up and the committee will see on the map *the full extent of the* works proposed to be done in the first five years, the Commonwealth providing £1 for every 15s. expended by the State. The arterial or interstate roads are shown in blue, trunk roads between important towns within the State of New South Wales in brown, developmental roads in red, and existing roads, which are not the subject of federal aid, in black. Apart from the work being done with the aid of federal money, the State of New South Wales is doing a considerable amount of road construction through the Main Roads Board as part of a general policy of road improvement. In drawing up our scheme, we considered first the 68 miles of road to Goulburn via Bungendore and Queanbeyan. We had to recognize that 37 miles of it, between Queanbeyan and Tarago was badly located, and twisty, with sharp curves and steep grades. Some of it was partially paved and other portions were not paved at all. Another section of 21 miles between Goulburn and *Collector was already in existence* and was part of a through road to be carried out with federal aid over a period of ten years. We decided that it would be better to carry it through to Canberra, immediately, rather than incur the very heavy expense of re-making the road via Queanbeyan and Bungendore. Not only would the old road be more costly and longer, but on account of the steep grades and sharp curves could never be made as satisfactory as the route via Collector. By constructing 21 miles in New South Wales and six miles within the Federal Capital Territory we could reduce the distance between Canberra and Goulburn by eight miles and get a very much better road at less cost. The matter was placed before the then Minister for Works who referred it to Cabinet and as a result of a conference with the New South Wales authorities, the then Treasurer (Dr. Earle *Page) wrote this letter to his colleague, the* Minister for Works and Railways—

Commonwealth Treasury,
Canberra,
26th July, 1928.

My dear Minister for Works and Railways,

In connexion with the Government's decision, I interviewed members of the New South Wales State Government with the result that the New South Wales Government *has agreed to contribute 20s. for every 40s. contributed by* the Commonwealth Government for the purpose of constructing the 22 miles of road from a point five and a half miles from Collector to the boundary of the Federal Territory, the estimate of the cost of which is £200,000, two-thirds of which will be found by the Federal Government and one-third by the State Government over a period of two years.

I have approved of the placing of the sum of £50,000 on the Estimates for the current year to provide for the construction of the road which lies outside the Federal Territory.

I am also placing on the Estimates a sum of £25,000 which will be made available to the Federal Capital Commission for the construction of that portion of the road which lies within the Federal Territory.

Yours faithfully,
(Signed) EARLE PAGE.

Hon. W. C. Hill, M.P.,
Minister for Works and Railways,
Melbourne.

The idea of making the special grant was to expedite the work, because, if the new connexion with Canberra were carried out under the Federal Aid Scheme, it would not be completed in less than ten years. The total distance from Goulburn to Parliament House, Canberra, via Collector, will be 59½ miles as against 68 miles via Queanbeyan and Bungendore. The former is *divided into four sections. The first section from* Goulburn to Collector, a distance of approximately twenty miles, is being dealt with by the State. It is in good running condition and well gravelled and probably will be surfaced with bitumen. *It is not the subject of* federal aid. The second section is from Collector to a point 6 miles 3,300 feet south of Collector, and the whole of it will be constructed from federal aid funds. Allocations for this work were made in 1926-27 and 1928, totalling £77,000. A contract has been let for 3 miles from approximately 6 miles south of Collector to 3 miles south of Collector to John Fowler Limited, for £11,859 8s. 7d. The remainder of the section from Collector to a point 3 miles 3,300 feet to the south, is in very good condition and will not require any attention *at present*, but ultimately it will be further improved by the State. The third section is from 6 miles 3,300 feet south of Collector to the Federal Territory boundary, a distance of 21 miles 360 feet. The cost of *it is charged to the special grant of £200,000, two-thirds* of which will be provided by the Commonwealth. Contracts have been let totalling £123,691. Some are completed, and others are due to be completed by the 30th June next. The first stretch from 6 miles to 12

miles south of Collector is completed in bitumen penetration macadam; the other two contracts are for earthworks and culverts only, and the fourth contract is for a bridge at the 16-mile point. The paving of the piece from the 12 to the 17-mile post yet remains to be done. That is estimated to cost £76,308 19s. 6d. As I explained to the committee yesterday, we have not been able to discover yet any really good stone or gravel, but we are exploring the locality in order to make sure that the best available is used. The fourth section of the road is the subject of the present reference to this committee. It extends from the boundary of the Federal Capital Territory to the boundary of the City of Canberra, a distance of 5 miles 3,439 feet, and is estimated to cost £50,000. This work is chargeable to a special grant of £50,000, the whole of which will be borne by the Commonwealth. A contract has been let for the earthworks, culverts, &c., to John Fowler and Company for £17,890 7s. 7d. When these four sections are completed, Canberra will have permanent access to Sydney via Goulburn by a first-class road. The second means of access to which we gave consideration was that from Canberra to Yass. An earlier Works Committee considered this road when dealing with a project for connecting Canberra with Yass by railway. Because that road passes through a lot of poor country and its adequate maintenance would place too great a burden on the local governing bodies, it was added to the federal aid programme. The length of road from Canberra City boundary is approximately 44 miles, of which 23 miles requires attention. Seventeen miles of that section is in the shire of Goodradigbee and the remainder in the municipality of Yass. The proposal is to re-locate the road in a permanent position, recondition and strengthen it, and ultimately surface it with bitumen, so that there will be a complete bitumen surfaced road from Canberra to Yass. Between Yass and Albury, considerable portions of the road have been rebuilt, and we hope that with the assistance of the States a bitumen surfaced road will be available right through to Melbourne. The Victorian road authorities are helping to realize this scheme. They recognize that independent of the requirements of Canberra the main Hume Highway must ultimately be surfaced with bitumen. We had hoped that this would be completed by the end of next year, but probably it will take another year. The road via Collector was given preference over that to Yass, because there is very little traffic on the latter, and it adds 50 miles to the distance between Canberra and Sydney. The road from Yass to Cowra, known as the North-Western Highway, will ultimately give access to Orange and Bathurst. A connexion between Goulburn and Bathurst is now being made. From the projects I have indicated, the committee will see that access to Canberra from the north and north-east is provided for. The next scheme is an eastward communication with Jervis Bay. The proposal is to make a connexion across to Bungendore from the new Federal Highway near Collector and improve the existing road via Braidwood to Bateman's Bay where it will link up with the Prince's Highway. The section from Bungendore to Bateman's Bay will be constructed out of State funds, and the State has definitely agreed to reconstruct and strengthen it in the near future. From Bateman's Bay one can go along the Prince's Highway either north to Jervis Bay or southward through Bega and Eden to Melbourne. The reason for selecting the Braidwood route is that road construction through the Kangaroo Valley would be difficult and costly, because of the ravines and sandstone. Another road on the programme will provide Canberra with an exit to the south, using the existing road to Cooma, Bombala and Cann River, where it links up with the Prince's Highway through Orbost to Melbourne. Already considerable amounts have been expended on this route from federal aid and State funds. Although this route is longer than the road to Yass, it is much more picturesque and for that reason is greatly favoured by motorists. Moreover, it would open a lot of good country. We hope that it will be completed in a couple of years. It is in very good motorable condition at present, except for a couple of water crossings which give trouble in wet weather. When bridges have been built there, this road will be motorable at all times. A road westward through Tumut was also considered. At present, there is a section of road to the Federal Capital boundary via the Cotter River and Uriarra, and under the Federal Aid Scheme another section has been developed through very good country in the valley east of Tumut. If the intervening space of 25 miles could be bridged at reasonable expense, we would have a shorter route to Albury and Melbourne, passing through Tumbarumba to the Murray River, giving access to very good country, and following the Hume Reservoir for a distance of about 30 miles. It would have to pass the snow level twice. Starting from Tumut, which has an altitude of 600 feet, the road would climb to 4,000 feet on the dividing spur, drop into the Goodradigbee Valley at 1,200 feet, rise again to 4,000 feet, drop into the Cotter River Valley at 1,500 feet, and rise again into Canberra at 1,800 feet. The surveys show side slopes of 1 to 1 in loose rock with curves as low as 70 feet radius, and the construction of a road suitable for motorists and heavy traffic would be so costly as to be beyond the realm of practical politics for the present. It does, however, offer a very attractive short cut, and the Tumut and Queanbeyan shires have recently conferred regarding the building of a rough through track. The two special grants of £50,000 are based on the provision of roads with bitumen surface. No other class of construction would be satisfactory to road users and the cost of maintenance would be excessive. When I was in America, I made a special study of road construction. In drawing up the scheme of Federal Aids Roads, I received every assistance from the State authorities in adopting the very latest engineering practice in regard to both the class of construction and the use of plant and machinery. As a means of opening up and settling the country, there is little to choose between the Bungendore and Collector routes. The advantage of the latter is that it is shorter, cheaper and better. It will give give access to Canberra by the Northbourne-avenue and conforms to the city plans. One stipulation was that the road should be of similar type to the standard roads being constructed by the State authorities. The first stage of construction is the formation of culverts and earthworks. While they are consolidating a 7-inch layer of gravel is spread. Traffic is then permitted over the road until it is thoroughly consolidated. When the weak spots of the road have been strengthened the road is surfaced, either by bitumen spray or by semi-bitumen penetration. We are at present experimenting to discover which method will be most suitable for the material available. It is the practice now to adapt the use of bitumen to the materials on the spot, and until one has experimented it is difficult to lay down definite practice. That can be done, if one imports materials into the locality, but it would involve very heavy expense for carriage. Following the American practice private firms are specializing in bitumen spraying. One plant has already been used in the locality by which the spray is used at a certain temperature under definite pressure and according to a precise chemical formula. Several of these machines are in use in New South Wales. The bitumen is internally heated and sprayed under pressure up to 80 lb. The first stage of the 6 miles of road to be constructed within the Federal Capital Territory should be completed by the end of February. The gravelling should be finished by September or October, and the bitumen spraying will be done the following summer. We hope that the road will be available for traffic during the gravelling stage. The road will require a second coat of bitumen after it has been in use for about twelve months, but that second spray is considered part of the third stage of construction. The maintenance costs should be comparatively very small. It may be £80 per mile annually; that will depend very much on the traffic. Experience shows that traffic develops tremendously on a road of this class, and usually when the maintenance cost exceeds 5 per cent. of the capital cost it is time to strengthen the road. I am aware of the provision in the Public Works Committee Act, that works costing £25,000 and upwards shall be referred to this committee, and I accept responsibility for the failure to refer this £50,000 undertaking in accordance with the act. It was an oversight due to the fact that I regarded this as a federal aid work. In respect of the 21 miles of road for which the Commonwealth is providing £2 for every £1 provided by the State, a special grant was made to expedite the work. The outlet from Canberra to the north was distinctly bad and a permanent improvement was wanted inside two years. If the work had been carried out under the Federal Aids Scheme it would not have been completed inside ten years. The State authorities have shown great willingness to improve the access to Canberra and the last Government felt that special help to speed up the work was warranted. The increased burden on the Commonwealth is not very great. The Federal Aid Roads Act provides that contributions shall be in the proportions of four-sevenths by the Commonwealth to three-sevenths by the State; in this case that has been altered to two-thirds and one-third. The grant was a separate item on the Estimates and will not be paid for out of the Federal Aid Roads Vote.

2. *To Senator Reid.*—The time is not yet ripe in Australia for the use of concrete on the ordinary highways outside the city, because the cost of concrete in comparison with bitumen is so great as not to be warranted by the traffic. Apart from earthworks, culverts, and other formation work, the paving of a cement concrete road averages 22s. 6d. per square yard. Whereas we are surfacing hundreds of miles with bitumen at a cost of 4s. to 5s. per square yard, whilst bitumen spraying costs as low at 3s. per square yard. The extensive deposits of gravel lend themselves particularly to the spraying method. Even in Canberra concrete paving is costing from 21s. to 22s. 6d. per square yard, or approximately £11,000 per mile. Moreover, bitumen treatment is more adaptable to an existing road; where there is some bed to work on, it can be treated and will give good wear, but concrete paving cannot be touched at a cost of less than 22s. 6d. per square yard. Even in the United States of America the extent of concrete road is not as great as it is generally understood to be. Of the 3,000,000 miles of roads, fully 2,500,000 miles have not been touched. Of the remaining 500,000 miles, about 50,000 miles are of concrete, 100,000 miles are surfaced with bitumen, and another 100,000 miles are gravel. The remainder are merely formed in dirt. Notwithstanding the great wealth and population of America it still has a very large proportion of gravelled and bitumen surfaced roads. I am certain that the bitumen road is the most suited to Australia's means and traffic. In spraying bitumen we use about half a gallon per square yard, which means a cost of about 1s. On the higher class bitumen road the cost of the material would be about 2s. 6d. per square yard. I am aware that some engineers advocate the construction of concrete roads because the whole of the money is spent within Australia. At the present time about 4,000,000 gallons of tar from the Broken Hill Proprietary Works at Newcastle is being adapted and used on the road. The gas companies are paying attention to the increase of this commodity. Annually between 15,000,000 and 20,000,000 gallons of bituminous material is used for road construction in Australia, and the whole of it cannot be supplied locally. The local article is quite satisfactory. The specifications for bituminous roads include a definite formula for the use of tar. It is the desire of the constructing authorities to use as much of Australian material as is available, but tar is only a by-product, and our supplies are limited to the product of coke ovens. Recently I investigated this matter and ascertained that if all the tar produced in Australia were used on the roads we would still have to import a large quantity. Road oil has roughly 50 per cent. asphaltic contents, whereas the percentage in bitumen is 98 per cent. Our first spray is usually an oil with a small asphaltic content, to produce greater penetration. The second spraying is with heavier material, which will act as a sort of envelope. Blows or faults in the bitumen surface are usually due to hurried construction. Traffic over a road for some months will give better consolidation than a heavy roller; after the weak spots have been disclosed by the traffic the bitumen can be applied without risk of blows or soft spots.

3. *To Mr. Holloway.*—Undoubtedly the concrete road is better than any other but the heavy capital cost, involving large outgoings for interest, make them impossible except in city areas or where the traffic is very heavy. Concrete is too costly for arterial roads and highways. The difference between the interest on the capital cost of a concrete road and the maintenance cost of a bituminous road would in a few years be sufficient to pay the cost of laying a concrete road. Interest and maintenance would cost 6 per cent., which, on a capital cost of £20,000 per mile, would be equal to £1,200 per year per annum. Tests we have made with individual sections of road show, unfortunately, that the cost of concrete is prohibitive. No road included in the federal aid programme has been built or improved merely for the benefit of tourist traffic. The purpose of these roads is to improve the means of communication and benefit the population. The requirements of tourists are not considered when the money is being allocated. Generally speaking, the struggling farmer gets the most benefit from the arterial roads we are building. The proportions of the expenditure by the Commonwealth and State respectively are fixed by statute at four-sevenths and three-sevenths. In allocating money we do not aim at equal distribution between districts. The only consideration we have is the traffic to be served and the possibilities of development. The cost of a road as certified by the Auditor-General of the State and the chairman of the Roads Board is divided between the Commonwealth and the States in the rigid proportions of four-sevenths and three-sevenths.

(*Taken at Canberra.*)

FRIDAY, 6TH DECEMBER, 1929.

Present:

Mr. LACEY, Chairman;

Senator Dooley	Mr. Curtin
Senator Reid	Mr. Gregory
Senator Sampson	Mr. Long.
Mr. M. Cameron	

Thomas Hill, Commonwealth Director-General of Works, recalled and further examined.

4. *To Mr. Curtin.*—It is not the usual practice to put kerbs down on road construction, though sometimes we put in a boxing to hold the gravel formation. If

the right kind of material is employed a kerb is not necessary. I am aware that there have been a number of complaints about corrugations in certain gravel roads, but when roads have been consolidated and surfaced with bitumen there should be no room for further complaint. Corrugations in a road are due either to an excessive quantity of bitumen or, in the case of what we call a hot mix, an incorrect proportion of the filling material. In every instance corrugations, if evident in a road with a bitumen surface, are due to some fault in construction. Gravel will move under traffic before the application of bitumen, especially if the percentage of "fines" is not carefully watched. Roads constructed under earlier methods frequently gave evidence of corrugation. This was due to the practice of taking the run of material from the sand-pit; but under modern methods gravel for road construction is screened, and we know what is the correct percentage of fines for the proper mixture. This material compacts under pressure and weather conditions. If, however, there is an excess of fluid, even dry fluid like sand, the mass will give under pressure, and the road become corrugated. We overcome this difficulty as regards gravel roads by the constant use of the grader. We regard expenditure on grading as part of the cost of construction, for it is necessary to keep all gravel roads well bladed by the use of a petrol-driven grader. If gravel is properly graded and screened, and if the "fines" are kept down to about 25 per cent. of the total mass, a gravel road should prove entirely satisfactory provided the grader is used. Under the agreement with the States for the construction of Federal Aid roads, the Commonwealth approves of the type of road to be constructed in a particular locality, but it does not exercise supervision over construction. My department is, however, supplied with complete plans, sections and specifications, and is informed of the estimated cost before the proposal is approved. When I visit a State I make it my business to inspect those roads which, in my judgment, require inspection, in company with the Chairman of the Roads Board; but the State authorities have a free hand in all construction work, and have to accept responsibility. If a road is down for, say, six months before it is surfaced with bitumen, it should not corrugate, especially if it has been well bladed during that time. We regard the construction period as ended when the second coat of bitumen has been put on. If traffic develops rapidly on a particular road, it is necessary sometimes to put on a coat of penetration macadam. I am familiar with the road between Armidale and Bunbury, in Western Australia. That was not constructed entirely by private contract. All the bitumen surfacing in Western Australia has been done by the Roads Board with day labour. I can recall no instance of bitumen surfacing that has not been done by the Roads Board in Western Australia, because it has the plant, and surfacing with bitumen calls for a certain amount of experience and skill. A number of penetration macadam roads have been done by contract. A few private contractors in New South Wales and Victoria, as well as in South Australia, have the necessary plant for bitumen surfacing, but nearly all of the surfacing on Federal Aid roads has been done by the roads boards in the respective States because they have the plant, and their employees have the experience. I regard bitumen surfacing as necessary to ensure a really good job. It is not an economy to omit it. I strongly favour all surfacing with bitumen to be done by roads boards with day labour. Those contractors who have the necessary plant to carry out the highest grade of road construction usually find sufficient work in the cities to keep them fully occupied. Federal Aid roads are in country districts, and country road contractors are not in a position to maintain a plant for surfacing with bitumen, and city contractors are not disposed to tender for country work.

5. To Mr. Gregory.—The road in front of the Canberra Hotel is sprayed with bitumen, and on the Queanbeyan road there is a section technically described as a re-tread, which is the type of road next in order after a bitumen spray road. The road in front of Parliament House is a bitumen penetration or hot mix. The exposed gravel which is lying about on it has never been treated, and practically nothing has been done in the way of spraying.

6. To Mr. Curtin.—Our original estimate of £50,000 for the work now before the committee was made without any survey, but it will prove to be pretty close to the actual cost. We based our estimate on the known cost of similar roads in New South Wales. Mr. Potts will be able to give you exact information as to all costs. We made the necessary surveys and estimates before calling tenders, and all the details are attached to the files. One contractor was £600 under and one £460 above our estimate. It is not unusual to have a wide margin between the highest and lowest tenderers because every tender, and even a departmental estimate, is in the nature of a bid. I have seen tenders for some works ranging from £2,500 to £7,500. If a contractor has plenty of work in hand he puts his price up; but if he is short of work he will do a job for the bare cost so as to keep his plant occupied and his teams together. There will be five different contractors on this road, but they will all be doing the same class of work. Prices have dropped appreciably since the contractor for the first section submitted his tender. I consider that some of the later prices are below the remunerative level. The first tenderer was fairly near the departmental estimate, but I am afraid the last contractor will lose money. There is no prohibition of sub-contracts, but a sub-contractor has to comply with all the conditions of the contract and pay the stipulated rate of wages. There is, however, very little sub-contracting in road work. The contractors for this road will be required to do all earth work, forming, construct culverts, and carting gravel from the pit to the site. The spreading and rolling will be done by departmental labour. The section from a point six miles to twelve miles out was let under a different contract. The successful tenderer had to finish that job, which included a 3-inch penetration macadam surface. Maintenance is the responsibility of the State Governments, and the practice of all roads boards is to keep men permanently employed grading over the whole length of a road. In the United States of America, where there is a great mileage of federal aid roads, the practice is to offer prizes for the best-kept section, and you would be surprised at the state of cleanliness on some sections. Our roads boards have adopted the same policy.

7. To Mr. Long.—In the case of all roads in the Federal Capital Territory, maintenance will be the responsibility of the Federal Capital Commission or whatever body takes its place. There is very little competition for Federal Aid road contracts, particularly in the more remote country districts. If the lowest tender is above the departmental estimate, the work is carried out departmentally. About 50 per cent. of the work on Federal Aid roads is carried out by contract and the balance by day labour under departmental supervision. The contract prices for earthwork, forming and culverting on this road totalled £17,890, and the total cost is put down at about £50,000. The gravel will be carted at a contract rate per square yard and delivered *in situ*. It would not be economical to maintain departmental drays and teams for the carting of gravel, so we get all this work done by private contract; but the spreading and grading and maintenance are carried out departmentally. Spraying is done usually by the Broken Hill Proprietary Company, which has an extensive plant of sprayers and supplies the material. Also we find it a good plan to hire our quarry crushing plant out to contractors and charge them about 1s. a cubic yard for its use. They undertake to deliver the crushed stone into the bins at so much a square yard or alternatively, deliver it to the job. The type of road to be constructed from Canberra to Collector is a good one. The use of gravels for road construction has been the subject of careful study in the United States of America, Canada and elsewhere. Bitumen gives an excellent surface for many years. For a 20 foot road surfaced with bitumen we allow a camber of about 3 inches, but the tendency is to flatten out to 2 inches, and sometimes even to 1 inch, and put in longitudinal instead of cross drainage. The flattening out of a road in this way makes it possible to distribute the traffic more evenly over its entire surface. In districts liable to heavy thunderstorms it might be advisable to vary the practice as regards the camber, but in my judgment 3 inches is ample for the Federal Capital Territory. The maintenance of a bitumen surfaced road depends upon the volume of traffic. Usually, it works out at about £80 a mile per annum. This would provide for from 500 to 800 vehicles a day, but if the traffic becomes very heavy, maintenance charges might go as high as £200 a mile per annum. There are 5 types of bitumen road, varying in price from 2s. per square yard up to 10s. In South Australia many of the Federal Aid roads are surfaced with 4 inches of metal. A new road with 8 inches of metal could be constructed for about 6s. a square yard. I prefer bitumen to concrete on the score of expense. A concrete road costs anything from 22s. 6d. a square yard, so it is possible to build three miles of road with a bitumen surface for the sum needed to construct one mile of concrete road. In other words a bitumen surfaced road would cost £3,500 a mile, and a concrete road £12,500. The interest on the first named at 5 per cent. amounts to £175 a year, and the interest on the concrete road would be £625 a year—a difference of £420, so the saving in interest over a period of 20 years would be more than £8,000. Maintenance charges for a bitumen road would be about £60 a year and for a concrete road about £40 a year, because culverts would have to be kept clean and side drains and slopes attended to. I should not feel justified in recommending any system other than bitumen surfacing for roads in the Federal Capital Territory.

8. To Senator Sampson.—The Act provides that on completion of Federal Aid road contracts the States must accept responsibility for their maintenance. In the Federal Capital Territory, the Federal Capital Commission will be responsible.

9. To Mr. Cameron.—Generally there is 6 inches or 7 inches of road material under the bitumen. If the sub-grade is good we can cut down the depth of crushed rock or gravel. The modern tendency is to roll new gravelled roads lightly, then to use the blader or grader constantly and allow the weather and traffic to consolidate the construction. We prefer to have a winter's rain on a new road before surfacing it with bitumen because then it is well compacted. We have had extensive experience with this class of road in all the States and find it quite satisfactory. If there were any possibility of a considerable amount of horse drawn traffic over a new road we should take steps to prevent it because of the damage that would be done. We find that as soon as we construct a new road horses seem to disappear and the small amount of horse-drawn traffic that is likely to use it will not do much damage. We can prevent heavy traction engines from being taken over a Federal Aid road, or compel the owners to remove the bars. Expenditure on kerbing is not justified and furthermore kerbing is a menace to traffic; but on roads where there is a liability to creeping it is the practice to put down sunken kerbs to take the side thrust of traffic and maintain the construction. Speaking generally I do not approve of the practice of kerbing country roads. It does not strengthen the work in any way. If a road displays a tendency to disintegrate at the edges, that is evidence that the width of the paved surface is insufficient. A road 16 feet wide would show a greater tendency to disintegrate than an 18 foot road, because there is more wear on the pavings. Even if a kerb were put down on the edge of the pavings, it would not arrest the process of disintegration at the edges. The object of the kerb is to take the horizontal thrust of the paving against the natural material in the shoulders, and distribute it evenly. Perhaps I should have mentioned that in an 18-foot gravel road I would recommend a camber of from 5 to 6 inches. We endeavour to get a definite price per cubic yard for the carting of gravel. For the road work now before the Committee the price is based on the actual haulage but in most cases we get a price based on the mean haulage. The cost of this road will work out at about £8,000 a mile, but Mr. Potts will be able to furnish the Committee with accurate information on this point. I would describe this road as first class construction. The highest grade of road has an asphaltic surface on a concrete bed. If there were not a concrete bed all the metal would be specially graded and carefully measured and hot mixed. The next grade is penetration macadam. Then comes what is known as the "re-tread," and bitumen sprayed road. A road stands better if there is a steady volume of traffic over it. Traffic seems to spread the bitumen evenly and if any faults occur or cracks appear, traffic seems to heal the wounds, and prevents the atmosphere from attacking the exposed tar. Our experience in South Australia is that departmental estimates for Federal Aid road construction are lower than contract prices. Last year we invited tenders for £200,000 worth of work in five sections of 10 miles each. The tenders received were all above the departmental estimate, and the work was carried out departmentally, for a sum considerably below even the departmental estimate. I do not suggest that the bids for private contractors were unduly high. The department, has the plant and the organization, and it should be in a position to do the work more economically than a private contractor. Bitumen surfacing should be done departmentally by men who have become skilled through long experience in that class of work. There is a good deal to be learned about the application of this mixture and every year it is becoming more and more highly technical. The country between Canberra and Goulburn is second class pastoral land. The proposal is to construct a gravel road 20 feet wide, bitumen sprayed to a width of 18 feet. I should not care to recommend spraying less than 18 feet. If, on the score of economy, it were deemed advisable to spray less than 18 feet, I should recommend coming down to 12 feet, and then regard it as a one-way traffic road. There is difference of opinion among engineers as to the width of bitumen surfaced roads; some prefer 20 feet and others 18 feet. In New South Wales the general practice is to bitumen spray for 20 feet wide, whereas Victoria prefers 18 feet. Since the inauguration of the Federal Aid roads scheme there has been a very marked improvement in road construction methods in all the States. Actually Federal Aid roads have put road making "on the map," so to speak, for it has directed the attention of all local governing authorities, including even shire councils, to the wisdom of

purchasing up-to-date road-making plant, and the adoption of scientific methods for construction and maintenance.

10. *To Mr. Gregory.*—The proposed road now before the Committee is roughly 5¼ miles in length. Earthworks, culverts and forming will cost about £20,000 and the gravel and bitumen spraying about £30,000. The gravel is going to cost us about 12s. a cubic yard, delivered on the job. Because of the extra haulage for the metal from the Mugga quarries, a concrete road would cost about 27s. 6d. a square yard. I have seen some concrete road that cost £20,000 a mile, and I know of none that has cost less than £12,000 a mile. We propose to get the gravel for the bitumen surfacing at the foot of Black Mountain where there is an almost unlimited supply upon which we have been drawing for the last 15 years. In the construction of this road we use the run of the pit for 4 or 5 inches and then screen and grade for the top two inches. The run of the pit contains a fair amount of sand and as the sub-grade is rather clayey, the pit material is highly satisfactory. Generally speaking I do not approve of the use of heavy boulders for a base, because a road constructed in that way has a tendency to set unevenly. We have an ample supply of metal at Mugga. There is a big outcrop there that will meet all our needs for many years. The cost of metal at the crusher varies from about 13s. to 15s. per square yard. Modern methods, including the use of explosives are employed to get it out. In Melbourne the price varies from 7s. 6d. to 8s. 6d. per square yard, but the rock there is softer. I agree that the price in Canberra is high, and I know that every endeavour has been made to reduce it, but certain factors, including labour costs, govern the price. The carters will deliver the material on the road and it will be immediately spread with the grader or by other means.

(*Taken at Canberra*).

TUESDAY, 10TH DECEMBER, 1929.

Present:

Mr. LACEY, Chairman;

Senator Reid	Mr. Gregory
Senator Sampson	*Mr. Holloway*
Mr. M. Cameron	Mr. Long.

Thomas Hill, Director-General of Works, Department of Works, Canberra, recalled and further examined.

11. *To the Chairman.*—In case there may have been any misunderstanding concerning the actual cost of a concrete road, I should like to make it quite clear that when speaking of a concrete road costing £12,500 a mile, I was referring only to the cost of the paving; the completed cost of such a road would be £18,000 to £19,000 a mile, as against approximately £8,000 a mile for a road with a bitumen surface. The earthworks, culverts, excavations, &c., would be similar, but after the gravel or other material constituting the bed has been laid, a period of two years or more should elapse to allow it to thoroughly consolidate before any attempt should be made to put the concrete bed on the top. The general practice in the United States of America is to allow three years to elapse before applying the concrete. For a concrete road there must be an absolutely perfect bed. I have just received the eighth annual report of the Commissioner of Main Roads for Queensland for the year ended 30th June, 1929, which contains some interesting information concerning plants. A paragraph on page 9 reads:—

> The book value of the plant and machinery owned by the Commission, which has all been purchased from revenue, is £169,376. Against this item a reserve of £109,505 is shown, which has been created from plant earnings after providing for maintenance. The major items of plant are:—
>
> | | |
> |---|---|
> | Halfyard mechanical navvy .. .. .. | 1 |
> | Engines and crushers (large) .. .. .. | 26 |
> | Engines and crushers (small) .. .. .. | 6 |
> | Rollers, steam, 10 to 12 tons .. .. .. | 17 |
> | Rollers, oil, 10 to 11 tons .. .. .. | 15 |
> | Rollers, oil, 5 to 6 tons .. .. .. | 8 |
> | Rollers, horse-drawn .. .. .. | 34 |
> | Compressors .. .. | 15 |
> | Tractors .. .. | 15 |
> | Power graders .. .. | 10 |
> | Bitumen kettles and sprayers .. .. | 15 |
> | Tramway track, waggons, drays, scoops, graders, &c. .. .. | 15 |
>
> The plant is hired out to contractors and local authorities for use on main road work. If any work is done by day labour the job is debited, and the plant account credited with the same hire rates as are charged to a contractor, so that day labour costs can be faithfully compared with contract costs. The plant account is credited with all moneys received for plant hire, and the cost of operating the different classes of plant is watched. An analysis of the plant account is made from time to time, and hire rates are adjusted as advisable.

Similar practice is followed in the other States. In the same report, opposite page 12, are three photographic plates showing a gravel road treated with bitumen and the method by which it is applied.

12. *To Mr. Gregory.*—For arterial roads I recommend an 18-feet roadway with 4-feet shoulders on each side. The earthworks on such a road would vary to the extent of a few feet, such as in going through a cutting, where the width would be reduced; but we would not interfere with the actual width of the paved area. If adopting a 30-feet formation in easy country we would probably reduce the width to 26 feet or 28 feet when encountering banks. The cost would vary owing to the number of culverts and bridges to be constructed. The costs of concrete, hot mixed or sprayed bitumen, or ordinary gravel roads, would vary from 20s. a square yard for concrete down to 2s. a square yard for bitumen spray. Penetration macadam would be about 5s. or 5s. 6d. a square yard, and hot mixed bitumen 7s. 6d. to 8s. a square yard. According to some costs which I obtained yesterday concrete is being laid at as low as 18s., but that would be where the conditions were favorable and the work was proceeding rapidly. I believe that in New South Wales concrete roads construction costs have been reduced to 16s. a square yard, but that would be where 1,800 square yards were being laid in a day. The maintenance cost per mile per annum of a hot mixed bitumen road might be the same as that of a sprayed bitumen road; it will depend upon the traffic. I have seen excellent bitumen sprayed roads carrying up to 2,000 vehicles a day, on which the maintenance costs were as high as £300 per mile per annum; but that was due to the fact that insufficient capital was available at the time to lay down a hot mixed bitumen road, on which maintenance costs would be lower. When the maintenance cost of any road exceeds 5 per cent. of its capital cost it is time to improve its quality. The road under consideration could be termed a 200-vehicle-a-day road, and if constructed under the bitumen spray system the capital cost would be lower, and the maintenance cost would be about 2 per cent. of the capital expenditure involved. It is not easy to give the actual life of concrete, hot mixed or sprayed gravel roads, as many factors are involved. I have known concrete roads to have shown no signs of wear after ten years' use; but this is due to the fact that such thoroughfares used almost exclusively for motor traffic eventually become covered with a thin film of oil, which acts as a protector and enables the road to remain in practically

the same condition as when laid. The life of a well-laid concrete road could be put down at twenty years, and even when it began to show signs of wear it could be sheeted with asphalt, the concrete making an excellent base. It is not essential to have a break in the centre for expansion purposes. The practice in the State of Carolina, where the roads are equal to almost any of those in any part of America, is to have a continuous sheet 18 feet wide without any expansion joints. The only joints are those where work is discontinued at night and commenced next morning. Such joints are heavily dowelled in order to ensure an even surface, and work is then proceeded with at the rate of about 1,800 feet a day. They are not reinforced concrete roads. In the State of Illinois as much as 38 miles of 18-feet wide concrete roads have been constructed in different parts of the State in one day. The practice in that State is to provide an expansion joint in the centre, and, if necessary, to allow the concrete to crack to a slight degree. I have walked over many miles of such roads, and have seen stretches of 100 yards without a crack. The central expansion joint provides a permanent division of traffic, and permits staggering or diagonal cracks across the road into which bitumen can be poured, when maintenance work is necessary. Where there are expansion joints every 60 feet a slight ridge is likely to occur at every joint, which is inconvenient to road passengers travelling long distances. As the result of personal experience, I would suggest the construction of a concrete road on the Illinois pattern without reinforcement, and with an expansion joint down the centre. Where the central joint is employed, the traffic is automatically regulated, and in America an additional speed of ten miles an hour is permitted. The "curling" of concrete is due to an incorrect mixture, but those difficulties are now being overcome as the result of more scientific study. The present practice is to weigh all the ingredients, including the water, and curling is due to the use of either too much or insufficient water in the mixture. In most instances concrete can be mixed on the job, and in others it may, without disadvantage, be mixed at some distance from the work. For concrete road work the usual practice is to have a central mixing station every 5 or 7 miles, from which point the concrete is distributed ready mixed. The latest practice in connexion with some work is to mix everything, except the water, which, including the water, is then transported to the point where it is required, where it is then mixed and placed in position. The old method of allowing the men to mix the concrete on the job has largely disappeared. In connexion with a hot mixed bitumen road it is better to have a depot every 7 miles. The bitumen mixture retains its heat, and under this system it can be applied hot, and then rolled. I am not in favour of reinforcement in concrete roads except in very special circumstances. The general practice with this form of construction is to put the reinforcement in the bottom, where it can take up the expansion, and this practice was followed for some time merely because it was the custom, but scientifically the method is one which is hard to justify. In order to obtain a perfect spray and secure the necessary adhesion of the rock, careful attention must be given to the contents and temperature of the bitumen mixture, and to the other material being used. Care must be taken to see that the "fines" are not coated with dust, which prevents the proper adhesion of the bitumen. Clean, fine sand is not a disadvantage, but there must be only a small percentage, if any, of clay. Great attention must be given to these details in order to ensure against an absence of corrugation or ripples. A second spray would be only a thin layer on top of the first application, and after a road has been under traffic for a while the weak spots will become apparent. The cost of a second spray is included in the estimate I have submitted. Arterial bitumen roads carrying a traffic of 200 vehicles a day should be 18 feet wide, but there are instances where it is necessary to spray such roads for only 9 feet, such as we have done near Port Augusta, as that width is sufficient to carry the traffic for some time to come. Our costs of road making are about double those in America. Our machinery is equal to that used in that country, but it costs about double the price. Moreover, in America they have an ample supply of labour at from 2 dollars to 3 dollars a day, and the working day consists of ten hours. There is no holiday pay or other concessions, the men being paid only for the actual time worked. In some parts of America road work is also undertaken on Sundays. Indian and Mexican labour is available at very low rates, and in one State I saw 1,200 prisoners engaged in road work at 2 dollars a day. A charge of half a dollar is made for maintaining the men, the balance being held until they were free men. Higher rates are, of course, paid in cities, and also in the Yosemite Valley, where they are paid up to 5 dollars a day. Slavs and Finns can easily be obtained in large numbers for this class of work all through the States. If reinforcing were used, black rods would be necessary, as galvanized rods prevent the adhesion of the concrete. The cost of cement in Australia is about 16s. 6d. a cask, or £4 19s. a ton, delivered at the factory, but authorized bodies, such as road boards, receive supplies at a special rate of 13s. a cask, or £3 18s. a ton, in truck loads at the factory. The cost of haulage between Queanbeyan and Canberra is about 25 per cent. of the cost from Sydney to Queanbeyan. As previously stated, our metal, which costs about 13s. at the bins, is very hard, and particularly rough on the grinding plates of the crushers. It is a dacite which is difficult to spall at the quarry. Generally, the cost of metal is higher here than in the cities, as in Melbourne, for instance, the cost is 7s. 6d. at the bins, as against 13s. to 15s. in Canberra. Metal from the south coast of New South Wales costs about 18s. to 21s. a yard delivered at Liverpool, but that is due to the remoteness of the locality from which it is taken. Bluestone or granite, such as is used in Melbourne, is not so heavy on the crushers. If other suitable quarries are not located the present system must be regarded as satisfactory. At present it is a fair distance from the quarry to the crusher, to which the stone is transported in trucks; but there is a possibility of moving the crushers nearer to the quarry in order to save haulage. One of our crushers has not been a success. If the crushers were removed we would endeavour to have a gravitation system between the quarry and the bins. River gravel is excellent, and has been used largely both for concrete and road-making work; it all depends on the location. We considered very carefully the question of the gravel to be used for the road in question, and believe it would be too far to haul it from a site other than that I have mentioned.

13. *To the Chairman.*—Hindley and Rundle streets in Adelaide were constructed in 1906 or 1907 of Trinidad asphalt, and if a thoroughfare of a similar construction were laid down to-day the cost would be 50 per cent. higher, or say 30s. a square yard. With a concrete base and an asphalt surface we could get the same results at a lower cost. If the asphalt surface of such a road gave any trouble it could be stripped off, remelted with an additional "mix," and reapplied. Roads of that construction are used only for main streets in cities. Our plant is all in good order. The main consideration in connexion with a road construction plant is to write off its full value long before its period of usefulness has expired, and if this is done it is practicable to take advantage of improved machinery coming on the market.

14. *To Senator Reid.*—When the concrete is made on the job the dry mix, the water and the concrete mixer are carried to the place where required, when the mixed concrete is placed in the machine from which it drops onto the road bed. The water is most carefully weighed and the whole process is watched to see that the contents are not varied. Tests are made over every 100 feet of road by laying down patches alongside the road or by filling six inch cylinders which are sunk into the gravel with the mixture, which are afterwards taken up and submitted to laboratory tests. It has been found that concrete mixed at a central depot and carried through the streets has been delayed, due to traffic interruptions, in reaching the job, or it has arrived when the men were knocking off. Under the spraying system the bitumen mixture is applied with either a can to which a spray is attached or under power pressure from an 800 gallon tank. It is internally heated and applied over the full 18 feet in order to ensure an even surface. Under the spraying system ¼ to ¾ gallon of the mixture is used to the square yard, but under the penetration method the interstices in the metal are filled by the application of 1½ gallons of the mixture to the square yard to a depth of 1½ to 2 inches. Under the penetration system the first coat of a gallon or a gallon and a quarter per square yard is used, a top dressing of screenings applied and the whole surface rolled. Another spray of probably a quarter of a gallon to the square yard is applied, some further screening applied and the surface rolled. A total of 1½ gallons is required for two coats.

15. *To Mr. M. Cameron.*—Even if cement were more extensively used in road construction I do not think it could be supplied cheaper than it is at present. In conversation with the manufacturers I was informed that 13s. a cask was practically cost price. Even if the output were trebled the manufacturing costs in the way of additional plant would be increased. The plant capacity of the Australian cement manufacturers is roughly about a million tons and the quantity used apart from road work is about 750,000 tons. The manufacturers are therefore selling about 250,000 tons at 13s. a cask. In San Francisco and Los Angeles the contract price for cement is about 6s. or 7s. 6d. a cask although it has been sold in the former city at 5s. a cask. The price in America is about one half of the Australian price. This is due to the lower cost of plant, installation, and lower labour costs.

(Taken at Melbourne.)

MONDAY, 13TH JANUARY, 1930.

Present:

MR. LACEY, Chairman;

Senator Sampson	Mr. Gregory
Mr. M. Cameron	Mr. Holloway
Mr. Curtin	Mr. Long.

Frederick John Skinner, Federal President, National Roads Association of Australia, sworn and examined.

16. *To the Chairman.*—I am aware that this committee is inquiring into a proposal to construct a federal highway from the boundary of the Federal Capital Territory into the city. I am not acquainted with Canberra, but I understand that the New South Wales Government is constructing a road to the boundary of the Federal Territory and that the Commonwealth is continuing it from that point into Canberra. It would be in the interests of economy to make this a first-class arterial road. I am acquainted to a certain extent with the roads that have been constructed throughout Victoria and the other States, but only as far as national roads are concerned. We have never advocated any special methods of construction, but like many other authorities, we think that perhaps the most expensive road is the cheapest in the long run. I have had ten years' experience as a member of a municipal council and have had a great deal to do with the roads constructed at South Melbourne. We always found that the most expensive road was the cheapest in the long run, and that if the money were available it was preferable to build better class roads. There are various methods of construction; the best type being a concrete foundation with wood blocks covered by a bitumen surface. Of course that type of road runs into money and would cost from £25,000 to £30,000 a mile to construct. That is the best class of road for heavy traffic. For motor traffic only, I do not think that there would be any necessity for that class of road. That expenditure, of course, would be out of the question at Canberra. In any case there would be no need for wood blocking. I understand that the proposed length of road in the Federal Territory is 5 miles 3,439 feet, and I consider that the expenditure of approximately £10,000 a mile on its construction would be money well spent. I have had no experience of concrete roads in other parts of the world, but I have been told by people who have visited America that the concrete foundation has become an established fact. A concrete foundation with wood blocks on top would be a more expensive type of road than a concrete road. I have had experience of roads in Victoria being treated with bitumen penetration, but only ordinary main highways, and the experience has proved that it is a suitable type of construction for motor car traffic. I should not like to advocate any special form of construction; that is a matter for road engineers to decide, but I should say that a bituminous road would be suitable for Canberra. I have heard no criticism of the bituminous roads constructed in hot climates. I suggest that the proposed road should have a concrete foundation with a bituminous surface. That would be the cheapest road in the long run. Of course the maintenance is the biggest factor in road construction. My association has no figures showing the maintenance costs of bituminous roads. We are not really concerned with the form of construction; all we advocate is the construction of roads.

17. *To Mr. Holloway.*—I should say that if the better class of road were constructed at Canberra the cost of maintenance would be practically nil for at least five years, but it costs money in the first place. The only road for heavy traffic is one with a concrete foundation, wood blocked and bituminous surface. I shall ascertain whether we have any statistics showing comparisons of costs of maintenance on new roads as against comparatively old roads.

18. *To Mr. M. Cameron.*—The function of our association is to create a roads atmosphere and to help municipalities in their efforts to obtain additional national highways. It is really a matter for the Government to decide whether roads running parallel with the railways should be so constructed as to allow of direct competition with the railways. I certainly think that good roads are the greatest asset to the Commonwealth, especially those between the capital cities, but I do not think it is a wise policy to encourage competition with the railways unless, of course, it is intended to scrap the railways. We should construct roads more to connect with railways than to compete with them. The policy of our association is generally to construct throughout Australia the best class of roads possible.

19. *To Mr. Gregory.*—There are throughout Australia three types of roads, arterial, main and developmental. I suggest that the national highways should be of a width sufficient to allow two cars to pass each other or of the width of three cars placed side by side. An arterial road would need to be about 18 feet wide and an ordinary main road perhaps a little less. Developmental and feeder roads would not need to be so wide as arterial and main roads. An arterial road should have a concrete foundation, but it would be too expensive to have wood blocks on top of that. An arterial road should have a concrete foundation with a solid bitumen surface. Macadam roads with bitumen penetration stand very well for motor car traffic. Some parts of the road to Seymour have been sprayed with bitumen and up to date the road has stood fairly well. Spraying with tar would apply more to suburban roads, and would not be of any use for heavy traffic, particularly where there is a likelihood of the hot weather affecting the surface. Tar does not seem to penetrate like the bitumen does, and I would not recommend tar paving. I have no idea of the cost of construction of roads, except that a concrete road with a solid bitumen surface would cost from £10,000 to £12,000 a mile. I believe that some roads, constructed at a cost of £8,000 a mile, have stood fairly well. Of course, a road costing £10,000 a mile would stand better. It all depends on the amount of money available for road construction, because the greater the first expenditure the less the maintenance. Our association is brought into touch with the Victorian Country Roads Board. That board has done wonderful work and has more than justified its existence. It is a splendid idea to place the construction of roads in the hands of one authority. That board carries out road construction both by day labour and by contract.

20. *To Mr. M. Cameron.*—There are a number of concrete roads in South Melbourne and the city council there is quite satisfied that the construction of those roads has been a good investment for the ratepayers. All classes of traffic travel over those roads.

21. *To Mr. Curtin.*—There is a lot of heavy traffic over those roads, such as timber waggons and motor lorries.

22. *To Mr. M. Cameron.*—The road that I am referring to particularly is Sturt-street, from Princes Bridge to Hanna-street. That road cost roughly £30,000 for about a mile and was constructed five years ago. Up to date the maintenance has been practically nil.

23. *To Mr. Curtin.*—A surface of bare concrete would at times be slippery and dangerous for motor cars. After a certain amount of wear and tear the surface would become like glass and exceedingly dangerous.

24. *To the Chairman.*—A bituminous surface would, to a great extent, prevent the road from becoming slippery, and in addition, a bituminous surface would be more elastic than a bare concrete surface.

The witness withdrew.

Percy Roach Pierson, Secretary, National Roads Association of Australia, sworn and examined.

25. *To the Chairman.*—During the latter part of the war I was attached to the military roads and railways section of the Royal Engineers. I am aware that this committee is inquiring into a proposal to construct a federal highway from the boundary of the Federal Capital Territory into the city. Just after the war I was in the United States of America attached to the British Military Mission, and, being an engineer, I went closely into the matter of the construction of roads. Subsequently, I was associated with a company that imported bituminous products into Australia. For a cheap road I would recommend a bituminous road entirely, but if the money were available I would prefer a concrete road with a bituminous surface, because it would pay in the long run. A bituminous road has a certain amount of resiliency and that naturally saves wear and tear. A bituminous surface can be renewed at any time. A road in the Federal Capital Territory should have a permanent foundation, and I suggest that, if the money is available, it should have a concrete foundation with a bitumen surface. That is the best road that could be constructed for the purpose. It is difficult for me to make any statement respecting the maintenance costs of roads constructed of concrete with a bituminous surface, but I shall let the committee have the approximate costs per mile of the various types of roads.

26. *To Mr. M. Cameron.*—I suggest that the concrete foundation should be from 3 to 4 inches thick, consisting of 2½ inches of broken metal with 1½ inches of solid concrete on top. I should hardly like to express an opinion respecting the depth of the bitumen. A bitumen surface, provided that it has a solid base, gives practically a permanent road. When the road begins to wear, the bitumen surface can be easily renewed. It is a much more difficult job to repair a concrete surface. There is a certain amount of resiliency in the bitumen which is not apparent in a concrete surface. A concrete road with a bitumen surface should carry a load of 10 tons. I suggest that in certain places in the country concrete roads, tar sprayed, would be quite all right for minor traffic, but a main arterial road such as that which is proposed from Canberra to Sydney would be used a great deal, and I strongly advocate that it be constructed of concrete with a bitumen surface.

27. *To Mr. Curtin.*—It might be sound policy for the Commonwealth Government to have less concrete in the bed of the road, and to place a limit on the traffic travelling over it, but it would not be fair to the general public as a whole. An ordinary road should stand loads of from 2 to 3 tons provided that the speed is limited for heavily loaded vehicles. I do not think that it is the actual weight on the road that causes damage. Little damage will result from heavy traffic provided that the lorries are limited to certain speeds. It is the weight plus the friction that damages the road.

28. *To Mr. Gregory.*—I was in America as an officer attached to the British Military Mission. As an engineer I have always been interested in road construction. One of the best roads in the world is from Washington through Baltimore and Philadelphia to New York. The greater portion of that road is of concrete with a bituminous surface. It is the finest road that I have ever driven on. It is really a speed track. I am not a civil engineer. I was originally a naval officer, and after the war I was connected with engineering. I have had no practical experience of road-making except while in the army. When I was with the Vacuum Oil Company I had a good deal to do with roads. I saw the construction of roads with bituminous preparations, and I have come to the conclusion that that is the best type of road to construct. I do not think that a well-rolled road covered with bitumen would be as suitable as a concrete foundation covered with bitumen. The former might last for two or three years, but it would not hold so well together. What is wanted is a lasting road. I have no knowledge of the cost of concrete roads, but when one is making roads for the Government there is no need to worry about the cost so long as one gets the material. I could go into that matter and supply the committee with figures.

29. *To Mr. Long.*—I do not consider that a bare concrete surface is any more dangerous than a bituminous surface. Both are liable to become slippery under certain conditions. I suggest that the foundation of

the proposed road should consist of some 3 to 4 inches of metal with 1½ inches of concrete on top, and then finished off with a bituminous surface. I do not consider that the climatic conditions of Australia or of any other country are detrimental to concrete roads. Of course, certain allowance should be made for expansion and contraction. Most of the troubles common to concrete roads have been caused through lack of efficiency at the building stage. If the civil engineers knew their job those troubles would not occur. I suggest that on concrete roads covered with a bituminous surface, loads should be limited and the vehicles limited to certain speeds.

30. *To Mr. Gregory.*—I should prefer the limitation to be on the speed rather than on the weight of a lorry.

(Taken at Melbourne.)

TUESDAY, 14TH JANUARY, 1930.

Present:

Mr. LACEY, Chairman;

Senator Sampson	Mr. Gregory
Mr. M. Cameron	Mr. Holloway
Mr. Curtin	Mr. Long.

William Thomas Bartholomew McCormack, Member of the Institution of Civil Engineers, London, and Chairman of the Country Roads Board of Victoria, sworn and examined.

31. *To the Chairman.*—I am aware that the committee is inquiring into a proposal to construct a federal highway from the boundary of the Federal Capital Territory into the city. I am acquainted with Canberra. I have had three trips there and have driven over the Territory. I know the class of country through which this road is to be constructed. The number of motor lorries likely to cart produce on a road plays a much more important part in the design of the road than the actual number of motor cars. I understand that the estimate of the number of motor cars travelling over this proposed road is 200 a day. I suggest that this road should be built in stages, what we call stage construction. It should be built with a gravel base, sprayed with coal tar for the primer coat and then given a bituminous coat. Gravel roads treated in this way are carrying up to 600 vehicles a day. If the traffic becomes too heavy another stage of construction takes place, and the road should be given a penetration coat consisting of three inches of metal penetrated with bitumen. When the traffic becomes again too heavy for that class of road, we cover it with either sand asphalt or bituminous concrete to a thickness of say two inches consolidated. First of all the foundation would be of gravel to a thickness of six or eight inches consolidated. It is very essential that the soil should be examined. We have saved enormous sums of money by a careful examination of the soil. In places where it is of an unsuitable character, like clay, we have introduced some poor class local material to stabilize and to get rid of the plastic condition of the soil. We think of drainage first and last. Where necessary we put in agricultural drain-pipes to get rid of the moisture. Then we spread the gravel, which is dragged instead of being rolled, because in rolling the front roller forms waves in the gravel and it comes to the point when consolidation takes place and the process is repeated. We use ordinary drags to sort the gravel and we allow the traffic to run over it. Every stone is thus placed in position. The greatest care must be exercised in this work. The gravel is then sprayed either with tar, of which we are using 800 tons this year, and for which we pay £2 17s. 6d. per ton, or with bitumen. The tar that we use is low class and cheap and we are hoping to use more of it next year. The spraying of bitumen is costing us 3½d. per square yard. Of course, it may be necessary the following year to again spray the road with bitumen. The road has to be watched and fed, to prevent it from breaking up, until we get to the stage that we have reached in connexion with the Geelong road. That road has not been sprayed for years. Fourteen years ago it cost us only £2,000 a mile to construct 32 miles of that road, and it has not been sprayed for three years.

32. *To Mr. Curtin.*—Roads can be sprayed too much, because in that case the action of the sun causes the surface to pick up, necessitating a covering of coarse gravel in order to stabilize it.

33. *To the Chairman.*—The road between Seymour and Tallarook, on the Hume Highway, has a gravel base which cost 1s. 5d. per square yard.

34. *To Mr. M. Cameron.*—The gravel base is natural pit gravel.

35. *To the Chairman.*—The sealed bituminous macadam is of 2½-inch consolidated thickness on a 6-inch consolidated gravel base. The bituminous macadam is costing 3s. 7d. per square yard, the total cost being 5s. per square yard. That comes out at about £2,000 a mile. It is a very cheap method of road construction, and we expect that road to carry up to 1,000 vehicles a day. The number of vehicles travelling on the Geelong road is 1,000 a day, to Bacchus Marsh and towards Ballarat 800, to Castlemaine and Bendigo 800 for the first few miles, rapidly dropping off to only 300. On the Seymour road the number of vehicles is 570 between here and Kilmore, 270 between Kilmore and Broadford, and 307 between Broadford and Seymour. Immediately Seymour is passed the number drops to 150. It would, therefore, be waste of money to have a road of extraordinarily heavy construction beyond Seymour, so beyond that town we are constructing a road such as I have described. The gravel is dragged and scarified and primed with tar before being sealed with bitumen. In twelve months' time we shall re-spray, and probably in five or six years' time we shall reach the next stage of construction. Samples from gravel used on our roads are put through a sieve on the ground to ascertain its character. There is no guess work. Formerly the gravel was dumped and scattered about and the lumps caused by concentration of fine material would be in evidence on the surface of the road for years afterwards. Now the gravel is distributed according to its own weight and is then harrowed. The stones are sorted in a similar manner to the sands on the sea-beach. Many years ago I lectured at the University, and one point that I always stressed during my lectures was that the sea-beach was the best surface in the world, because it enabled a speed of 200 miles an hour to be attained. The reason is that the waves sort into position every particle of sand according to its weight. The men trained for our work are taught to study every aspect. I have some interesting figures of testing right down to failure point. May I place before the committee the view of the greatest road construction authority in the world, Sir Henry Maybury? In a brilliant review of the work in Great Britain in 1927-28 he showed that £61,000,000 was expended on 178,914 miles of highways. He also made impressive observations on the economical construction of roads. Amongst other things he said that there is no "best road surface material" for all purposes. Each case should be dealt with on its merits in regard to subsoil, climate and rainfall and to the volume and weight of traffic. He had seen materials costing up to 20s. a super. yard laid upon a highway where a fifth of such expenditure would have sufficed, and had the work been executed at the lower figures the life of the material laid might have been from eight to ten

years without, in the interim, being any charge upon maintenance account. Having dealt for many years with 3,000 local authorities charged and entrusted with the maintenance of highways, he had invariably impressed upon the responsible officers the importance of thinking in terms of pence per super. yard, pointing out to them that every penny so expended would represent, on an 18-foot road, approximately £60 a mile. If this feature were kept well in view by the highway engineer, then relative values would soon make themselves apparent, and he would be surprised if many serious mistakes were made. From our point of view it is almost criminal to expend on a road any more than is absolutely necessary. In Victoria we have a long way to go and anything that we do is a foundation for something better. The road between Seymour and Avenel has a foundation of gravel 6 inches consolidated, which is obtained from the Mangalore pit, situated about three miles from the centre of operations. The gravel cost 1s. 6d. per square yard and the seal coat, consisting of ¼ of a gallon of coal tar plus 3 gallons of bitumen seal, cost approximately 8d. per square yard. That is 2s. 2d. altogether. The road which has just been completed is at present carrying 180 vehicles a day, and will take up to 1,000 vehicles. Beyond that number, the foundation of 6 inches of gravel would take another seal coat at a cost of about 5½d. in order to keep the road in decent order. It is difficult to realize the low cost of that construction. On the Geelong-Queenscliff road, between Wallington and Queenscliff, there was a section of old road consisting of ordinary ironstone metal. The council could not afford to pay its share towards constructing a penetration road which we considered would be necessary to enable 2,000 vehicles on Sundays and holidays to be carried over it. As an alternative the old road was scarified, re-shaped and surfaced with sand, the consolidated thickness of sand being approximately one inch. The whole road was consolidated. This was then sealed with a mixture of fuel oil and bitumen, a quarter gallon of oil per square yard plus 3 gallons of bitumen. The total cost for the whole of this work was only 1s. 3d. a square yard. I think the cost was £700 a mile. Of course, the old road provided a good foundation for the new road, and for an entirely new work much more money would have to be expended. The cost of the road between Seymour and Avenel was 2s. 2d. a square yard. That is for paving only. It is not formation. The cost of every job differs according to local conditions. The material is being carted for about 9d. a ton per mile. I shall supply the committee with the cost per mile of that road. The maximum grade would be approximately 1 in 20, but the conditions vary especially with motor transport. We deal with every case according to the circumstances. In cutting through a hill we have a grade of 1 in 15 if the circumstances justified it. Of course the easier the grade the less is the cost of maintenance. Water rushing down a steep grade has an erosive action and the greater the force of water the greater is the erosive effect. On the road to Ballarat we are putting in a grade of 1 in 12 in order to save a detour of over a mile.

36. *To Mr. Curtin.*—Of course grades are reduced on curves, and we like to obtain 500 feet radius at least on important roads, and in other cases, 300 feet down to 75 feet. On a road in the Federal Capital Territory it would be necessary to have the best curve possible.

37. *To the Chairman.*—Our board has constructed roads with concrete foundations. One section of the Geelong road near the Guiding Star Hotel has a concrete base. That is necessary because of the volcanic clay in the ground and the enormous traffic that is likely to travel over the road. In the city the roads should have a concrete base with a bituminous carpet of sheet asphalt such as may be seen on Point Nepean-road in the city of Brighton. At Canberra, if a concrete road is constructed, I should not bother about covering it because there would be no heavy traffic upon it. The road may need a bituminous surface in three or four year's time, and by that time the old foundation would be well consolidated and three inches of penetration could be placed upon it. The road should be built by stages. The nature of the covering depends entirely on the traffic. I should say that bitumen penetration on top of gravel in the case of the Federal Highway at Canberra would last a long time. I have had experience of concrete roads. I spent 5½ months in England with the English Roads Boards. I spent a week or a fortnight with their best engineers and still keep in close touch with them. I examined the roads in England, Ireland and Scotland and came to the conclusion that roads in the cities should have a concrete foundation. That has been borne out by the experience of Mr. Calder, who had three trips to America. He came back and laid down the policy that we are following to-day. The Williamstown short road cost us £12,400 a mile, for paving only, and the Geelong road £15,100. We have since spent £1,700 in placing drains parallel to the road. We found that the water running off the road caused the foundations under the edges of the concrete to become sodden, and to obviate that we put in agricultural drains alongside the road. The interest bill on one section of the Geelong road costing £12,000, is £720 a year. For the last twelve years the average cost of tar spraying the surface of 32 miles of that road has been £156 a mile. The original cost of the road was £2,000 a mile. That is a very low figure. It is difficult to say what cannot be done with cheap construction. We sprayed a road in Gippsland at a cost of 10d. a square yard. The work has been done for eighteen months or two years and we have not spent anything on the road since. It is an ordinary sandy road sprayed with oil and bitumen. Because of that result we are putting down sixteen miles of similar road near Avenel, where the soil consists of granitic sand. Naturally, we have had some failures in road construction. When we first commenced this work the men were new to it. We thought that we would never construct the road to Bendigo, so instead of taking off the whole of the old metal it was scarified and a 2½-inch thickness of bitumen penetration placed on top. In small sections water got in between the bitumen and the pitchers and the surface became mushy. The men were unused to this class of work at the time, but they now take great interest in the work and are getting wonderful results. I know of the concrete penetration process. I have examined Mr. Sunderland's work at Sandringham, the cost of which was 7s. 1d. per square yard. The road was covered with metal to a thickness of six inches and rolled, not very much but sufficient to put every stone in position. Mr. Sunderland used a mixture of one part of cement to twelve parts of sand. He placed a mixing machine on a Ford truck and as the truck moved along the road the cement was poured on to the metal. The road was then rolled, bringing up the cement and causing a mechanical interlocking of the metal. At first the surface of the road was a little rough because of waving caused by the roller, but Mr. Sutherland has overcome that by spreading screenings on top and smoothing the surface. I am not quite sure what would result if the process of concrete penetration were introduced on a clay foundation. Roads similar to the one at Sandringham have been constructed elsewhere in Australia, and Mr. Fleming could probably give the committee particulars of the road constructed at Port Adelaide. We constructed a penetration road between Seymour and Tallarook at a cost of 3s. 7d. per square yard, and in that case the metal was carted twelve miles. I would not risk heavy traffic on a concrete road unless it were protected by a covering of bitumen. Let me give an illustration

A steel ball dropped on to a sheet of glass, would immediately smash it to pieces, but if a piece of rubber were placed on the glass the ball would bounce off without injuring it. On the Oakleigh road we put down 4 inches of concrete and 1½ inches of bituminous or sheet asphalt covering. That road *has stood for the last nine years and the concrete* is still good. We have made tests with bare concrete roads but they have all gone to pieces, showing that it is necessary to cover them. If I were constructing a concrete road along the St. Kilda road, I would leave it entirely bare, because the traffic consists largely of motor cars. The *Botany road, Sydney, is being covered* as quickly as possible. The Williamstown short road is a concrete road and it cost 18s. 5d. per square yard. Its width is 20 feet, and thickness 10—8½—10, reinforced. The Geelong road to Corio, pavement only, cost 18s. 10d. per square yard, the width being 20 feet, thickness 9—7—9, reinforced. The Guiding Star deviation is of 2-inch asphaltic concrete placed on top of a concrete base. The width of the asphaltic concrete is 20 feet, and the total width of base, including kerbs, 21 ft. 4 in. The thickness of base, excluding kerbs, is 9—7—9, unreinforced. The total cost per square yard was £1 3s. 2d., being base 12s. 10d., and asphaltic concrete, 10s. 4d. per square yard. Concrete roads can be recovered with bitumen without holding up the traffic at all. On the northern highway between Elmore and Rochester, crushed gravel, rail borne, spread on new formation to a consolidated depth of 6 inches, cost 3s. 1d. per square yard. If the committee desired the figures to be given per cubic yard, I shall forward them later. The seal coat would cost, approximately, 9½d. per square yard, as materials are costly in that area. The total cost is 3s. 10½. That road between *Elmore and Echuca has an exceedingly bad foundation.* I think the cost at the quarry of the gravel is about 7s. or 8s. per cubic yard. We generally get it carted at 10d. a ton a mile delivered on the road. I do not know of any cases of concrete roads being constructed at the same cost as bitumen roads. The portion of the Geelong road from the Guiding Star Hotel to Point Cook cost £12,000 a mile. It has two concrete kerbs 9 inches thick by 2 feet wide adjacent to the old pitcher foundation. On top of that foundation is 8 inches of metal consolidated to 5 inches. On top of that is an asphalt carpet of 2 inches. The work was done approximately at the cost of a concrete road. The reason that we did not put concrete for the whole width was that there was a certain amount of salvage from the old base which we thought it would be a pity to throw out. We have what is known as a roughometer which carries out surface tests and registers bumps per mile. Taking 100 as an excellent road, the following are some of the results: Flemington-road, west side, 148; east side, 191; St. Kilda-road, east side, 259. The latter is a block road with a solid concrete base, but the bitumen on top of the blocks has been lifted and moved until it is a series of little pot holes. The road from Kilmore to Broadford registered 150, and the road from Tallarook to Seymour, 158, 138 and 124. The road from Tynong to Bunyip registered 125 to 380, the road near Sale, consisting of sprayed gravel, 150 to 300. The Geelong road on the section between Corio *and Point Cook registered 95 and the section from* Point Cook to Werribee, consisting of sheet asphalt, 110 The concrete road opposite Ford's, Geelong, registered 140, the penetration macadam beyond Geelong to Colac 150, and beyond that 130 to 170.

38. *To Mr. Gregory.*—We are allowing £80 a mile for *the cost of maintaining penetration roads. We have* a flying gang of seven men, and they operate with a truck for 50 miles. That is between here and Broadford. Certain sections of that road have been only sprayed, but later we will put down penetration. I will let the committee have figures showing maintenance costs per mile.

39. *To the Chairman.*—We are using reinforcement in certain sections where we have had to fill in over bad places, the section of the road near the Guiding Star Hotel is reinforced at the edges with three bars. The road is 9 inches thick at the edges to a width of 2 feet, and then 7 inches thick to the centre. Reinforcing is absolutely necessary in the case of heavy traffic because it keeps to the outer edges. Kerbing is necessary to prevent the edges being torn away. Three years ago we thought that we should have to put in kerbs from here to Bendigo and Ballarat. The cost would be about £1,200 a mile, and the interest £60. Seeing that the total *cost of maintaining pavement is between £60 and £80,* we decided to leave the kerbing out and to keep close control of the maintenance of the edges. A motor car occupies a width of about 6 feet and two cars passing 12 feet. If they kept 3 feet apart, that would leave about 2 ft. 6 in. of the road that would never be touched except in certain places, therefore, our edge maintenance is low. There is another point. We put in kerbs on the Geelong road, but the moment that we did that the vehicles ran right to the edges and frequently the wheels went over, so that unless there is an excellent foundation alongside the road, trouble soon occurs at the edges. It is questionable whether any kerbs are needed on country roads. It is better to have an extra width of surface. I do not think that the difference between the cost of mass concrete and reinforced concrete construction is very much. It is not more than 1s. per square yard. It depends upon the nature of the job. If I had to construct the proposed road in the Federal Capital Territory, I would treat the clay foundation with some poor class material and bring it to the standard of the other portion of the road. That could only be done by examining the soil upon which *the road is to be made. I would then put down* in two layers, say, 9 inches of gravel consolidated, keeping in mind the height and curvature so that at some future time a penetration surface could be superimposed. Then spray the gravel with a coat of primer, or coat of bitumen, roll in further *gravel, and then carefully maintain it,* attending to all holes and breaks. I would spray it again the next year. When the bitumen tended to become fat or satiny, I would spread dry gravel over it and roll it in.

40. *To Mr. Gregory.*—Sweeping would not be necessary because that would disturb the gravel.

41. *To the Chairman.*—The tar spraying kills the dust and prepares the way for the seal coat of bitumen. We would use tar exclusively were it not for the fact that when exposed to the weather it becomes crystallized, but when placed under a coat of bitumen it is quite efficient.

42. *To Mr. M. Cameron.*—It is special tar supplied by the gas works. We have been using for a primary coat 50 per cent. of fuel oil and 50 per cent. bitumen. The tar is only of use as a primer underneath the bitumen and is used merely to kill the dust. It is difficult to construct roads to meet all traffic requirements. We may meet the requirements of 99 per cent. of the people who travel over the roads, but not the requirements of the one per cent. whose sole idea is to smash everything up. The road from Mumbannah to the border of Victoria and South Australia, on the way to Mount Gam*bier, is of semi-penetration macadam. Limestone is* used, 3 inches loose for re-shaping the old road, and 4 inches loose for the semi-penetration top. The cost per square yard is 3s. 7d. The amount of Duratar No. 3 used was .7 of a gallon. I have not heard that motor lorries are carting building stone from Mount *Gambier to Melbourne* over that road; in any case we have not anticipated such traffic over that road, but if it did occur we should have to put a heavy coating upon it. The road from here to Ballarat is 20 feet wide; from there to Horsham 18 feet wide, and beyond that 16 feet. The road can always be widened if necessary. Other than highways the width of roads,

such as developmental roads and railway feeders, is not less than 12 feet. It ranges from 12 feet to 20 feet. A metal shod vehicle cuts the surface of a bitumen road, but it would not do so much damage on a penetration road. If the surface is properly fed, it does not pick up during hot weather, but a heavily laden truck *moving fast would be likely to disturb the* foundation of a penetration road, especially if it were not built for that class of traffic.

43. *To Senator Sampson.*—I should not advocate the covering of concrete roads at Canberra, because the traffic there consists mostly of rubber shod vehicles. We allow for expansion and contraction of concrete by putting in expansion joints.

44. *To Mr. Curtin.*—The Victorian Roads Board does a good deal of its own constructional work on the highways, *especially in connexion with bitu*minous penetration. The men have to be carefully educated in the work of pouring. We have no machine that is capable of doing this work, and the man on the job runs at a certain pace and pours the bitumen on the surface. Excellent results are thus obtained. We have an extensive and varied plant, on which £112,000 has been expended. We have about 54 rollers, but in any case we have not too much plant. No plant is allowed to lie idle. We have no large concrete mixers; we prefer to invite tenders for concrete mixing, and to invite tenders from owners of adjacent quarries and gravel deposits. Tenders are invited for supplies for five years, with the result that at Bendigo the contractors are putting in a steam shovel. We find it preferable to purchase plant sufficient for our own requirements. Some motor trucks were purchased, but, as we could not compete with the contractors, tenders are now invited for all work on the highways, with the exception of the pouring of the bitumen and the spraying of the metal. Stone is delivered in trucks on to the road by contractors and the bitumen is even delivered from the ship's side to the job by contract.

45. *To Mr. Gregory.*—I have had experience of porphyry gravel. It is the hardest in the world. There is some at Gippsland. The average price of crushed metal in Victoria is between 7s. and 8s. a ton. We obtain our gravel generally by contract. When the contractor submits his tender, he supplies with it about 10 lb. weight of gravel. That is immediately put through a sieve and the result recorded. When the gravel is delivered on the job, it is sieved and if not up to standard, is rejected. In that way we get the *very best gravel.* Under the Motor Car Act, a load of 8 tons is the limit that can be carried on a road parallel with a railway, but 10 tons is the maximum load on a road feeding a railway. We do not use the penetration process on developmental and feeder roads. They are usually ordinary macadam roads, and when the traffic becomes too heavy we declare them main roads. Another method of construction is to spray half an inch of sand on top of the macadam, on the principle that, like the sand on the seashore, it ultimately finds its position. We are successfully main*taining roads by that means.* Our best work has been done in the back country. We have been attending to the highways only during the last five years, so as to give the city some connexion with the country. We were able to do that because of £1,000,000 collected in motor fees, being placed at our disposal. Before that we spent something like £10,000,000 on main and developmental roads. The whole of the money expended on the highways is from revenue, but develop mental and main roads are being constructed out of loan money.

46. *To Mr. Long.*—In constructing roads we are guided mainly by local conditions. I know the conditions at Canberra only by general observation in travelling over the roads in company with Mr. Hill. I have noticed in the cuttings the clay sections to which reference has already been made. Where the soil *is of a clayey character we take it out and replace it* with solid ordinary loam, in fact, any cheap material that is handy to the work. I would suggest that for a gravel road with a bituminous surface the gauge of the gravel be about one inch. On top of the gravel there would need to be a layer of metal because gravel cannot be penetrated. *With a road formation con*sisting of 9-inch gravel to a maximum of one inch gauge, the binding should be sufficient so long as the gravel is properly consolidated. I estimate that 10 tons would be the maximum load over the proposed road. There is a similar class of road between Mangalore and Seymour, and it is absolutely safe for 600 vehicles a day. We are hoping to run 1,000 vehicles a day over it When we treat a road with bitumen so as to give a fine surface we bring the camber of the road down to as low as 1 in 30. If the camber is any higher the edges of the wheels cut into the sides of the crown and start trouble. That attracts all the traffic on one part of the road, whereas with a flat road every yard of it is utilized. The general trend of motor cars is to use the crown of the road. The flatter the road is, the wider is the travelling space. Of course, it is difficult to give an opinion upon the proposed road without seeing the location. I always stress the fact that the ground must be studied before roads are constructed, and there may be points seen on the ground that are not now apparent to me.

47. *To the Chairman.*—I should construct, in this case, a penetration road capable of carrying a traffic of 200 vehicles a day, but within the city I prefer concrete roads, not covered at all, because there is no steel tyre traffic worthy of the name at Canberra. I suggest the use of reinforced concrete only, because *the foundation* is already there.

48. *To Mr. M. Cameron.*—We cover macadam roads with a ¼ inch of sand only until we have time to cover them with bitumen. It is difficult to consolidate macadam unless it is sprayed. Macadam roads are out *of date for motor traffic, unless sprayed* with about ¼ gallon of coal tar per square yard, and later given a seal coat of bitumen.

WEDNESDAY, 26TH FEBRUARY, 1930.

(*Taken at Adelaide.*)

Present:

Mr. LACEY, Chairman;

Senator Dooley	Mr. Gregory
Senator Reid	Mr. *Holloway*
Mr. M. Cameron	Mr. Long.
Mr. Curtin	

Major Ronald Hinder, B.E., A.M.I.E. (Aust.), General Manager of the Australian Cement Manufacturers' *Association,* sworn and examined:—

49. *To the Chairman.*—On behalf of my association I submit to the committee a statement regarding what is in our opinion the best type of road for the Federal Capital Territory.

I realize that in the short time available, it is quite impossible to cover more than a small portion of the ground, *concerning which many words have been, and many more are* likely to be, written and spoken, so I shall confine my remarks briefly to a consideration of the economics of road construction, the principles of which should underlie the laying out of any road programme, and I shall show that, subject to certain limitations and conditions that follow, the concrete road is the most economical of all types.

In determining that a pavement is an economical proposition *for any particular road or locality, a number of factors* must be taken into consideration; not necessarily in their order of importance. Some of these are:—

(1). The existing condition and importance of the road to be paved.

(2). The volume of traffic it is now carrying or will in the future be likely to carry.

(3). The ability to maintain it in good condition at a reasonable cost.

(4). The reduction in cost to users that a pavement with its smooth surface and minimum of resistance to tractive effort, its cleanliness, and dependability, will ensure.

(5). The benefit it will confer on the residents on the road and in the locality, by reason of its good qualities, and in lessening freight costs, improving passenger transportation and eliminating the dust nuisance, and incidentally increasing the value of their properties.

(6). *The first cost of the pavement itself.*

(7). The life of the pavement in determining the annual interest and sinking fund charges.

(8). The probable cost of maintenance.

(9). The ability of the pavement to carry the load.

In regard to (2) various attempts have been made to define the quantity of traffic that should be carried by variously surfaced roads, to economically justify their construction, but it is necessary to forecast the future traffic, which increases rapidly with any improved surface and may, therefore, soon pass the economical limit of some apparently *cheaper, but less satisfactory type than concrete.* The board of Wayne County, United States of America, road commissioners, in their twelfth annual report emphasize this, and point out, "Not only does existing traffic shift to paved roads, but what was once termed a theory has in practice proved to be a fact; the time saved in marketing on concrete roads results in greater production on farms and truck gardens. This adds to the tonnage which the roads must carry."

In regard to (3) it is found generally impossible to satisfactorily maintain the macadam surface of important roads, even when these have a hand-packed foundation, except *at excessive cost, and the renewed surface quickly deteriorates*; the question then becomes one of continuing to pay for a road that is never really satisfactory, and of paying perhaps a little more for one that gives complete satisfaction.

In regard to (4) evidence has been gathered by actual test to show the large saving to motorists and transport firms by reduced benzine consumption, wear of tyres and fewer repairs, and the larger loads carried and more quickly transported, but the extent of this can be gauged for each *individual road by an analysis of the traffic using it, but* would not be less than one penny per ton mile. A quotation is significant. In "*Concrete Roads and their Construction*" the following paragraph appears:—

> At the close of 1919 there was a thirty-mile stretch of concrete highway known as the "Ridge Route," in California, opened to the public. The cost of this road was something like 1,200,000 dollars, and it was estimated by *conservative State officials that with the heavy traffic* that would pass over this road the total cost of building would be absorbed in less than 200 days by saving in petrol, tyres, and upkeep on the vehicles passing over it.

In regard to (5) the fact that in states where the frontager pays the greater part of the cost, the preference again and again given to the cement concrete pavement is a sufficient indication that they regard it as a sound financial proposition.

In regard to (6) thickness for thickness there is no other first-class pavement that can be laid at the same cost as *cement concrete, and it becomes a question as to whether* a first-class pavement or one of an inferior character is required, and if the former, the concrete pavement is entitled to the serious consideration of those who will have to furnish the money for its construction.

In regard to (7) it is difficult to assess the life of a concrete pavement, as this will be determined by the character and intensity of the traffic using it, by the design and quality of the pavement itself and the subsequent care taken in its maintenance, *and it will again be influenced by the control* exercised by statute, regulation or by-law in regard to maximum wheel and axle loads. In this connexion the necessity for adopting and adhering to a definite maximum wheel load and minimum width of tyre for such load should be strongly emphasized.

In regard to (8) the cost of maintenance for the first six years should not exceed 1d. per square yard per annum for a plain concrete surface.

In regard to (9) a concrete road can be constructed of such strength as to carry any particular load desired.

If all the above factors are duly considered in connexion with any important road, and an imaginary balance sheet of profit and loss prepared, it will be found that, provided the necessary capital can be secured, concrete pavements are a payable proposition.

The qualities that have made concrete pavements so increasingly popular are well summed up by Mr. Hill, Chief Engineer, Commonwealth Department of Works and Railways, in his report, viz., "durability, smoothness of surface, low maintenance cost, freedom from dust and slipperiness, and *its adaptability to practically all climatic conditions.*" To these may be added that it can be constructed wholly by local labour and with materials obtained locally.

It is the cheapest form of first-class pavement that has yet been laid in Auckland, is the report of Mr. W. E. Bush, late City Engineer of Auckland. He goes on to say "It is efficient and effective, for up to the present it has done its job in providing a smooth, unyielding and clean pavement, capable of being maintained at very small expense." There *are over 18 miles of concrete pavement in that city.*

With the excellent rapid-hardening cement now procurable, repairs to trenches can be readily affected, with a minimum inconvenience to the road user, and, in any case, if the *practice adopted in Auckland of locating in paved streets* service mains and of practicable sewers under each footpath, can be followed, there should be very little occasion for the cutting of trenches.

In cities, it gives the street a fine, clean appearance, and at nights is really an advantage.

Cracks and joints, even if well repaired, may mar its appearance, and necessitate periodical attention, but given this, do not affect its good traffic qualities in the slightest, and the longitudinal joint serves to divide traffic.

It is somewhat difficult and costly to cut through, but this is really an advantage to the road, for public utility companies and departments are learning to avoid such disturbances.

After a careful review of the whole subject, Mr. Bush states, "The policy of laying concrete pavements is a sound one, and any change therefrom will only be brought about because of altered conditions and new knowledge."

I shall now make certain assumptions which can be considered reasonable under the circumstances assumed in relation to specification, life, and cost of various types of roads, and in doing so it must be assumed that the surface be maintained up to its original standard.

Any comparison of road types must necessarily take into account not only the initial cost, depreciation and maintenance, but also the costs that accrue on account of the transport using the road—the true cost being the combination of both road and vehicle cost—or the overall cost of transportation.

If it could be shown that ¼d. per ton mile could be saved on even a moderate volume of traffic, say, 600,000 tons per mile per annum, the sum of £1,250 per mile per year could be saved to the community, which sum represents the interest on £25,000 at 5 per cent. for one year.

At Canberra the registration of motor vehicles is 1303. Making the same assumptions as before, the saving to Canberra residents alone would be £27,260 in one year by running *on concrete roads in place of gravel roads. This means that* a sum of £545,000 could be spent yearly on permanently

paving the roads, and result in an economy, not only on operating cost, but because a definite asset is secured.

I make no apology for presenting the following standard figures from authentic American sources showing the saving effected in operating costs by using cement concrete. I give them in their original form, and in making comparisons it *must be borne in mind that motor vehicles cost twice as* much here, petrol and oil twice as much, so that operating costs are just double. The figures referred to are taken from the Iowa State College Engineering Experiment Station, an independent body, from which it will be seen that the said ¼d. can be saved by operating on cement concrete over any other surface.

I also present another table showing the average total cost, &c.

Still another table is given showing traction tests by the Good Roads Bureau of the California State Automobile Association. These tables show the reason for the low operating cost on concrete roads.

TABLE 1.

RELATIVE COSTS OF VEHICLE OPERATION ONLY ON VARIOUS CLASSES OF ROADWAY SURFACES.

Type of Surface.	Solid-tired Trucks, 10 Miles per Hour.	Pneumatic-tired Trucks, 15 Miles per Hour.	Automobiles, 25–35 Miles per Hour	Motor Buses, 25 Miles per Hour
	Cents per ton-mile.	Cents per ton-mile.	Cents per vehicle-mile.	Cents per ton-mile.
Average cement concrete	8.00	8.30	10.00	21.00
Bituminous macadam (well maintained)	8.50	8.80	10.60	25.70
Water-bound macadam (well maintained)	8.70	8.95	11.10	26.00
Ordinary gravel	9.00	9.40	11.80	27.30
Ordinary earth	9.50	9.95	12.60	29.60

TABLE 2.

COMBINED (OR TOTAL) COSTS OF INTEREST, MAINTENANCE, DEPRECIATION OF ROAD SURFACES, PLUS THE COST OF VEHICLE OPERATION.

Average number of vehicles per day ..	100	250	500	750	1,000	1,500	2,500
Average tons per day	150	375	745	1,120	1,500	2,250	3,700
	$	$	$	$	$	$	$
Average cement concrete	5,790	11,840	21,930	32,120	42,310	58,630	103,070
Brick	6,190	12,230	22,390	32,630	42,660	62,080	103,430
Asphaltic concrete	6,080	12,140	22,300	32,490	42,680	62,000	103,480
Sheet asphalt	6,090	12,160	22,400	32,540	42,750	62,010	103,670
Bituminous macadam	6,810	13,270	24,100	34,920	47,730	69,180	109,970
Water-bound macadam	6,670	13,080	24,070	35,870	47,040	69,390	114,110
Ordinary gravel	5,350	12,470	24,360	36,240	48,140	71,020	..
Ordinary earth	5,320	12,850	25,580	..	..	..	..

TABLE 3.

PULL IN POUNDS PER TON.

Over a level, unsurfaced concrete	27.6
Concrete base, ¾-in. "Skin Top" asphaltic oil and screenings	49.2
Water-bound macadam, level, good condition ..	64.3
Concrete base, 1½-in. Topeka top, level, good condition	68.5
Gravel road, good condition, level	78.2
Earth road, fine dust, level	92.0
Earth road, stiff mud on top, firm underneath, level	218.0
Loose gravel, not packed down, new road, level ..	263.0

These tables are interesting because they show the average money cost of operating trucks, automobiles, and motor-buses, and the extent to which these costs are affected by the degree of improvement of the road surface. The first table shows these costs for vehicles only. In the second table there has been added to the vehicle costs the expense of the highway, thus giving the total annual cost of motor vehicle transport to a community. This table shows that, with a total traffic of only 100 vehicles per day, the cost of a concrete road is lower than that of any other paved road, and is only slightly more than the cost of an ordinary gravel and dirt road. As traffic increases, at about 100 vehicles per day, and for all traffic volumes above this figure, the total transportation cost on concrete is substantially lower than for any other road, *including gravel and dirt. Thus it* can be seen that concrete roads really pay for themselves.

The figures given in tables 1 and 2 are American, but although the actual cost would be higher in this country, the relationship will still stand.

The assumptions previously referred to for a comparison as to the total annual cost per mile of various classes of pavement, are as follows. This matter was discussed by me before the Institute of Engineers (Australia) and the discussion was reprinted in the magazine, *Highways*, of 14th December, 1928, from which the following is extracted:—

Specifications for—

1. Cement concrete road—Penetration type.—8 inches of 2-in. to 2½ in. metal, consolidated to 6 inches and grouted with 1 cement, 2½ sand 20 feet wide, estimated cost £4,500 per mile.
2. Cement concrete—pre-mixed type.—Cement by volume 1 : 2 : 4, 20 feet wide, 9 : 6½ : 9, ¾-inch diameter bars (edge), bituminous expansion joints. Estimated cost per square yard about 15s., per mile at about £8,000.
3. Bituminous penetration macadam.—20 feet wide, 8-in. Telford base, 3-in macadam wearing surface penetrated and sealed with asphalt. The estimated cost of this type under the conditions assumed is 11s. 6d. per square yard, and £6,800 per mile.
4. Pre-mixed bituminous macadam.—Twenty feet wide, with 8-in Telford base, and 3 in. pre mixed wearing surface sealed with asphalt. The estimated cost of this type is 13s. 4d., and per mile, £7,820.
5. Bituminous concrete on macadam foundation.—Specification for this is type, 20 feet wide, 7-in. water bound macadam, and 2-in. asphaltic concrete wearing surface, the estimated cost of which is 19s. per square yard, and £9,400 per mile.

It will be seen from these estimates that the disparities between the estimates of first cost are not very great, and it will now be shown that under the conditions estimated, the ultimate cost of concrete roads is the most economical

The true annual cost of each of the four types are tabulated below, the tabulation being based on the formula $A = M + (C - S) + P.C.$, where—

A = annual cost per mile.

M = equated annual maintenance cost of the road surfacing (exclusive of shoulders, ditches, fences, culverts, &c., which are common to all types).

C = initial cost per mile.

S = salvage value at end of this economic life of the surfacing.

D = annual deposit necessary to provide the sum of £1 in a period equal to the economic life, with interest compound annually at the prevailing rate.

P = prevailing rate of interest applicable to work of this character.

Put into words, this means that the total cost of the road is really the sum of the equated annual cost of maintenance per mile, and the annual sinking fund, which, with interest compounded annually, will accumulate at the end of the road's economic life a sum equal to the initial cost, less salvage value, and the annual interest charge on the initial cost per mile.

Under these assumptions the following table gives the initial cost per mile, &c.:—

—	Type 1—Cement Concrete Penetration Method.	Type 2—Cement Concrete Pre-mixed Method.	Type 3—Bituminous Penetration Macadam.	Type 4—Bituminous Macadam Pre-mixed.	Type—Bituminous Concrete.
Initial cost per mile (20 feet wide)	£4,500	£8,000	£6,800	£7,820	£9,400
Economic life	10 years	18 years	10 years	12 years	15 years
Salvage value per mile at end of economic life	£2,200	£4,700	£3,000	£3,000	£2,000
Total depreciation per mile during economic life C-S	£2,300	£4,100	£3,800	4,820	£7,400
Annual deposit required to accumulate £1 at the end of economic life, with interest compounded annually (5 per cent.) .. D	19.08d.	8.52d.	19.08d.	15.08d.	11.12d.
Annual sinking fund required to accumulate total depreciation per mile at end of economic life .. .. (C–S) D	£190	£146	£302	£303	£343
Annual interest on initial cost per mile (5 per cent.) I.C.	£225	£440	£340	£391	£470
Annual sinking fund, plus interest .. (C–S) D 4 P.C.	£415	£586	£642	£694	£813
Annual maintenance per mile—					
Traffic— 200,000 tons per annum	£24	£24	£81	£55	£30
Traffic— 600,000 tons per annum	£38	£28	£99	£74	£48
Traffic—1,000,000 tons per annum	£52	£52	£117	£90	£66
Traffic—1,600,000 tons per annum	£69	£69	£140	£115	£89
Total annual cost per mile—					
Annual traffic in tons :—					
200,000	£439	£610	£723	£740	£843
600,000	£453	£624	£741	£768	£801
1,000,000	£467	£638	£769	£784	£879
1,600,000	£484	£655	£782	£809	£902

From a study of the above analysis it will be seen that the concrete road is the cheapest for the conditions assumed.

Other factors which can hardly be given a monetary value, but which nevertheless are part of the advantages of concrete roads, are their safety in all weathers, neat and clean appearance, lack of glare, their value for night driving, and owing to their method of construction they automatically provide lines which divide the traffic. Concrete roads will not wear excessively; being rigid, they can be designed to carry any required load. They provide, owing to their gritty surface, safe and sure footing for animals, especially on steep grades.

In many American cities by-laws provide that, on grades steeper than 10 per cent., roads must be paved of concrete.

In carefully-conducted experiments as well as in the hard grind of actual service, concrete roads have demonstrated their superiority.

The most extensive of these experiments was made by the State of Illinois. A road two miles long was built containing 63 sections of asphalt, brick, and concrete pavement of different thicknesses, laid on various bases.

A fleet of army trucks made 23,200 round trips over this pavement. At first only the bare truck chassis was used. Then loads were gradually increased until a gross weight of 15½ tons was reached.

Many of the sections were destroyed early in the test. Only those sections survived which were of 1 : 2 : 3½ unsurfaced concrete or were of other types having bases of equally strong concrete from 5½ to 8 inches thick. In every case, it was concrete which gave the pavement the needed strength to support the loads and withstand the test.

In tests made at Arlington, Va., the engineers of the United States Bureau of Public Roads found that rigid materials, like concrete, were necessary to provide load supporting value. It was also found that various surfacing materials other than concrete had practically no "cushioning" effect at common summer temperatures. In nearly every case, the strength of the pavement tested was measured by the amount and strength of the concrete slab which either comprised the pavement or formed its foundation.

One of the principal reasons for the popularity of concrete is its long life. The life of a pavement depends upon wear, failure under load, destruction by weather, or a combination of these.

In a wear test made by the United States Bureau of Public Roads, two solid-tired truck wheels, loaded so that each weighed 3,000 pounds, made 53,000 circuits of a track built of concrete containing all the common kinds of concrete aggregates. Many of these aggregates were softer than are allowed on any properly built road, yet the maximum wear on any section was only 0.018 of an inch. The wheels travelled in a path only 6 inches wide, and a slight discoloration of the surface was about the only visible evidence of the traffic which had passed over the concrete.

When the wheels were equipped with heavy skid chains, and enough circuits were made to represent the traffic of 250,000 two-ton trucks on an 18-ft. road, the maximum wear on any section containing aggregates acceptable under federal aid specifications was 0.52 inch, and the average of all such sections was only 0.25 inch.

It is evident from these tests that unless a concrete pavement is subjected to enormous steel-tire or skid-chain traffic it will never wear out.

Observations of many old concrete pavements indicate that surface marks which would be obliterated by as little as 1-32nd of an inch of wear are still plainly visible after subjection to many years' traffic.

The science of road design has been developed until it is now possible to determine how thick a concrete slab should be to support a given maximum load. So long as that load is not exceeded, the concrete slab will not be broken by traffic.

Experience in all extremes of rainfall and temperature in all parts of the world has shown that good concrete is unaffected by weather and actually grows stronger with age.

A good deal of the evidence contained in this statement is the result of my observations during a recent tour of the North American Continent for the express purpose of inquiring into road construction in general; most of the information available concerning concrete roads is of American origin because it is in that country that modern road development has made the greatest strides. Many thousands of pounds have been spent in that country in scientific research on road construction. Some of the information obtained has already been given to you.

I have recently conducted a survey of the mileage of concrete roads in Australia, which, unfortunately, is not yet complete, but the following figures give an idea of the extent to which concrete is being used:—

New South Wales—equivalent of 343 miles of road 18 feet wide.
Queensland—equivalent of 30 miles of road 18 feet wide.
South Australia—Incomplete.
Victoria—Incomplete. *sic*

It will be observed, considering up till 1919 except in a few city streets, very little concrete road construction has been undertaken, that the progress made has been excellent, and that the people generally are appreciative of the value of concrete roads.

I would here like to stress the fact that concrete roads are constructed entirely of Australian-made material, thus giving employment to Australian workmen both in the manufacture and distribution of cement, and in the construction of the road.

This point should not be overlooked when it is considered that other and less satisfactory binding materials to the value of £600,000 per year are imported into Australia.

Cement is used extensively abroad in the construction of roads of every class. In 1919 a commission sat in California to advise as to the best means of getting the

roads in that state out of the mud. That object was achieved by providing roads of 4-inch concrete, 10 feet wide. Only recently those roads have been widened and resurfaced; this was necessitated by the rapid development of traffic. In the meantime the roads had given ten years of wear. Most of the concrete road construction in Australia has been in the cities, but in New South Wales the Main Roads Board is gradually extending this type of road into the country. Various country towns have laid down concrete roads; amongst them are Queanbeyan and Murwillumbah. A traffic of 200 vehicles per day is an economical proposition for concrete road construction. That takes into account the life of the road, interest, depreciation and operating costs. Bituminous penetration on an 8-inch Telford base costs about 11s. 6d. per square yard, or approximately £6,800 per mile. A cement concrete road of the best type costs 15s. a square yard, or £8,000 per mile. The latter, however, involves no maintenance cost except an occasional attention to joints with bitumen. The life of a bitumen penetration road depends largely on the volume and character of the traffic using it, but it will probably require to be resurfaced at intervals of not more than two years. A bitumen road must be sealed in order to prevent the water from getting into it. On normal foundations mass concrete without general reinforcement is usually sufficient. The usual thickness of concrete for an average road is 6½ inches in the centre. The class of construction has to be determined by a number of factors, the drainage of the surrounding country being one of them. But in average condition a mixture of 1 : 2 : 4 and a cross section of 9 inches: 6½ inches: 9 inches, reinforced with edge bars and at the corners is all that is necessary. The construction of a more expensive type of road might temporarily mean a smaller mileage of good road, but ultimately that disability would be overcome. I do not suggest that all the roads in Australia should be laid down in concrete. It would be wrong to hang such a millstone about the necks of the community, but in cities and country towns the main streets and the immediate approaches should be of concrete. At the present time Australia is able to produce about 1,300,000 tons of cement per annum. Last year the total sales did not exceed 700,000 tons; therefore a capacity of 600,000 tons is lying idle, and the interest on the capital expended must be charged to the existing output, thus making cement more costly than it should be. This Australian industry should be better supported by the public and by the Federal and State governments. Bitumen is an imported product. Australia produces tars which approximate bitumen in appearance and physical properties, but they are not of the same quality, and are not used to so great an extent. In laying down concrete roads I prefer to make definite breaks, both longitudinal and transverse. In Queensland those breaks would be at more frequent intervals than in Melbourne, because they are made for the express purpose of minimizing cracking due to temperature changes. At Canberra a break could be made in the centre of the road and transverse breaks at 50 feet intervals. I should think that a 20-foot concrete road could be laid down at Canberra for about £8,000 per mile. If road construction there has cost £14,000 per mile probably between £4,000 and £5,000 is represented by earthworks, drainage, guttering and kerbing.

50. *To Mr. Long.*—Before placing concrete on a "spewy" foundation the constructing engineer would probably scarify the ground, and mix some sand with the clay, and then add more sand on top before putting down the metal. That would tend to prevent the expansion and contraction that usually takes place on a clay road. It would not be necessary to lay a greater thickness of concrete. If the drainage at the sides of the road were efficient, there would be little danger of the concrete breaking. The specifications to which Australian cement is manufactured are more severe than the specifications employed in America; therefore, the Australian cement is superior. The only movement that takes place in concrete is the expansion and contraction due to varying temperatures. If the concrete in the sidewalks at Canberra has cracked, the cause might be found in faulty manipulation, excessive water, bad puddling or insufficient curing. The sticky nature of the natural foundations would not deter me from using concrete on the Federal highway. Concrete would give a better surface and the operating costs would be lower than with any other type of road. A concrete road should be almost flat, with just sufficient camber to throw off the water. I would suggest a camber of 1 in 50.

51. *To Mr. Carlin.*—Provided the work is efficiently supervised by a qualified foreman, unskilled workmen can be usefully employed in the construction of concrete roads. The man in charge of the mixer should be an expert. There is more in mixing concrete than is generally known. Where the filling exceeds 4 feet, I would prefer the ground to be consolidated by traffic and the weather before paving it. Under normal conditions a concrete road can be built from start to finish in one continuous process. Fillings exceeding 4 feet are rare, and the usual practice is to surface them temporarily. In cuttings and on level ground it is not necessary to do that. There is a second class of construction in concrete which is proving quite practicable. It is known as cement penetration. One road has been constructed in that way at Canberra; unfortunately, the operators were not thoroughly conversant with the business, and did not get as good a surface as is desirable. Any engineer will agree that it is easier to make a mess of bitumen penetration than concrete. Care must be taken to heat the bitumen to the proper temperature, and to get it into and through the road so thoroughly that no void is left. The foundation is an important part of the road. Without a good foundation a road will not last, but a concrete road has more chance of doing so, because it can act as a bridge. Instead of letting one contract for formation and another for concrete or bitumen penetration, I would prefer the whole job to be let to one contractor who should do all the work from the turning of the first sod to the final surfacing.

52. *To Mr. Cameron.*—The concrete roads in Adelaide have a concrete base and a bitumen surface. In Woodville and Port Adelaide concrete has been used as a base. The Henley Beach road has a section of concrete across a flood area. It has been in use five years, and although water is frequently flowing over the road only one corner of one slab has failed; the remainder is in perfect condition. Probably it has been reinforced. At Port Adelaide a stretch of cement penetration was reinforced. I recommend concrete roads without reinforcement if the concrete is satisfactory and the drainage is good. I have seen many roads constructed in that way. I am aware that a section of about 400 yards at Botany in a total length of about 4 miles of concrete road in New South Wales failed. The reason for that failure is known. The association of which I am the general manager is formed for the express purpose of servicing the product of the cement factories and promoting its further use. I am not in a position to express an opinion regarding the likelihood of the price of cement being reduced in the event of the output being increased, but I should say that if production were increased the price could be reduced. It is the general desire of the cement trade to reduce the price to the lowest possible level, because the lower the price the

greater the consumption will be. The consumption of cement has increased gradually, but not nearly in proportion to the increase in the plant capacity.

53. *To Mr. Gregory.*—In "spewy" country good drainage is essential. If the foundation is of clay and is liable to expand and contract, thus throwing stresses on the concrete, it is advisable to spread a 2 inch layer of sand under the paving. Latest investigations show that sand used in the making of concrete should be well graded from coarse to fine; it need not be sharp, and if it contains no organic matter does not require washing. It is safe to mix concrete at a central depot and convey it to the place where it is to be used provided that not more than three-quarters of an hour elapses between the mixing and the laying, under average temperature conditions. In our specifications for cement the minimum setting time is one hour. Concrete increases in strength by being allowed to stand for a little time before being put into position. In the United States of America concrete can be bought at central mixing depots, and often it is an hour in transit to the job. It is carried in specially-designed steel waggons which retain the water. If concrete is properly mixed there is no danger of segregation of the components. In the United States of America the price of cement is approximately half the price in Australia. Possibly the present cost of cement is limiting the use of concrete in road construction, but only about one bag of cement is required for every square yard of concrete road. A ton of cement is equal to 24 bags, and if the price were reduced as much as £1 per ton the cost would not be reduced by more than 1s. per square yard. A good deal of the cost in concrete road construction is represented by labour.

54. *To Senator Reid.*—The percentage costs of the materials used in a square yard of concrete, averaging 7 inches thick, 1 : 2 : 4 mix, are—

	per cent.
Broken stone or gravel	32
Sand	10
Cement	48
Labour	10

These percentages are based on the following prices:—Cement, £5 11s. in the mixer; sand, 10s. 6d. in the mixer; stone, 17s. 6d. in the mixer; labour at standard rates. The percentage given for labour includes only cost of mixing, laying, placing and curing, but not that entailed in hauling or placing in the mixer—these are charges to the cement, sand or stone as may be. Engineers differ in regard to the need for reinforcement. Under average conditions concrete does not require general reinforcement throughout. I prefer edge bar and corner reinforcement. In swampy country the bottom of the concrete would be reinforced in order to give greater strength and the top could be reinforced to minimise cracking. Bitumen penetration would not stand in swampy country without enormous expenditure on its maintenance. The Queensland Main Roads Commission will not construct anything but concrete roads in swampy country. Bitumen will not stand water and the road being of a flexible type it collapses when the foundations are weakened. Concrete, on the other hand, can function like a bridge. The specifications for a concrete road vary according to the nature of the country and the anticipated traffic conditions. Concrete roads do not cause a dust nuisance and are not in any way detrimental to health. Engineers prefer a central mixing depot, where that is economically possible, because the concrete is mixed under the direct control of experts and generally it gives better results than concrete mixed on the job. Often, too, it is less costly Usually sand from the seashore can be used without detriment to the concrete. The reason why it is not used more generally it that it is badly graded, being mostly of one size and that too fine. If the concrete is being reinforced interaction may occur between the steel and the salts. The only effect of salt would be to produce laitance on the road, but that becomes worn off. The use of tar in place of bitumen has passed the experimental stage, and, in my opinion, bitumen is being used because of the pressure exerted by the sellers. At the present time the gasworks cannot supply the demand for tar, but I feel sure that if they were assured of a regular and increasing market for this by-product of their ovens they would see that it was forthcoming, provided, of course, that the coal-mines were in operation. I think they could produce tar at a price which would enable it to compete with bitumen. A tar road properly prepared is no more affected by heat than is bitumen. A fortnight ago the bitumen surfaces of the Adelaide streets had to be covered with screenings because the heat had made them so soft. I am convinced that efficient local tars suitable for road-making purposes will be produced if sufficient encouragement is given to the manufacturers. The Newcastle-Maitland road, made of local slag and tar from the Broken Hill Proprietary Company's retorts, is an excellent example of a tar penetration road. The use of concrete on country roads should be governed by the character and quantity of the traffic. Agricultural roads should be kept out of the mud. A little more discrimination could be used in the making of roads; more should be of concrete.

55. *To Senator Dooley.*—A cement penetration road 6 inches thick can be laid for £4,500 per mile. Bitumen penetration costs about £6,000 per mile. In suggesting a longitudinal break in a concrete road I had in mind a 20-feet track. A slab 10 feet wide would not require a central break. Usually the centre joint is connected with dowels of half-inch rods. One edge is butted against another, the two are connected by dowels, and by this means vertical movement of one slab in relation to another is prevented. In making breaks at intervals of 50 feet, I would allow about ¾ of an inch for expansion. These joints also should be dowelled. The concrete materials should be churned in the drum for at least a minute to ensure thorough mixing. The proportion of water should be strictly regulated; some aggregates require more water than others. The mixing should be under constant supervision. If a shower has occurred overnight the sand may contain, instead of about one-half gallon of water to the cubic foot, about one and a half gallons. In that event the quantity of water put into the drum should be correspondingly decreased. If a minute is not sufficient for the thorough mixing of the concrete, I would increase the time rather than the quantity of water. The more time that is given to the mixing the stronger the concrete will be. It is not necessary, in all circumstances, to consolidate a road by traffic before laying down the concrete slab. Ordinarily as soon as the road has been consolidated by roller, the concrete can be laid. A filling of 20 feet depth would probably require twelve months to consolidate. Much depends on the material used and the season.

56. *To the Chairman.*—Under average conditions concrete does not require surfacing with bitumen. An exceptional instance is the Botany road, where the traffic is confined by a kerb and tram rail to an 11-feet track. For roads of the type that this committee is inquiring into bitumen surfacing would be a waste of money. I cannot see any advantage in surfacing a concrete road. If, however, surfacing should be considered necessary at some future time why do the work immediately? The concrete will always have its value as a base, and if you can defer the surfacing of it for ten or fifteen years, you save interest on the extra money for that period. If a concrete road without reinforcement could be built for £8,000 a mile, reinforcement for the full width might increase the cost to £9,200.

57. *To Mr. Gregory.*—A concrete road should stand up to motor traffic indefinitely. If the road is narrow and subject to heavy steel traffic the concrete should be covered. Tar is not as good as bitumen. The two materials have different bases and physical characteristics. The usual practice is to give a priming coating of tar because of the difficulty of getting bitumen to adhere to the metal or gravel, particularly if it is not clean.

58. *To Mr. Holloway.*—The limit to the volume of traffic that a 6-inch road with bar reinforcement on the sides will carry is governed by the width of the road and the spread of the traffic. It is hardly likely that any traffic on the Federal Highway would injure such a road. In Brisbane unsurfaced concrete roads are functioning satisfactorily.

59. *To Mr. Curtin.*—Kerbing is not required except when the road is subject to a heavy scour. I would urge the committee, when considering the comparative costs of different classes of roads, to take into account not only the initial cost, but also the saving in operating and maintenance expenses that can be affected by the use of concrete.

The witness withdrew.

Gilbert Josiah Pickett, manager of the Adelaide Cement Company, Limited, sworn and examined.

60. *By the Chairman.*—On behalf of myself and Mr. John James Grierson, acting manager of the South Australian Portland Cement Company, Limited, I submit the following joint statement in the hope that it will assist the committee to formulate a road-making policy for recommendation to the Federal Government:—

As managers of the two local cement works our duties comprise the supervision of the actual raising and handling of the raw materials; and the manufacture, despatch, and delivery of the finished article. Under normal conditions, when the two plants are operating at their full capacity, the industry finds employment for a considerable number of workmen, the average number under these circumstances being:—

In quarries	..	100 men
Freighting and transporting ..	..	20 men
In cement factories	..	180 men
Total	..	300 men

In addition to these men a considerable number are employed from time in construction and repair work, partly at the cement works and partly in outside engineering shops. Apart from the direct employment of labour the cement industry creates a very large volume of indirect labour. For example, our companies normally consume approximately 30,000 tons of coal per annum. This involves labour in hewing, loading, and discharging, and in both sea and land transport. Another large item of continually recurring expenditure is in connexion with cement containers. Employment is given to both jute and paper bag makers. On an estimated output of 65,000 tons of cement per annum the requirements for packing would amount to the equivalent of some one and a half million paper bags. The whole of the material for the paper bags is produced and made up in Australia, and this industry affords employment for a large number of employees. Expenditure on the purchase of materials for plant repairs and renewals is a very heavy item in a cement works owing to the enormous wear and tear of massive machinery which has to run at fairly high rates of speed. Practically all steel, and other materials used for these purposes are made in Australia. It might be observed that it is the settled policy of the South Australian Cement Manufacturers to purchase all their requirements, including new machinery, in Australia as far as practicable. As a further indication of the value of the cement industry to the general community we might state that we are large purchasers of electric current, contribute largely to the income of the Water Supply Department, and pay substantial sums in local rates and Federal and State taxation. Our employees also make contributions under these headings. From what has been said it will be obvious that the running and upkeep of a cement factory gives widespread employment to a large number of men, and that the disbursements and wages are spent in our own country to the great social and economic benefit of the whole community. We each and all conform to the laws of our country and bear our share of the burdens of citizenship. In our opinion then, it is unsound business to use binding materials for road making which are of less value than cement, especially when such materials have to be imported into this country thereby swelling the already huge trade balance against the Commonwealth, and incidently enriching people who do not contribute to our national revenue. The South Australian Cement Companies have invested over £500,000 in property and plant, and have spent annually large sums of money in keeping their machinery up to date, as the standard of quality of cement has been continually raised, in order that they may produce an article which will compare favorably with any other cement manufactured. Under the trading conditions now prevailing in this State the cement plants are not working to full capacity or employing the maximum number of workmen. Something should be done to provide new channels for the consumption of cement to enable the industry to function fully and render the utmost service to the community as a whole. The cement industry is an essential and genuine all-Australian industry, which, in addition to providing employment, affords an important means of developing the natural resources of the country. For the foregoing reasons we urge that the inauguration of a comprehensive policy of cement concrete road construction in all the Australian States would be of very distinct advantage not only to the industry with which we are immediately connected, but in the long run to practically every inhabitant of the Commonwealth. As far as the State of South Australia is concerned very little cement concrete roads have been constructed. Such work so far has been confined almost exclusively to the Government Highways Department, the Corporation of the City of Adelaide, and the Corporation of the City of Port Adelaide. Outside these bodies only a few isolated patches of this class of road have been laid down. This result is insignificant when compared with the magnitude of cement concrete road work carried out in the metropolitan areas of Melbourne, Sydney, and Brisbane, to quote Australian examples, and Auckland, New Zealand. The fact that these cities and their environs are continuing the construction of cement concrete roads is undoubted evidence that the method has merits well recognized by road-constructing authorities. Readily accessible statistics show that road transport has increased enormously during the past few years, and the tendency is to still further increase. It appears to us then, that the type of road to be selected should take fully into consideration the probable increase of traffic in the future, and future necessities provided for rather than merely treating the question as one of expediency and putting down a pavement which might in a few years prove inadequate to carry the traffic incressed by natural evolution. The experience of the cities mentioned above, and other instances which no doubt will be brought to your notice with appropriate details, point to the eminent suitability of cement concrete as the material for road-making. In conclusion, it will be appreciated that the committee can render valuable assistance to the cement and allied industries, to the increase of employment of various classes of labour, and to enhanced transport efficiency by advocating the construction of cement concrete roads and, as specifically referring to South Australia, by recommending that a portion of Federal Aid Roads Grants be allocated to that purpose.

I have had no experience of the construction of roads, but when I was in America two years ago, I saw large mileages of concrete road. The stretch from Los Angeles to San Francisco is of pre-mixed cement concrete. In places it was 20 feet wide, but away from the cities it narrowed to 14 feet. Alongside concrete roads in America I saw oil wells which used rubber tyred traffic and steel shod trailers, and neither had any effect on the wearing surface. While I was in Chicago I discussed with engineers the advantages of concrete road construction, and they were opposed to the use of bitumen penetration. I was informed that all the materials they used in concrete are subject to laboratory tests. On my return to Adelaide, we submitted stone from the local quarries to similar tests, and they revealed that the quarry at Rockdale yields a stone superior to any other in Australia for concrete road purposes. Concrete has not been in favour with road engineers because quarrymen used to give them the "run" of the quarry, and would not supply properly graded and clean stone. Now they are prepared to supply tested metal. In America, I saw chemists taking samples from each car load of sand and stone; in fact the materials were accepted only on the chemists' certificates. When the concrete was mixed, the constructing authorities took tests of every batch before

it was put into the road. I should say that a highway with a traffic averaging 200 vehicles per day warrants concrete construction. The wear and tear on an ordinary macadam road would be tremendous; indeed, it would last *not more than six months*; a bitumen penetration road would require to be re-surfaced within two years, but a properly constructed concrete road would last from eight to ten years. With metal at 12s. per yard, sand at 10s., cement at about £1 per barrel, and using up-to-date appliances, pre-mixed concrete should cost not more than 10s. per square yard. *Pre-mixed bituminous macadam would cost 11s. to 12s.*, and a 9-inch penetration road about the same. Even a concrete road will require regular inspection, but the only bad wear occurs at the joints. A properly constructed concrete road should require practically no maintenance for the first eight years, then it will require patching and perhaps renewal at the joints. *My observation of bitumen penetration roads is that* they require patching in the first twelve months. Premixed bitumen on the Birkenhead-road cost between 11s. and 12s. per square yard. I have never heard of a bitumen road being put down for 4s. per square yard. Not a penny has been spent on the concrete section of the Henley Beach-road during the five years it has *been in use. That is in a flood area*, but a concrete road can be guaranteed to stand under any conditions. Cement should have preference over bitumen, because it gives a better job, and all the materials used in a concrete road are of Australian origin. The Australian tar that is now being used on roads could still be used with sand for top-dressing and repairs.

61. *To Mr. Curtin.*—The Americans instead of building all their roads to a width of 18 feet or 21 feet put down narrow strips of only 9 feet, and the sides are ordinary macadam. In that way the cost of con*crete construction is reduced. In country areas it is* not necessary to lay concrete roads to the full width of 21 feet. In many parts of South Australia the construction of concrete roads would be warranted. If the farmer could cart his produce to the market or the railway siding over good roads he would save much time and labour. A narrow concrete road would not *cost more than a double width road of bitumen.* Many pastoralists are using road transport instead of the railways. It is an advantage to be able to load the lorries at the woolshed and convey the wool straight to the merchants' stores. Motor lorries are transporting goods between Adelaide and Port Augusta.

62. *To Mr. Holloway.*—The high initial cost of a concrete road can be overcome by laying down, in the first place, only narrow strips.

63. *To Mr. Cameron.*—We contend that the final cost of narrow concrete roads would be less than the cost of full macadamized roads Less haulage power is required on concrete roads, and there is less consumption *of petrol and less wear of tyres.* We used to pay for coal 37s. per ton; now we are paying as much as 52s. The price of cement in South Australia is *approxi*mately £6, as compared with £5 8s. to £5 10s. in New South Wales. The South Australian companies have to pay more for electric power than have the manufacturers in New South Wales, and our production is on a smaller scale. If we had the larger output our cost of production would be *reduced. Some of the New South Wales companies* get coal for 12s. a ton. We are able to hold our own *in the South Australian market, except that some* builders from Europe, who are accustomed to English cement, cannot overcome their *prejudice against the* colonial article. In Auckland two years ago, I saw roads which formerly were of bitumen penetration but had been converted to concrete. They had been down for eight years and still had a long life. Cement was costing, in New Zealand, about £5 15s. a ton, but the manufacturers were working a natural cement rock and had the advantage of cheap coal.

64. *To Mr. Holloway.*—The Australian cement specification is the most severe in the world; and because we have to work to that standard our product is superior.

65. *To Mr. Long.*—If a 9-ft. concrete road were put *down for a cost of £2,500, the width could be doubled* when the traffic warranted by duplicating the expenditure. A greater demand for local cement would keep the factories going full time, and they would employ more labour. Further employment would be given by *the greater consumption of coal and bags for the cement.* I am confident that the local companies would not *endeavour to exploit the market if the greater demand* for cement enabled them to produce to their full capacity. If we were to increase our prices *the foreign* cement would get control of the market.

66. *To Mr. Curtin.*—I do not think that we would ask that a higher duty be imposed on cement in order to shut out foreign competition.

67. *To Mr. Long.*—*If the factories* were working to full capacity the natural tendency would be to lower the price of cement. Two and a half years ago, *when* the Adelaide Cement Company was working to full capacity, my directors sent me on a trip round the world to ascertain whether we could produce cement more efficiently and at less cost. We intended to put *in a plant capable of producing 250 tons per day, but* owing to the depression we cannot sell the whole of the output of our present plant.

68. *To Mr. Holloway.*—If we were working to full capacity I believe we could reduce the price of cement because our overhead costs would be distributed over a greater output.

(*Taken at Adelaide.*)

THURSDAY, 27TH FEBRUARY, 1930.

Present:

Mr. LACEY, Chairman;

Senator Dooley	Mr. Curtin
Senator Reid	Mr. Gregory
Senator Sampson	Mr. *Holloway*
Mr. M. Cameron	Mr. Long.

Michael Joseph Murphy, *President, Adelaide Branch* of the Australian Workers Union, sworn and examined.

69. *To the Chairman.*—All of the men engaged in the manufacture of cement in South Australia are members of the Australian Workers Union, and because cement is not used as extensively as it might be, many of them are out of work. Most of the men engaged in road construction also are members of my union. Through the *diminution in the output*, one cement factory has reduced its employees from 150 to between 40 and 50. In the other factory the position is *some*what similar. Both establishments when in full operation employ about 300 men. If a policy of concrete road construction were in operation both cement factories would be working to full capacity, and many men *who are now unemployed would be absorbed* in them or in the actual road construction. On account of the dirty character of the work, men engaged in spraying bitumen and laying concrete receive a little extra payment. Those who spread the metal and screenings are paid at ordinary labourers" rates. I believe that concrete construction would give more employment to *members of my union than* bitumen penetration. In the absence of experience of concrete road work in this State, it is difficult to estimate what would be *the effect,*

but as the whole of the materials used in concrete construction would be produced locally, it follows that a large number of additional men would get employment in the quarries and cement works. Bituminous penetration roads are not standing very well. I have in mind a road between Adelaide and Callington, which *is bitumen over a concrete foundation.* Another bituminous penetration road is that approaching Port Wakefield. When I saw it about four months ago holes were wearing in it.

70. *To Mr. Cameron.*—The portion of the Callington road which is not wearing well is that on the Adelaide side; some of it has been built for two or three years, *but one section was completed only during last summer.* Despite the fact that the road is comparatively new, it already bears indications of pot-holes. I support the policy of constructing roads in cement concrete, and I suggest that in building roads in the Federal Capital Territory the Commonwealth Government should set an example by using an all-Australian product. I am not afraid that the longevity of concrete roads would diminish the employment of those who are ordinarily *engaged in road maintenance*, because the money that is now wasted on the maintenance of inferior roads would be available for a further extension of concrete roads. After a concrete road is completed it needs no further attention for several years. In the interests of Australia, the Government should develop roads of this kind.

71. *To Mr. Gregory.*—My experience suggests that concrete road construction would give employment to as many men as bituminous penetration. A road that will stand practically for all time is the most economical in the long run. If roads were built to country railway stations instead of all converging on the city, they would be of greater advantage to the producers. I *admit that with a limited sum of money available* the adoption of concrete construction would reduce the mileage of new roads. I am advocating the use of cement in road construction rather than bitumen, which is an imported article. Ordinary developmental roads in the country are in a different category from highways and metropolitan roads.

72. *To Senator Dooley.*—Men *engaged in the melting* down of bitumen receive a special rate of pay; those who spread the bitumen and lay the concrete receive about the same wage. Quarrymen receive the same rate of pay whether the metal they are working is hard or soft.

73. *To Senator Reid.*—That portion of the Callington road which is now showing defects has been in use for about two years. Previously it was *macadamized; the defects cannot be due to faulty foun*dation. I do not think that more men would be employed in building three miles of bitumen penetration than in building one mile of cement concrete.

74. *To Mr. Curtin.*—I do not suggest that developmental roads in the country should be laid down in concrete instead of the ordinary gravel road, which gives the farmer access to the railways, but for surfaced roads I believe that concrete, being made of local *materials, should have preference over bitumen.* Instead of using bitumen on top of concrete, we could use concrete only. Where the penetration system is employed cement is preferable. Country roads are constructed by the local government authorities, but contracts are let for the supply of stone. I favour the construction of roads departmentally because the *local government authorities, having a complete plant,* can do the work more economically. To-day plant belonging to the Highways Department is lying idle while work is being let on contract. Judging by what I have seen in Sydney during the last three weeks, I should say that concrete should be employed, even on a road having a traffic not exceeding 200 vehicles per day. *Well made and properly consolidated gravel roads* should stand for a long time, and it might be a sound policy to build roads of that character for the time being and surface them some years hence, when they are properly consolidated. I believe that concrete penetration would stand better than bitumen or bitumen penetration. For four years I *worked for the* Adelaide Corporation. Many metal roads were tar-dressed annually, and often had to be patched during the year. In latter years there has been little steel traffic on the city roads, but there is still a good deal on the Port Adelaide roads.

75. *To Mr. Long.*—Doughy or spewy soil should be treated with sand. Macadam would be a good foundation for a surface of either concrete or bitumen. Fast moving motor traffic creates potholes in gravel roads, but not corrugations. Potholes do not occur on concrete roads. *Taking into account construction and main*tenance, the ordinary macadam road directly employs the most men, but directly and indirectly concrete construction gives most employment. Concrete construction requires careful supervision, particularly in the mixing of the concrete. Skilled labour is not needed so long as there is efficient supervision of the materials and the mixing. *Having regard to the enormous outlay* at Canberra in creating a model city, it would be advisable to lay down first-class roads of a permanent character. Therefore, notwithstanding the greater initial expenditure involved, I would recommend concrete road construction there.

76. *To Mr. Cameron.*—The Highways Department used to tender in competition with private firms for various road construction jobs. But the present State Government is favorable to the contract system, and I am not sure that the Highways Department continues to tender.

77. *To the Chairman.*—In choosing between bituminous penetration and concrete, it is the duty of the Commonwealth to give preference to Australian *industries rather than continue* to import bitumen.

The witness withdrew.

Stanley R. Whitford, M.L.C., South Australia, sworn and examined.

78. *To the Chairman.*—I appear before the committee in the interests of the cement companies. I have acted as buyer for the Adelaide Cement Company for two and a half years, and have a good idea of the ramifications of the industry and its *importance to* South Australia. According to a table of costs pre*pared by persons connected* with the cement industry bituminous penetration 6 inches thick costs £2,500 per mile, and cement penetration 6 inches thick from £2,815 to £3,284 according to the local conditions. Concrete roads in various parts of the State have proved to be all that could be desired and the cost of maintenance has been practically nil. A stretch of *concrete on the Jetty-road, Semaphore*, has been laid for ten or twelve years, and there is not a mark on it. It carries heavy commercial traffic and the railway runs alongside, causing a good deal of vibration. Yet it has worn perfectly. A section of concrete on the Henley Beach-road through swampy country has been in use many years and not a penny has been spent on *maintenance. An area of concrete carelessly laid* in the Adelaide Cement Company's yard has carried heavy traffic for years remarkably well. I am told that bitumen penetration costs 6s. per square yard. Bitumen spraying may cost only about 2s., but the cost of upkeep must be taken into account. A test section of cement penetration was laid in Dunniker-road, Port Adelaide. *I do not think the road required* surfacing, but it was covered with 2 or 3 inches of *bitumen*, and within twelve months the heavy corrugations had to be ironed out. Had it not been covered

with bitumen it would not have required any attention for years. In answer to a question I asked in Parliament, the Highways Commissioner stated that the upkeep of bitumen penetration roads amounts to £72 per mile per annum. That must be added to the capital cost of the road. As far as we can judge a concrete road requires no renovation for ten or twelve years.

79. *To Mr. Gregory.*—In laying down the experimental section of cement penetration in Dunniker-road we first used 5 inches of specially picked 2-inch metal. That was lightly rolled and a ½-inch steel reinforcement was laid. On top of that was put about 6 inches of 2-inch metal, which also was lightly rolled. Cement, sand and water were mixed in a big tank on a lorry and grouted into the road by means of a large hose with a fan shaped nozzle. The cement penetrated right to the bottom of the road, and while it was still wet it was again rolled. Finally it was top dressed with light screenings. I saw a sample taken out of that road. There is hardly a tool in South Australia that would cut it. The road is not kerbed. When it was finished it was consolidated to a depth of 9 inches. After it was finally rolled it was kept moist for a time. Cement penetration was employed on the new wharves without reinforcement and within a week iron shod vehicles were running over it. The experimental section in Dunniker-road is about two miles long and 30 feet wide. It was built by the efforts of the Adelaide Cement Company who brought over Mr. Sunderland and his outfit from Melbourne. Most of the metal used for road-making about Adelaide is porphyry rock. We have no granite.

80. *To Mr. Holloway.*—I suppose merchants import cement because they can make a better profit out of it than out of local cement. The quality of the South Australian article is not questioned. The preference for the imported cement is due to the cheaper price and to a certain extent to prejudice against the local article. The Adelaide Cement Company could supply the whole of South Australia's requirements. In years gone by it supplied cement to Western Australia and Tasmania. The existing plants are capable of doubling their present output. If the output were considerably increased a reduction of price should follow. The present price is too high. The local companies should make a definite offer that if, without increasing proportionately their overhead expenses, they can considerably enlarge their output, the price of cement will be reduced. Under existing conditions the demand is not great enough to keep both the Adelaide and Brighton Cement Companies in full operation, and I have often suggested that they should amalgamate. The resultant reductions in overhead costs should mean a corresponding reduction of the price to the consumer.

81. *To Mr. Cameron.*—At present very little cement is sent out of South Australia. The higher price in this State as compared with New South Wales and Victoria is probably accounted for by the higher price we have to pay for coal.

82.2 *To the Chairman.*—I would like the committee to be seized of the importance of the cement industry in South Australia. When I joined the service of the Adelaide Cement Company, it employed 120 men. I suppose the Brighton Cement Company employed about the same number. Both companies have reduced their employment by two-thirds. The wages of 120 men amounted to about £2,000 per month. I bought for the company each month approximately £5,000 worth of coal, oil, rods, chains, &c. That £5,000 mostly represents labour and is spent in wages somewhere in Australia. The company employs men of varying classes earning from £1,000 a year to the basic wage. If we spend monthly £2,000 in wages and £5,000 on material, we keep in outside employment about two and a half times as many people as are actually engaged in the manufacture of cement. For that reason the industry is of special value to the community. If any local industry is to be protected, the cement makers have a good claim.

(*Taken at Adelaide.*)

FRIDAY, 28TH FEBRUARY, 1930.

Present:

Mr. LACEY, Chairman;

Senator Dooley	Mr. Curtin
Senator Reid	Mr. Gregory
Senator Sampson	Mr. Holloway
Mr. M. Cameron	Mr. Long.

Daniel Victor Fleming, Commissioner of Highways, sworn and examined.

83. *To the Chairman.*—I am acquainted with Canberra, and recently travelled over the route of the proposed federal highway. In South Australia we have done a lot of road reconstruction in similar country. Bituminous concrete is the highest type of road we have put down, but our standard road is bituminous penetration. The committee saw yesterday samples of bituminous penetration in use and in course of construction on the Mount Barker-road, and I shall supply it with a complete specification. I submit the following statement of actual costs of various types of road pavement:—

ACTUAL COSTS OF VARIOUS TYPES OF ROAD PAVEMENTS.

BITUMINOUS PENETRATION ON EXISTING MACADAM BASE.

	Cost per square yard. s. d.
3-in. compacted depth of penetration ..	3 11.1
Strengthening old base	7.8
Rough stone edging	6.5
	5 1.4

Cost per mile for pavement 20 feet wide, £3,000 (approximately).

Costs of materials on above job were as follows:—

Metal (2½-in.)	9s. 3d. per cubic yard.
Screenings	9s. 3d. per cubic yard.
Bitumen	£7 10s. per ton on road.

Where an old macadam base is not available, and a new foundation has to be constructed the cost would be as follows:—

	Per square yard. s. d.
3-in. compacted depth of penetration ..	3 11.1
6-in. compacted metal foundation (approx.) ..	3 0
Rough stone edging	6.5
	7 5.6

Cost per mile 20 feet pavement £4,400 (approximately)

BITUMINOUS CONCRETE ON OLD MACADAM FOUNDATION.

	Cost per square yard. s. d.
3-in. depth of bituminous concrete ..	8 2
Scarifying and strengthening of old base ..	1 10
	10 0

Cost per mile 20 feet pavement, £5,867 (approximately).

Cost of materials on above job:—

	£ s. d.
2½-in. metal for strengthening base	0 12 6 per cubic yard.
Screenings for bituminous concrete	0 18 7 per cubic yard.
Sand for bituminous concrete ..	0 11 0 per cubic yard.
Filler for bituminous concrete ..	2 8 3 per ton.
Bitumen for bituminous concrete	8 5 0 per ton gross.

NOTE:—A 3-in. depth of bituminous concrete would have cost approximately 6s. 6d. per square yard or a total of approximately 8s. 4d. per square yard.

On the Mount Barker-road we put down 3 inches of bituminous concrete, because it is used by a heavy type of iron shod traffic, loading up to 4 tons per wheel. The usual thickness is only 2 inches, and if that were used the cost would be reduced from 8s, 2d. to 6s. 6d. per square yard. The first portion of the Mount Barker-road was completed in 1924. The total distance of bituminous concrete is about 13 miles. The annual cost for maintenance has been 1¼d. per square yard including shouldering. There are three or four quarries in the district and between 700 and 800 tons of metal are carried over that section every day. When it was first constructed iron tired lorries, carrying between 6 and 7 tons of metal, were using the road. To-day the limit is 8 tons per axle, but the motor lorries travel up to 20 miles per hour. That is the most severe test to which any road within my knowledge is subjected. In reconstructing that road we had to build one side while traffic continued on the other. That was a big disadvantage in maintaining the shape of the road, and added considerably to the cost. Except on the shoulders the maintenance of that portion above the quarries has been practically nil, and there is no evidence that any maintenance will be required within the next couple of years. Since the Federal Aid Roads Agreement has been in operation we have called for tenders for road construction as a check on the departmental estimates. At the present time the work is being done by the Road Construction Department, but the materials are supplied by contract. The fact that the Commonwealth Government has always approved of our federal aid roads being constructed by day labour is proof that the department has been able to tender successfully. In every instance but one the final cost was below the tender price. The Green Hills-road, which the committee saw yesterday, is bituminous penetration on an existing macadam base. For maintenance we are allowing £100 per mile per annum, but three quarters of that is absorbed in shouldering and drainage. That expenditure has to be incurred on any type of road. The Green Hills-road was commenced in October, 1928. We edge the road with rough stone, this serves to strengthen the shoulder and prevent the road from spreading under the influence of heavy traffic. South Australia is unfortunate in having practically no large deposits of gravel. We have small isolated pockets of gravel, but we have not been able to construct gravel roads to anything like the same extent as in Victoria and New South Wales. The price of metal delivered on the road depends upon the distance of the job from the quarry. The price averages 6s. per cubic yard in the bins. The Adelaide-Tweedvale-road is being constructed at approximately the same cost as the Green Hills-road. The lead from the Dunstan Quarry averages between 11 and 12 miles and the price delivered on the job is 12s. 6d. per cubic yard. The cartage is estimated at 6d. to 7d. per ton mile. On a good penetration road it might be 7d.; on a rough road, 8d. Unfortunately our metal is very mixed, and it is difficult to get a consistent sample from any quarry. That is one of the faults of quartzite, and we have no basalt like that in New South Wales. I have studied road-making in America and England and have seen abroad many examples of concrete construction. Given a big percentage of iron tired traffic the maintenance of a concrete road would be heavy. With mainly rubber tired traffic cement concrete would sustain very little wear. As soon as iron traffic gets on to an unprotected concrete road a certain amount of wear is inevitable. In such circumstances it is advisable to surface it with bitumen. The only sections of concrete roads that have been put down in South Australia have been short and isolated, and it is difficult to estimate what would be the average cost. We have always calculated that a properly designed cement concrete road in the metropolitan area would cost about 17s. 6d. per square yard. Short strips of cement penetration have been laid; that class of construction on a long stretch of road would cost about 8s. per square yard. The experimental sections that

have been put down have not been sufficiently long under traffic to enable us to estimate their durability. My opinion is that if they are subject to iron traffic the maintenance cost will be heavy in comparison with other roads unless they are covered. If they are surfaced they become expensive. It is advisable to allow a road to settle before putting any permanent type of surfacing on it. It can be temporarily surfaced with gravel or other local material, and when traffic has been using it for twelve months a good foundation for any type of surface will be available. It would be courting failure to put even a concrete base on a new road immediately. A good gravel road will carry up to 400 vehicles a day for three or four years with proper maintenance. Much depends on the convenience you are prepared to give to the public. On a gravel road dust is a nuisance and you have to consider whether it is not worth while to incur the cost of providing a better surface in order to obviate that inconvenience. The number of vehicles using a road does not give much idea of the work which the road is actually doing. Two or three hundred commercial vehicles would do more damage than 5,000 motor cars, but having regard to the class of traffic that is likely to use the Federal Highway, I should say that a bitumen penetration road would carry up to 2,000 vehicles a day without much maintenance cost. One road in this State is carrying 1,200 vehicles per day. The first portion of it was laid three years ago and we have spent nothing in maintenance except in respect of failures due to the water trench. My experience of cement penetration is not sufficient to warrant me in expressing an opinion regarding its suitability for Canberra. My advice would be to put down a gravel road for the time being, allow it to be consolidated by traffic and then surface it with bitumen. Within Canberra itself you could not do better than employ cement concrete. In a garden city you want something more than mere wearing qualities. Cement concrete has a pleasing appearance and its one disadvantage is the glare in summer. If concrete roads at Canberra are costing £14,000 per mile, the figure seems high, but much depends on the cost of materials and the basic wage. If I were constructing concrete roads under conditions similar to those in Canberra, I would employ reinforcement at the corners and on the edges; I have not had much experience of mesh reinforcement throughout.

84. *To Mr. Gregory.*—The section of cement penetration in Dunniker-road, Port Adelaide, was laid as a test under the direction of the cement manufacturers, but not in accordance with the ideas of my department. In order that there should be no doubt regarding the genuineness of the test, the construction was handed over to Mr. Sunderland, of Melbourne. He was scared by the heaviness of the traffic, and put down an extra thickness of cement penetration. One difficulty in this type of construction is to get an even surface. Cement penetration would not require surfacing for motor traffic, but Dunniker-road is used by excessively heavy iron traffic. Sub-soil drainage will correct the disabilities of spewy ground such as that through which portion of the Federal Highway passes. On ground that is doubtful or spongy we put a coating of sand or rubble before adding the metal. In constructing the Green Hills-road the metal was rolled heavily before the bitumen was applied. Provided the base is good, a heavy roller does not cause much movement in a shallow depth of metal. Some metal will not compact; the more you roll it the worse it becomes. Porphory, however, should stand heavy rolling. There is so much competition for cartage that prices are down as low as 5d. per ton mile. The Tweedvale-road is being constructed with portion of the special grant of £1,000,000 made by the Commonwealth Government recently for the relief of unemployment. The main purpose of the road is to serve and develop the market gardens' traffic.

Ordinary developmental roads in the country are constructed by the local government authorities, who usually invite tenders.

86. *To Senator Dooley.*—I should think that a 3-inch coat of cement penetration before adding the 3-inch of bitumen penetration would be inclined to crack. In new formations the banks should be allowed to settle for a winter. It is advisable to allow the traffic to compact the base, but in urgent cases we have put bitumen penetration straight on to small deviations. We have come to the conclusion, however, that it would have been better to wait, because the maintenance cost for the first year or two was bound to be high on account of settlement. The wages of the men employed in reconstructing the Tweedvale-road are as follow:—

HIGHWAYS AND LOCAL GOVERNMENT DEPARTMENT.

PRINCIPAL RATES OF PAY.

	Per hour.		Per day.
	s. d.		s. d.
Bituminous Concrete Workers—			
Boardmen	1 10½	or	15 3
Barrowman	2 1	,,	16 8
Feederman	2 0½	,,	16 6
Kettlemen	2 0½	,,	16 5
Mixers and weighers	2 5½	,,	19 8
Motor drivers	from 2 0½	,,	16 1
	to 2 2½	to	17 5
Plant labourers	1 11½	or	15 6
Plant foremen	2 11	,,	23 4
Raker (hot)	2 1½	,,	16 11
Roller drivers	2 2⁷/₄₈	,,	17 5¼
Shovellers (hot)	2 0½	,,	16 2
Labourer on road in or about bitumen ..	1 10½	,,	14 11
Bituminous Penetration Workers—			
Labourers in or about bitumen ..	1 10½	or	14 11
Labourers (other)	1 10½	,,	14 9
Kettlemen, pourers	2 0½	,,	16 5
Road Foremen	from 2 6½	,,	20 4
	to 2 8	,,	21 4
Roller drivers	2 2⁷/₄₈	,,	17 5¼
Metal spreader	1 10½	,,	15 3
Pitchers	1 11½	,,	15 9
Gangers	2 1½	,,	17 3
	to 2 3½	to	18 3

NOTE.—*Country workers*, —plus 1s. per day camp allowance.

Of course, the rate of wages affects only that proportion of the cost which is due to labour. The total labour cost on a bituminous penetration job is from 9d. to 1s. per square yard, so that the variation between the rates in New South Wales and South Australia would not represent a difference of more than 3d. per square yard.

86. *To Senator Reid.*—I have been in the service of the South Australian Government for nearly twenty years, and had experience of ordinary road construction before handling bitumen and concrete. The old water-bound macadam road, before the advent of the motor-car, used to last about seven years before requiring re-conditioning. But when subject to motor traffic it became very rough within twelve months. A gravel road in the Federal Capital Territory could be given an indefinite life by adding new material every year, but the cost of maintenance would be proportionately large. It might be about £200 per mile per annum. The upkeep consists principally in maintaining the shape of the surface and replacing the metal that is worn or washed away. At a maintenance cost of £200 per mile per annum, a gravel road would stand the wear and tear of motor traffic. A gravel road might be cheaper, but it is questionable whether a road entering the Federal Capital should not be as free of dust as is possible. Even under the best conditions a gravel road does create dust. If gravel is employed it should have a compacted depth of 6 inches. Our experience in South Australia shows that a stone edging is necessary on practically all penetration roads. It is more difficult to get an even surface with cement penetration than with bitumen penetration, because, when using cement a greater depth of metal has to be penetrated; 6 inches is the minimum. It is a rigid type of paving and, unless it has a good body, is inclined to crack. The depth of it makes hollows unavoidable. From an economical point of view concrete roads are not necessary in Canberra, but you are dealing with a federal capital city, in which appearance must be studied. A good road will improve the appearance of the city, and concrete is more pleasing to the eye than bitumen. It is a matter to be determined by the amount of funds available. I am not considering whether cement is better than bitumen. I am concerned to get the greatest length of standard road with the money available.

87. *To Mr. Curtin.*—My department has an extensive plant for the construction of roads. Part of the quarrying equipment is hired to contractors. If we employed only contractors who have their own plant, they would have almost a monopoly of the work, and there would be no competition. By making our own plant available, and charging the contractors so much per day for the use of it, we get more competition. They tender merely for the supply of material; we do not hire out the road-making plant. The department does practically the whole of the road construction and the whole of its plant is in commission. The department has no quarries. If we put our plant into a quarry we tender from that quarry. We decide which quarry has the best class of metal. Where several quarries are available, we call for tenders and allow the contractor to employ his own plant. No roads have been constructed by contractors for the department. The only maintenance required on the concrete section of the Henley Beach-road is for the repair of small defects. The concrete is laid on a raised causeway over a swamp, and is only subject to light motor traffic. Despite construction breaks cracks will occur, and they involve a slight maintenance charge. If such a road were subject to iron-tyred traffic the wear and tear on the joints and cracks would become excessive and maintenance would be very heavy. If that road did not pass through a flood area the volume of traffic on it would not warrant concrete construction. On a road that has a light traffic burden concrete is not warranted except for the sake of appearance. The Adelaide-Glenelg-road was constructed six years ago. It has only 2 inches of bitumen concrete on the old macadam, and the traffic averages from 5,000 to 6,000 vehicles per day, including, until recently, double-deck buses. It is still carrying the traffic successfully. No doubt the foundation is very good. Being only 2 inches thick the cost did not exceed 8s. per square yard. A cement road would have cost 10s. In making a new road you are bringing the cost of bituminous penetration up to the level of concrete. When providing an absolutely new road, one must allow time for the foundations to settle. I would recommend a surface of gravel to carry the traffic temporarily, and that would become a foundation for the permanent surface to be applied later. If agricultural drain pipes are necessary they should be put down under the permanent surface.

88. *To Mr. Long.*—If a bitumen penetration road is properly put down it should not have a tendency to form pot holes. The old type of penetration road did corrugate, but that was due to faulty construction—inadequate compaction, and uneven distribution of the bitumen, causing the surface to lift in hot weather. This class of work has greatly improved. The present load limit on a bituminous penetration road is eight tons per axle or four tons on each wheel. Light motor traffic should have very little effect on a good, bituminous-penetration road. We employ stone edging on all penetration roads. With a four-ton wheel load the strain on the edge of a road is very heavy. The main advantage of the edging is to strengthen the shoulder, which is the weakest part of any road. The kerbing costs about £240 a mile. The proposed Federal Highway is beyond the environs of the city, and, therefore, the initial expenditure of laying a concrete road would not be justified. I would recommend bituminous penetration. Soft gravel would be no detriment to that method of construction. An excess of dust in the gravel might prevent the bitumen from penetrating effectively. I saw the type of screenings that are used at Canberra, and I do not think the proportion of dust was sufficient to be objectionable. The installation of equipment to suck the dust out of the screenings would be costly, but the Mines Department has suggested the installation of a suction plant to get rid of the dust for the sake of public health.

89. *To Mr. Cameron.*—The ordinary macadam road is obsolete for motor traffic unless top-dressed in some way. Fast traffic, instead of consolidating it, causes it to disintegrate. The cost of bitumen penetration is considerably less now than when we started. For instance, the Gorge-road cost 6s. 4d. per square yard; now we are doing similar work for 5s. 1d. This is due to reduced cost of metal supplied, larger output, better organization, and improved knowledge. We try to keep our gangs permanently employed, except the men engaged with pick and shovel on formation work. The bitumen penetration roads are built to a standard specification, but I believe the Mount Gambier to Port Macdonnell-road is of slightly less thickness than the Green Hills-road. We used a smaller grade of metal, and that meant less thickness of material when consolidated. That road has quite a good foundation and will carry any traffic. In building a new road I would not recommend penetration before it has been compacted by traffic.

90. *To Mr. Curtin.*—A road 16 feet wide would not be adequate for the Federal Highway. That should be built to the standard width of arterial highways in New South Wales. We build to a width of 16 feet only where we consider volume of traffic does not warrant a wider road. By reducing the width to 16 feet we are able to build a greater mileage with the same amount of money. The maintenance of the shoulders on a narrow road is slightly higher, but not sufficient to make up the difference between the capital cost of 16 feet and 20 feet widths. The Victor Harbour-road is only 16 feet wide. It has been laid for three years, and there has been no shoulder maintenance to date.

91. *To Mr. Cameron.*—The passing traffic at any particular point is very small, and if it gets off the shoulder the wear and tear is not very heavy, provided the shoulder is kept in order.

92. *To Mr. Curtin.*—A road wide enough to permit three vehicles to pass simultaneously is dangerous; it encourages passing. A width of 20 feet is standard for two-ways traffic on main roads.

93. *To the Chairman.*—I do not see any great advantage in concrete kerbing. It has a better appearance than stone, but the extra cost is not warranted. I am not aware of any undue wear on the Callington bituminous penetration road. The Port Wakefield-road near Two Wells is not of penetration type; it is a limestone road that has been covered with bitumen. There we are dealing with an inferior class of stone; but the results we have had from it during the last two or three years have been wonderfully good. I would not expect to get anything better than the last 16 miles of that road.

94. *To Mr. Long.*—On the 16-ft. road we camber 3 inches; on a 20-ft. road 3½ inches is sufficient.

95. *To Mr. Holloway.*—I understand that adjacent to the proposed federal highway deposits of suitable rubble are available. Under average conditions the additional cost of an entirely new road would be 2s. 6d a square yard. If a gravel or rubble road is put down to be surfaced later, value is got from it by allowing the traffic to use it while it is consolidating.

96. *To the Chairman.*—A good cement penetration road should cost approximately 8s. a square yard. Tenders were invited for the road from Selleck's Hill to Noarlunga. Included in the tenders was an offer from the cement companies to construct a cement penetration road 6 inches thick and not reinforced. Their tender was £4,000 per mile for a 16-ft. roadway without any drainage or side shouldering. Bituminous penetration is costing 4s. 10d. per square yard complete with drainage and shouldering.

97. *To Mr. Curtin.*—The men engaged on the Mount Barker-road construction work 48 hours in five days.

(Taken at Canberra.)

(Sectional Committee.)

TUESDAY, 4TH MARCH, 1930.

Present:

Mr. LACEY, Chairman;

Mr. Curtin	Mr. Holloway.

William Elmhirst Potts, Chief Engineer, Federal Capital Commission, sworn and examined

99. *To the Chairman.*—I am aware of the proposal to construct a federal highway from the boundary of the Federal Capital Territory to the city. The work begins at the intersection of Northbourne-avenue and the Canberra-Yass road. At the point of commencement the mileage is 26 miles, and 3,571 feet from Collector and the elevation is 1,875 feet. The road is located at first in the northerly prolongation of the constructed portion of the eastern roadway of Northbourne-avenue and continues therein to mileage 25 miles and 4,100 feet (near the northern limit of the city plan), i.e., about a mile from the point of commencement. It then turns on a curve of 2,000 feet radius to run in a north-easterly direction. The road at first runs parallel to and distant about 700 feet westerly from the located route of the Canberra-Yass railway but crosses the location of the railway at 25 miles and 2,900 feet, i.e., about 1 mile and 851 feet from the point of commencement. The lowest part of a low range is crossed at a point known as Ginn's Gap, elevation 2,263 feet, distant approximately 4 miles and 3,880 feet from the point of commencement. The work in the Federal Capital Territory terminates on the Federal Capital Territory-New South Wales boundary, elevation 2,268 feet, at a distance of 4,838 feet from Ginn's Gap. Total length is 5 miles and 3,438 feet. Fine vistas of the Canberra Valley will be obtained by the traveller from Sydney at the point of crossing the range at Ginn's Gap, and at other points as he approaches the city. For three miles from the commencement of the work the country traversed is clear of timber and gently rising, and the earthworks are light. Thereafter the country is open timbered and the location is in sidling ground. The earthworks in this part are heavier. The deepest cutting is approximately 6 ft. 6 in. deep and the highest fill is approximately 11 feet. The sharpest curves (of 500 feet and 600 feet radius) occur at Ginn's Gap; all others being of 1,000 feet or 2,000 feet radius. Curves are super-elevated in accordance with the following table:—

Radius of curve 500 feet or less, 1 inch per foot side slope.
Radius of curve 550 feet to 800 feet, ¾ inch per foot side slope.
Radius of curve 850 feet to 1,400 feet, ½ inch per foot side slope.
Radius of curve 1,450 feet to 1,950 feet, ⅜ inch per foot side slope.

Owing to the large radii of the curves in this particular job, no widening is required and super-elevation is only required for two curves, those at Ginn's Gap. The heaviest grade is one in twenty and the minimum grade is one in 300. Vertical curves have been determined so as to give a visibility of not less than 500 feet. That visibility is calculated with the eye of the observer 4 feet above ground. The grading, curvature, &c., conforms to the best standards and the road is properly designed for fast motor traffic. Outside the city area the work conforms with the Main Roads Board of New South Wales details for the same highway in New South Wales. The paved width will be 20 feet, the shoulders will be 4 feet wide and the formation 28 feet wide. The formation width is measured between the tops of banks and the bottoms of cuttings. The clear width of bridges and culverts will be 20 feet between kerbs except that pipe

and box culverts will be made sufficiently wide to carry the full 38 feet width of formation. In the city area the width of shoulders will be increased to 5 feet to conform with the city standards. The formation will thus be 30 feet wide in that section and pipe and box culverts will be made an extra 2 feet wide accordingly. Surface water drainage will be collected by table and catch drains, and the water will be carried under the road by pipe and box culverts, all constructed in reinforced concrete to designs standard for the whole of the highway. The pipe culverts will vary from 15 in. to 36 in. diameter. The pipes will be purchased from the Commission by the contractor. Box culverts range in size from one opening 6 ft. x 3 ft. to three openings 6 ft. x 3 ft. each. There will be one bridge opening of 30-ft. span at mileage 25 miles 2,500 feet, which is so designed that it can easily be enlarged later by the construction of an additional span to carry storm-water which it will be called upon to discharge should ever the Mt. Ainslie intercepting drain be extended in a northerly direction to protect further development of the city subdivision. The metal, sand, and cement required will be purchased from the Commission by the contractor. The reservation for the road is 200 feet wide within the limits of the city plan, and 100 feet wide elsewhere. Provision is being made for an avenue of trees alongside the road.

100. *To Mr. Curtin.*—The trees will be planted about from 30 to 35 feet from the centre of the road, and adequate provision will be made for the subsequent erection of any telegraph and telephone poles. It depends, of course, upon the type of tree planted and naturally we shall, if possible, plant native trees. The plans and specifications for this work have been approved by the Works Department and the Commission is acting as the constructing authority on behalf of that department. Tenders for earthworks and drainage structures were called in Melbourne, Sydney and Canberra, and were made returnable on 4th June, 1929. The maintenance period specified was two months. The following schedule sets out the tenders received and the departmental estimate:—

EARTHWORKS, ETC., FEDERAL HIGHWAY.

Item.	Quantity	Rate.	J. Fowler and Co.	Rate.	W. D. McDonald.	Rate.	H. Wallace and Son.	Rate.	Aust. Roads Ltd.	Rate	Depart-mental.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Clearing and Grubbing	20 acres.	9 10 0	190 0 0	25 0 0	500 0 0	10 0 0	200 0 0	25 0 0	500 0 0	8 0 0	160 0 0
Earthworks	31,930 cub. yds.	0 5 0	8,290 15 0	0 0 3	9,978 2 6	0 8 4	13,304 3 4	0 7 0	11,972 15 0	0 6 7	11,575 0 0
Trim and consolidate subgrade and shoulders	298.4 (p. 100)	6 3 10	1,847 17 7	3 10 0	1,044 8 0	10 10 0	3,129 0 0	5 3 8	1,546 14 1	5 0 0	372 10 0
Pipe culverts—18"	274 feet.	0 13 5	183 0 6	0 14 0	191 16 0	0 15 0	200 0 0	0 10 9	147 5 8	0 11 0	150 14 0
Pipe culverts—21"	151 feet	1 2 1	169 11 11	1 2 6	169 17 6	1 0 0	151 0 0	0 16 9	126 9 3	0 17 6	132 2 6
Pipe culverts—30"	266.5 feet	1 9 11	338 8 8	1 5 0	336 8 6	1 5 0	322 0 0	1 2 9	303 2 10	1 2 6	313 14 6
Pipe culverts—36"	506 feet.	1 13 6	953 18 0	1 12 0	953 12 0	1 10 0	853 0 0	1 4 0	715 4 0	1 5 6	759 18 0
Pipe culvert headwalls (concrete)	63 cub. yds.	5 5 8	332 15 3	6 10 0	409 10 0	7 9 0	567 0 0	9 16 0	428 8 0	8 0 0	504 0 0
Steel in headwalls	3 cwt.	2 2 0	6 5 11	1 15 0	5 5 0	2 0 0	6 0 0	1 9 0	3 12 0	1 12 0	4 16 0
Concrete in box culverts (with headwalls)	294 cub. yds.	8 2 0	2,389 8 2	7 10 0	2,205 0 0	7 9 0	2,646 0 0	7 0 0	2,058 0 0	6 10 0	1,911 0 0
Steel in box culverts	302 cwts.	2 2 4	638 18 9	1 15 0	528 10 0	2 0 0	604 0 0	1 7 0	362 6 0	..	488 0 6
Catch drains	1,207 cub. yds.	0 3 10	230 7 9	..	445 0 0	..	400 0 0	..	..	..	144 0 0
Trim and form batters	29,800 feet.	..	..	..	..	..	..	..	..	..	447 0 0
Concrete Bridge	..	..	1,104 2 1	..	840 0 0	..	1,000 0 0	..	1,355 8 0	..	824 0 0
Maintenance of works	..	..	137 9 0	..	..	(Office)	20 0 0	..	..	..	..
Excavation for box culvert	..	..	..	..	..	..	..	..	..	..	67 10 0
Camp and water supply	..	..	..	..	..	..	..	..	..	..	500 0 0
Field overhead charges	..	..	..	..	..	..	..	..	..	..	892 0 0
Provisional sum	..	..	500 0 0	..	500 0 0	..	500 0 0	..	500 0 0	..	500 0 0
Total	..	..	17,809 7 7	..	18,157 9 6	..	23,912 3 4	..	20,029 7 5	..	19,740 5 0
Time for completion	..	..	Six months.	..	Not shown.	..	Six months.	..	Four months.	..	Six months.

The following is a copy of the detailed departmental estimate:—

ESTIMATE (DEPARTMENTAL) FOR CONSTRUCTION OF EARTHWORKS, CULVERTS AND REINFORCED CONCRETE BRIDGE ON FEDERAL HIGHWAY.

Item.	Description.	Quantity.	Rate. Labour.	Rate. Material.	Labour.	Material.	Total.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
	Earthworks .. ..cub. yds.	31,930	0 7 3	..	11,575 0 0	..	11,575 0 0
	Clearing and grubbing .. .. .. acres	20	8 0 0	..	160 0 0	..	160 0 0
	Consolidating sub-grade and shoulders	298	..	1 5 0	..	372 10 0	372 10 0
	Trimming formation and batters ..	298	1 10 0	..	447 0 0	..	447 0 0
	Catch drains .. .. .. 100 lin. ft.	36	4 0 0	..	144 0 0	..	144 0 0
	R.C. pipe culverts—						
	36-in. R.C. Pipe .. .. .. lin. ft.	506	0 4 0	1 1 6	119 4 0	640 14 0	759 18 0
	30-in. R.C. pipe .. .. .. lin. ft.	267	0 3 6	1 0 0	46 14 0	267 0 0	313 14 6
	24-in. R.C. pipe .. .. .. lin. ft.	151	0 3 0	0 14 6	22 13 0	109 9 6	132 2 6
	18-in. R.C. pipe .. .. .. lin. ft.	274	0 2 0	0 9 0	27 8 0	123 6 0	150 14 0
	Concrete in headwalls .. .. ..cub. yds.	63	2 0 0	6 0 0	126 0 0	378 0 0	504 0 0
	Reinforcement in headwalls .. .. cwt.	3	0 7 0	1 5 0	1 1 0	3 15 0	4 16 0
	Box culverts—						
	Excavation .. .. .. cub. yds.	270	0 5 0	..	67 10 0	..	67 10 0
	Concrete, including framework	294	2 0 0	4 10 0	588 0 0	1,323 0 0	1,911 0 0
	Reinforcement .. .. .. tons	15½	7 0 0	25 0 0	106 15 0	381 5 0	488 0 0
	Camp establishment and temporary buildings ..	..	..	..	20 0 0	100 0 0	120 0 0
	Water supply	..	..	..	..	450 0 0	450 0 0
	Contingency sum	..	..	..	250 0 0	250 0 0	500 0 0
	Tool depreciation, 1 per cent. on labour	..	..	..	13,701 5 6	4,398 19 6	18,100 0 0
	Accident pay, 1 per cent. on labour	..	..	..	..	..	137 0 0
	Holiday and wet pay, 4 per cent. on labour ..	..	..	..	..	..	137 0 0
	Cost of reinforced concrete bridge	..	..	..	..	..	548 0 0
	Net total for comparison with Tender ..	..	..	..	..	..	824 0 0
						..	19,746 0 0

The work of erecting fencing and gates is being supervised by the Lands Department of the Commission, and the estimated cost thereof is £1,300, the lowest and successful tenderer being Mr. A. E. Monk, of Queanbeyan. The road work was commenced by the contractors, Messrs. Fowler and Company, early in July, and the contract date for completion was 10th December, 1929. The contract date has already been exceeded by several months. The extra time taken on the job will increase the cost of supervision, the additional cost of which will have to be recovered from the contractors. But otherwise no liquidated damages will be incurred or inconvenience caused because it will be impracticable to use the road until the construction of that section in New South Wales has reached a trafficable stage. It is anticipated that the whole of the work, including surfacing, will be completed by the end of the year. There have been certain variations of the contract, particularly in respect of drainage structures, but that will not add anything to the cost. The total additions to date amount to £497 5s. 1d., and the total deductions to £599 2s. 3d., so that the balance in favour of the deductions is £101 17s. 2d. Taking the contingency sum of £500 into account, it will therefore seem that the contract will be completed for about £600 less than the actual accepted figure. The Commission is carrying out the work free of survey and other administrative charges. Only the actual cost of the supervisors on the job is being charged to the Works Department. The following is a statement of the additions and deductions to date:—

STATEMENT OF ADDITIONS AND DEDUCTIONS ON MESSRS. JOHN FOWLER'S CONTRACT. FEDERAL HIGHWAY

—	—	Addition.	Deduction.
		£ s. d.	£ s. d.
1	Box culvert at 23m2730—3/6 x 3—to be placed at an angle of 63 degrees to centre line of road. Invert level raised to 90.15. Length to be 43 feet instead of 48 feet. Estimated cost of deduction 5-ft. length = 6¼ cubic yards @ £3 2s. 6d. = £50 15s. 8d.; 2¾ cwt. steel @ £2 2s. 4d. = £6 16s. 4d.	..	57 11 0
	Extra concrete in curtain wall—44 cubic feet @ £3 2s. 6d. per cubic yard	13 4 8	
2	Extra pipe culvert at 0m4150—36 feet x 18 inches	24 3 0	
3	Extra pipe culvert at 0m4570—33 feet x 15 inches	16 10 0	
4	Extra pipe culvert at 22m625—35 feet x 15 inches	17 10 0	
5	Extra pipe culvert at 22m1100—34 feet x 15 inches	17 0 0	
6	Extra pipe culvert at 23m1150—32 ft. 6 in. x 15 inches	16 5 0	
7	Extra pipe culvert at 24m650—33 ft. 4 in. x 15 inches	16 13 4	
8	Deduct 2/30-in. R.C. pipe culvert at 24m1600	..	118 3 5
9	Extra pipe culvert at 26m3150—78 feet x 30 inches, double	110 13 6	
10	Extra pipe culvert at 26m3460—78 feet x 30 inches, double	110 13 6	
11	Deduct 18-in. pipe culvert at 26m3150—33 feet long	..	22 2 9
12	Additional catch drains at 24m650 to 24m1700—1,050 lineal feet x 1 foot deep and 1 to 1 side slopes =78 cubic yards @ 3s. 10d.	18 0 0	
13	Additional catch drain—24m1600 to 24m2600—1,000 feet x 6 feet x 1 ft. 6 in. = 417 cubic yards @ 3s. 10d.	79 18 6	
14	Culvert at 25m1018—Reduce length from 47 feet to 36 feet = 11 feet = 13.8 cubic yards concrete @ £3 2s. 6d. = £112 2s. 6d.; 14.6 cwt. steel @ £2 2s. 4d. = £30 18s. 1d.	..	143 0 7
15	Deduct 46 feet—6 feet x 3 feet box culvert at 26m3460— Concrete in culvert — 2¾ cubic yards @ £3 2s. 6d.	..	205 3 2
	Reinforcement — 25.07 cwt. @ £2 2s. 4d.	..	53 1 4
16	Catch drain addition—26m3150 to 3460—150 feet long—major section 3 feet deep, say 33 cubic yards @ 3s. 10d.	6 6 6	
17	Additional re-inforcement and concrete in pipe culvert headwalls— *Concrete* *Reinforcement*		
	0m4150 (18 inches) .. .. .85 cubic yards .. 4.5 lb.		
	0m4750 (15 inches) .. .. .67 cubic yards .. 4.25 lb.		
	22m625 (15 inches) .. .. .67 cubic yards .. 4.25 lb.		
	22m1100 (15 inches) .. .. .67 cubic yards .. 4.25 lb.		
	23m1150 (15 inches) .. .. .67 cubic yards .. 4.25 lb.		
	24m650 (15 inches) .. .. .67 cubic yards .. 4.25 lb.		
	26m3150 (30 inches) x 2 .. .. .. 3.75 cubic yards .. 23.40 lb.		
	26m3469 (30 inches) x 2 .. .. .. 3.75 cubic yards .. 23.40 lb.		
	11.70 cubic yards .. 72.55 lb.		
	Deductions reinforcement and concrete in pipe culvert headwalls— *Concrete* *Reinforcement*		
	24m1600 (2/30 inches) .. .. 3.75 cubic yards .. 23.4 lb.		
	24m3150 (1/18 inches) .. .. .85 cubic yards .. 4.5 lb.		
	4.60 cubic yards .. 27.9 lb.		
	Additions .. .. 11.70 cubic yards .. 72.55 lb.		
	Deductions .. .. 4.60 cubic yards .. 27.90 lb.		
	Balance additional—		
	7.1 cubic yards concrete @ £5 5s. 8d.	37 10 3	
	.4 cwt. steel @ £2 2s. 4d.	16 10	
		497 5 1	599 2 3
	Total Balance Deduction	101 17 2	

Note.—This does not include extras for additional rates charged for purchase of concrete pipes by Controller of Stores.

In respect of the surfacing of the road, the actual type of pavement to be laid down was not decided upon before the commencement of the work. After consideration, the conclusion was reached that it would be desirable to proceed with the earthworks and all drainage structures, and as the formation progressed to note the class of country passed through and the local materials that might be suitable for pavement work. It was thus hoped to find a good gravel suitable for surface treatment with bituminous materials. Stage construction was adopted and a surfaced road was aimed at throughout. On the contract plans the levels of the earthworks were so fixed and the boxing out so specified that it would be possible as a first construction stage to provide a thin 3-inch wearing course of gravel to carry the traffic during consolidation of

the earthworks. It was considered that this gravel would be available either as part of the pavement foundations or as material for use on the shoulders of the road when the time came to construct the final surfacing. When the committee inspected the road it will be remembered that I pointed out the site from which the gravel would be obtained. That site was determined upon after a most thorough investigation, assisted by the Commonwealth Geological Adviser. No new proved mass of stone or gravel was found within payable distance of the road. The gravel for the base course will be supplied to the works from Black Mountain gravel pits at 4s. 3d. per cubic yard at the pit, and 8s. per cubic yard crushed for surfacing. Good deposits of natural gravel are practically non-existent near the city area. It is therefore necessary to make most of the gravel that is used on the roads. The nature of the traffic will warrant only a light type of bituminous surface course at first. Experiments will be tried on existing city roads constructed of Black Mountain gravel to prove the possibility of the proposed method of surface treatment. (*a*) This method comprises a first spray with a light tar or bitumen road oil as a primer coat. (*b*) Sealing with 80-100 penetration bitumen, finished with ⅜-inch metal chips from Mugga quarry applied at the rate of approximately 150 cubic yards per mile. If the experiments are successful, and the experimental work will be subjected to similar traffic to that anticipated on the highway, this method will be adopted. The gravel pavement will be first subjected to traffic for a period of approximately three months, meantime being kept in proper condition and shape with power graders, prior to the commencement of sealing operations. The total estimated cost of this class of work, if adopted, is approximately £5,000, or about 1s. 6d. per square yard; this estimate being based on a treated width of 18 feet. It will be noticed that a width of 18 feet of bitumen surface is mentioned. The idea is to gradually enlarge the width of the road to 20 feet when carrying out the subsequent necessary applications of bitumen. The width of 18 feet is considered sufficient in the first instance, but the gravelling is actually being carried out to a width of 20 feet. The estimated cost of the gravelling, including the cost of maintenance and grading for three months, is £12,000. The length of the job is 5.7 miles, the distance from the pit to nearest end of job being 3 miles. The average lead is about 6 miles. The specification now calls for 6 inches of consolidated gravel pavement, consisting of 5-inch loose run of pit gravel and 3-inch loose crushed gravel. The number of square yards in the 20-feet width is 66,310. The following is a detailed estimate of the cost of gravelling:—

ESTIMATE FOR GRAVELLING—FEDERAL HIGHWAY.

Item	Description.	Quantity.	Rate. Labour.	Rate. Material.	Labour.	Material.	Total.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
	Length, 29,840 lineal feet. Width 20 feet = 66,310 square yards						
	Total, 8-in. loose gravel pavement						
	5-in. loose pit run gravel at 4s. 3d. per cubic yard loaded						
	3-in. crushed gravel at 8s. per cubic yard, loaded						
	Average load—say, 6 miles						
1	Forming and boxing shoulders, .. 100 lineal ft.	..	1 0 0	..	208 8 0	..	208 8 0
2	Pit gravel (Pit, 4s. 3d.—Cartage, 6s.) cubic yards	9,200	0 1 6	0 10 3	690 0 0	4,715 0 0	5,405 0 0
3	Crushed gravel .. .. cubic yards	5,600	0 1 6	0 14 0	420 0 0	3,920 0 0	4,340 0 0
4	Rolling sub-grade and gravel .. .. days	150	..	6 0 0	..	900 0 0	900 0 0
5	Maintenance for four months—						
	Six miles at £100 per mile .. per annum		..	..	100 0 0	100 0 0	200 0 0
	Field supervision and overhead on labour (6 per cent.)		..	..	..	..	300 0 0
	Contingencies		..	..	..	..	200 0 0
							11,643 8 0
	Add £300 for removal, repair and erection of plant ..		..	..	..	..	300 0 0
	Say: £12,000						11,943 0 0
	Time required, 4½ months.						

The sealed surface to be satisfactory will require to be maintained for about one year and then given a further coating of bitumen. The total estimated cost of the bitumen sealed surface would therefore be £8,925, including cost of maintenance for one year at £100 per mile per annum, £600; cost of third seal coat at 1s. per square yard, £3,325; and initial cost, £5,000. The following is a detailed estimate of the two-course seal coat:—

ESTIMATE FOR TWO-COURSE SEAL COAT—FEDERAL HIGHWAY.

Item.	Description.	Quantity.	Rate. Labour.	Rate. Material.	Labour.	Material.	Total.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
	Area, 66,310 square yards						
	Sweeping .. .. .. square yards	66,310	0 0 2	..	552 12 0	..	552 12 0
	First Course—						
	¼ gallon yard of bitumen and oil, 50 per cent. of each 80/100 bitumen .. .. .. tons	39	..	10 10 0	..	409 10 0	409 10 0
	Asphaltic base oil .. .. .. tons	39	..	10 10 0	..	409 10 0	409 10 0
	Heating .. .. gallons	16,580	0 0 0¾	0 0 0¾	51 16 3	51 16 3	103 12 6
	Second Course—						
	¼ gallon yard of 80/100 bitumen = 80/100 bitumen tons	78	..	10 10 0	..	819 0 0	819 0 0
	Heating .. .. gallons	16,580	0 0 0¾	0 0 0¾	51 16 3	51 16 3	103 12 6
	¾ inch screenings, 1/80 cub. yards, per sq. yard tons	850	0 2 0	1 5 3	85 0 0	1,073 2 6	1,158 2 6
	Spraying, gritting and rolling both courses sq. yards	66,310	..	0 0 3¼	..	898 0 0	898 0 0
	Plant hire	..	..	..	..	..	100 0 0
	Supervision	..	..	..	100 0 0	..	100 0 0
	Contingencies	5%	..	..	47 0 6	189 0 0	236 0 6
					988 5 0	3,901 15 0	4,890 0 0

Cost per square yards—1s. 5¾d.

If the experiments with the seal coat are not successful, it is proposed to lay down what is known as a "retread" surface. This form of construction has been successfully tried on the Canberra-Queanbeyan road. The following is the specification for that class of construction:—

SPECIFICATION FOR SURFACE MIX TAR MACADAM.

DESCRIPTION.

The work comprises the following operations:—

(*a*) The preparation of the sub grade including shoulders, boxing and consolidation to such width and convexity as may be specified.
(*b*) The spreading of a layer of crushed stone on the prepared sub-grade.
(*c*) The spraying of surface with tar at the specified quantity per square yard.
(*d*) The blading and surface mixing of tarred metal.
(*e*) Light rolling.
(*f*) The application of ¾-in. screenings to fill surface voids.
(*g*) Rolling to consolidation.
(*h*) The application of seal coat.

BROKEN STONE.

The broken stone shall consist of clean, tough, durable stone, free from dust, dirt or other foreign matter occurring either free or as a coating on the fragments and having a French co-efficient of wear of not less than ten (10). It shall be of one and a half (1½) inch gauge, and shall be uniformly graded between the specified screen sizes, and of such size that all will pass over a screen having circular openings not less than three-quarters (¾) of an inch nor more than one (1) inch in diameter, and through a screen having circular openings not less than one and three-quarter (1¾) inches nor more than 2 inches in diameter, and it shall be free from an excess of flat and elongated pieces. Only one class of material shall be used on any section of roadway.

SCREENINGS.

The screenings shall consist of material prepared from clean, tough, durable stone, having a French co efficient of wear of not less than ten (10), and shall be free from dirt and other foreign substance. They shall be of three-quarter (¾) inch and of five-sixteenths (5-16) inch gauge for the respective purposes hereinafter specified, and shall be free from stone dust.

TAR.

The tar used in this work shall conform to the following specification, which provides for two grades, as specified hereinafter:—

	Coke Oven Tar No. 2. Minimum.		Coke Oven Tar No. 3. Minimum.
Specific gravity at 77° F. ..	1.185	..	1.195
Free carbon, per cent. by weight	9 to 13%	..	12 to 17%
Distillation Test.	By Volume.		By Volume.
0° to 170° C., light tar oils not more than ..	2%	..	2%
170° to 230° C., light tar oils not more than ..	12%	..	7%
230° to 300° C., heavy tar oils at least and preferably more than: ..	14%	..	12%
Total oils	24 to 30%	..	19 to 25%
Pitch residue	70 to 76%	..	75 to 81%
Softening point of the pitch residue by the ring and ball method not less than	140° F.	..	140° F.

SUB-GRADE.

The sub-grade shall be trimmed and re-shaped and thoroughly consolidated in accordance with the plan and sections, and shall have a full width of 20 feet. All loose patches of material shall be removed and same replaced with suitable gravel or metal and consolidated by rolling.

SPREADING BROKEN STONE.

Broken stone shall be spread on the prepared sub-grade, in such quantities as will give a uniform thickness of 3 inches before consolidation. Spreading may be done by hand, or by means of grader.

SPRAYING AND MIXING.

The surface of the broken stone, after being spread on sub-grade, shall be sprayed with tar in accordance with that already specified for No. 2 tar, heated to a temperature of from 220° to 250° degrees Fahrenheit, at the rate of three-quarter gallon per square yard, by means of a pressure distributor.

The whole of the tarred metal shall be bladed into windrows by means of a power grader fitted with suitable blade in such a manner as will ensure every stone being turned over at least once. The blade shall be operated while set at an angle of 40 degrees and shall have the trailing end lowered. Blading operations shall be continued until the whole of the material shows even colour, and the surface has been brought to an even convexity as required, and the mass to a uniform thickness. Should any patches occur that have not received sufficient tar, these shall be lightly sprayed and again mixed with the grader.

The surface shall then be lightly rolled, with a roller weighing not less than 10 tons, and at the same time ¾ inch screenings already specified shall be spread on the surface at the rate of about 1 cubic yard to 50 square yards.

Screenings shall be spread evenly and with a full sweeping motion as the material leaves the shovel. Rolling shall be continued until all movement ceases under the roller, and the material is thoroughly consolidated for the full thickness.

APPLICATION OF SEAL COAT.

Within a few days after the completion of the mixing and consolidation of the macadam surface, a seal coat of tar conforming with that part of the specification for No. 3 tar shall be applied. The surface of the road shall be swept clean of any loose screenings and dirt, and any hollows and weak spots which may have developed shall be made good by removing material and reconstruction with the addition of new material, and thoroughly consolidated to correct profile. The tar, heated to a temperature of between 220 degrees and 250 degrees Fahrenheit shall then be applied to the surface by means of a pressure distributor in a uniform manner, and at the rate of ¾ gallon per square yard of surface.

Immediately after the application of the sealing coat of tar, dry 5-16-inch screenings, already specified, shall be spread over the surface in sufficient quantities to take up all excess tar, and rolled, the same precautions being taken in their application and in rolling as in that for the ¾-inch screenings, already specified. Excess application of screenings is to be particularly avoided.

The seal coat, as well as that part of the work already specified for spraying and mixing shall only be carried out when the surface is perfectly dry and the air temperature is not less than 50 degrees Fahrenheit.

The Canberra-Queanbeyan road, which was constructed to the above specification, has been down for about a year, and it is in perfect condition. The estimated cost for the re-tread type of construction, if adopted on the basis of a paved width of 18 feet, is, if metal from Mugga quarry is used, £17,990, or 6s. ½d. per square yard. If, however, a suitable stone can be obtained, say, at Mt. Ainslie or Mt. Russell, or if it proves possible after experiment to use the Black Mountain stone for this class of work, the estimated cost will be reduced to £15,150, or 5s. 1d. per square yard. The following are the alternative estimated costs—

ALTERNATIVE ESTIMATED COSTS.

	£	s.	d.
(*a*) Contract prices for earth work and drainage structures	17,890	7	7
Less possible savings, say	500	0	0
Total, say	17,400	0	0
Add cost of gravelling as estimated ..	12,000	0	0
	29,400	0	0
equal to approximately £5,170 per mile.			
FIRST ALTERNATIVE FOR SURFACING.			
(*a*) Bituminous seal coat, *add*	9,000	0	0
	38,400	0	0
or £6,750 approximately per mile.			
SECOND ALTERNATIVE FOR SURFACING.			
(*b*) Re-trend surface using Black Mountain or Russell Hill or Ainslie stone, *add*	15,150	0	0
	44,550	0	0
or approximately £7,830 per mile.			
THIRD ALTERNATIVE.			
Re-tread surface using Mugga metal, *add* or approximately £8,330 per mile.	17,990	0	0
	47,390	0	0

The following is the detailed estimate for the re-tread method of construction:—

ESTIMATE FOR RETREAD SURFACES—FEDERAL HIGHWAY.

Item.	Description.	Quantity.	Rate. Labour.	Rate. Material.	Labour.	Material.	Total.
			s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.
	Length, 20,340 feet						
	Area of retread—59,680 square yards, 18 feet wide						
	Making shoulders 5 feet wide each side cubic yards	2,260	6 0	..	678 0 0	..	678 0 0
	Metal, 3-inch loose Black Mountain cubic yards	4,975	2 0	14 0	497 10 0	3,382 10 0	3,879 0 0
	Screenings, 3/4 Mugga metal, 1/72 cubic yards per square yard						
	cubic yards	830	3 6	25 0	145 5 0	1,037 10 0	1,182 15 0
	Rolling .. .. .. square yards	59,680	..	0 4	..	994 13 4	994 13 4
	Grading .. .. .. ,, ,,	,,	..	0 2½	..	621 13 4	621 13 4
	Tar No. 2, ¾ gallon square yard .. .. gallons	44,760	..	1 4	..	4,476 0 0	4,476 0 0
	Tar No. 3, ¾ gallon square yard .. .. gallons	22,380	..	1 4	..	..	..
	Heating tar .. .. .. gallons	67,140	..	0 0½	..	139 17 6	139 17 6
	Seal coat—						
	¾ screenings	830	3 6	25 0	145 5 0	1,037 10 0	1,182 15 0
	Bitumen, ¼ gallon square yard	14,920	..	1 0	..	746 0 0	746 0 0
	Spraying .. .. .. square yards	59,680	..	0 2½	..	559 10 0	559 10 0
	Heating bitumen	14,920	0 0¾	0 0¾	46 12 6	46 12 6	93 5 0
	Field supervision and overhead on labour (6 per cent.)	..	..	..	..	..	100 0 0
	Contingencies	..	..	..	..	..	500 0 0
					5s. 1d. square yard ..		15,153 0 2
	Additional cost using Mugga metal throughout ..	4,975	2 0	25 0	497 10 0	6,218 15 0	6,716 5 0
					Less Black Mountain metal		3,879 0 0
							2,837 5 0
					Total cost 6s. 0¼d, ..		17,990 14 2

In regard to the general construction of the whole road, the first stage is to locate the route by inspection on the ground. The next stage is to have the road surveyed and pegged out on the ground, elevation taken, drawings made, grading and cross sections prepared and the design of drainage structures completed. An estimate is then made, specifications drawn up and the work is proceeded with either by day-labour or by contract. A contract defines the cost of the work with a provision under which additions and deductions can be made by the engineer. There is also provision for liquidated damages. After the contract is let the contractor establishes a camp, collects his plant and labour and commences work. It is usual to commence the drainage structures first, and then to proceed with the earthworks. In this instance, the contract was let for the construction of drainage structures and formation only. The gravel work is being carried out by the Commission's day-labour organization. The gravel for the base course is being obtained from the pits by hand loading and hand excavation. That is due to the fact that large stones are frequently found in a mass of gravel and it is necessary to pick them out by hand. It is, therefore, impracticable to load by machine. Gravel for the surface course will, however, be dug and loaded by machine, and put through the crusher in order to reduce it to the necessary gauge. It will then be placed on the road, rolled, and the whole of it subjected to traffic for a period of three or four months. That is done to ensure consolidation before the bituminous surface is applied.

101. *To Mr. Curtin.*—I should say that a period of three or four months would be sufficient in this case, as the earthworks are light. If the earthworks were heavy it would be necessary to have a longer period for consolidation.

102. *To the Chairman.*—I think that a period of two years would be too long. A lot depends on the actual traffic that develops on the roadway. If the traffic approaches anything like that on the road between Canberra and Queanbeyan, or even Bungendore, I should say that two years would be far too long, and would result in excessive maintenance costs in order to keep up the gravel surface. This is an important highway, and will provide a direct link with Goulburn. It will carry considerable traffic at certain periods of the year. The traffic will be fast, and therefore destructive to a gravel surface. It is not intended to put in kerbs. Miles of bituminous roads in New South Wales are supported by plank edging or have no edging at all, and either method seems perfectly satisfactory. The culverts will be located mainly in the natural water courses, and water will be concentrated thereto when necessary by the provision of catch drains on the upper side of the road. Our established practice now is to obtain gravel from the Black Mountain pit. It is proposed to use bitumen for the surface of the road. I have had experience of the cement penetration process. A section of the road in Giles-street, Kingston, comprising an area of about 1,400 square yards, is of that type. I have inspected similar roads in course of construction elsewhere. Cement penetration is more expensive than bitumen penetration. The bituminous penetration work, including the foundation, costs us about 11s. 0d. per square yard. The cement penetration work, and this really is not a fair comparison, because the work is so small, cost 16s. 3d. per square yard. But I know that cement penetration has proved to be very expensive elsewhere. The committee may, perhaps, be given information to the effect that the cost of such work is from 7s. to 8s. per square yard. I am of the opinion that a cement penetration road would not be justified in this instance. I have no information to indicate when the New South Wales section of the road will be completed, but I know that construction has commenced on a 10-mile section immediately adjacent to our end. The road when finished will be a light type of bituminous road. In that category I would include the seal coat, the retread, and two methods of bituminous macadam—(*a*) the penetration method, and (*b*) the hot mix method. We use machinery to spray bitumen on the roads. Hand-spraying is a perfectly good method provided that experienced men are available. In Canberra we have no continuous programme of road construction, and we have not attempted to develop an experienced corps of labourers for pouring bitumen by hand. We do not possess a spraying plant. We usually purchase tar

from the Broken Hill Proprietary Company at so much a gallon spread on the road. When spraying bitumen we hire a spraying plant. The same sprayer can be used for both tar and bitumen.

103. *To Mr. Holloway.*—There is no good pit of gravel available in Canberra. We have to make most of our gravel by putting the metal through the crusher. Transport is a big item, the average cost being about 9s. per cubic yard for this job. We have not yet applied the bituminous treatment to this particular class of gravel. That treatment requires a fairly clean type of gravel in order to get good results. I am waiting to ascertain how the gravel will respond to bituminous treatment. We let out by contract earthworks, drainage structures, and fencing. That is in accordance with the policy operating in connexion with Federal Aid roads. This is a Federal Aid road, and the work is being done by the Commission for the Works Department. It is my firm conviction that it is more profitable and practicable to have all the work carried out by one authority. I think that the type of road that we are now constructing will meet the present traffic needs. A concrete road would be entirely unjustified. The average cost of maintaining a bituminous surface is about £200 per mile per annum. Bituminous surfacing would require a seal coat say once in every three or four years. It would also require periodical attention by way of patrol and repairs to shoulders and elimination of pot-holes. A fair estimate for a seal coat is £400 a mile, and over a period of three years that would work out at the rate of £133 per mile per annum. The patrol work would cost about an additional £60, bringing the total to £200. The maintenance of a surface and shoulders would cost about the same. That is our experience of roads in the city area. By allowing a long period between the various stages of construction, we should add more to the cost of the actual application of the bitumen. If a road is to have a bituminous coating, it is preferable to apply it fairly soon after its construction. I estimate that the cost of this road when completed will be about £6,750 per mile. Fencing would cost about £200 a mile, and assuming that that is included in the estimate, the total cost would be nearly nearly £7,000 per mile.

104. *To Mr. Curtin.*—Cement penetration would probably be more durable than bitumen penetration, but the additional cost would outweigh that advantage. Cement at Canberra costs about £5 for a ton on trucks. It is obtained from the new works at Berrima. I have not seen many cement penetration roads in Australia, but I understand that that type of construction is becoming quite a vogue in Victoria. It is hard to make an economic comparison of the two types of construction, particularly under the local conditions obtaining here. Experience as to capital costs, particularly in cement penetration, varies in a most extraordinary manner. Certain claims are made by the cement companies which seem rarely to have been borne out. I know that in a number of cases the costs have been far higher than the calculations of the cement companies. The work of constructing this roadway is practically completed, and it would therefore be very difficult to make a recommendation at this stage that the work be done departmentally. The standard of the work carried out by the contractors is quite up to specification, and I cannot say that the department would have done better work. The cost of maintenance depends to a great extent on the type of material used in construction and the amount of traffic over the road. I am a firm believer in the execution of, at any rate, all engineering works by departmental labour and plant. I have had considerable experience of both day labour and contract work. In Canberra all the engineering works have been carried out by day labour. That includes sewerage, water supply, roads, parks and gardens, and footpaths. The quality and cost of that work, is as good as that obtaining elsewhere. When two large subdivisions were being made at Canberra in the early stages we called tenders for the whole of the road work and earthwork. The lowest tender was well above the departmental estimate, and we carried out the work at less than our own estimate. Of course, that is an exceptional case, because the conditions in Canberra in those days were not favorable to contract work. We cannot compete with contract work in respect of kerbing and guttering, although in that case the work is really equivalent to day labour, because the contractors are in a small way and they work in with the department. It is more like the butty-gang system. In my opinion, the contractors, in the process of tendering, are to-day engaging in cut-throat competition.

(Taken at Sydney.)

THURSDAY, 6TH MARCH, 1930.

Present:

(Sectional Committee).

Mr. GREGORY, in the Chair.

Senator Reid	Mr. M. Cameron.
Senator Sampson	

Lewis Preston Sibley, Manager of the Broken Hill Proprietary By-products Proprietary Limited, Marrickville, sworn and examined.

105. *To Mr. Gregory.*—I submit the following statement:—

I am in the business of distilling and selling coal tar and it may be presumptuous for me to express opinions on the economics of road construction and maintenance, but as the tar business brings me into intimate contact with such work, I have some rather pronounced views, and will express them before talking about tar and its merits as compared with bitumen.

1. There is an immediate need for a large mileage of low cost improved roads having a traffic capacity of from 100 to 1,000 vehicles per day.

2. Progressive or stage construction in which the road is improved with successively higher type surfaces as required by increasing traffic, is the economic method of improving highways. It avoids building in excess of traffic require ments. Progressive type surfaces can be built which are adequate for existing traffic, and which can be improved from time to time so as to serve satisfactorily increased volumes of traffic without the destruction of or waste of original investments.

3. Except in urban areas where the dust nuisance is a factor, tar surfacing is not generally warranted on gravel roads until the cost of maintaining them approximately equals the cost of maintaining a tar surface, the initial cost of which is from £300 to £400 per mile and the annual maintenance cost from £100 to perhaps £200 per mile.

4. No road carrying a traffic of less than 800-1,000 vehicles per day warrants reconstruction in a higher type than gravel maintained by surfacing with tar, where gravel suitable for the purpose is available at a reasonable price. A higher type of surface is generally warranted when the cost of maintaining it with tar exceeds £200 per mile per year.

5. When the cost of maintaining a tar surface on gravel exceeds the interest charge on the cost of a penetration macadam or a "retread" or "mixed-in-place" surface extensively used in America and now being introduced here, such a surface can be constructed on the existing road without waste of the original investment. It may also be constructed on gravel or sand-clay or some earth roads that are not suitable for tar surfacing.

6. The employing of labour instead of paying a dole may warrant improving grades and curves far in advance of the needs of existing traffic, but does not warrant constructing a wearing surface far in advance of such needs.

7 *Tar and Bitumen.*- Tar and bitumen are competitive the world over, and the opinions of engineers regarding the relative merits of the two materials for different purposes are as wide apart as opinions of men generally on the subjects of politics and religion and are apparently as irreconcilable, but when tar has been used as successfully as has bitumen for every type of road construction (except sheet asphalt) and maintenance for which either have been employed, and as tar is produced locally while all bitumen is imported, there are logical reasons why in the interests of the States and the Commonwealth every road engineer should make the fullest possible use of tar to the exclusion of bitumen, and if he does not get as good results as have been obtained elsewhere, then try, try and try again. Failure to do so is nothing less than personal human failure.

8. I do not like to talk shop at a time like this, but I cannot very well talk about tar without doing so, for the quality or value of tars for different purposes depends to a large extent on the conditions under which they are produced and to a far less extent on the processing of them.

9 It so happens that my supply of tar comes from the by-product coke ovens of the steel works at Newcastle, and is the same kind of tar as is generally used so successfully in England and America. It is the only supply of that kind of tar in Australia. The only other tar of the same general character available here is that produced by the smaller gas companies using horizontal retorts. The larger gas companies generally have vertical retort plants and the tar recovered from them is of a different character, and in the opinion of most road engineers is not as suitable for road construction and maintenance purposes as is coke oven or horizontal retort tar or bitumen However, it is my opinion that in the interests of the Commonwealth, all tar produced in Australia should be used for road construction and maintenance purposes, and that bitumen should not be admitted free of duty when tar produced here is available.

10. Tar and bitumen are in every way as competitive as are, for example, road rollers built in Australia with road rollers built in England. At the present time bitumen comes into the Commonwealth free of duty and is being used where tar could be used, and although some tar may not in some cases give as good value for the money expended as if bitumen were used, I suggest that in order that those who insist on using bitumen may in a measure be forced to recognize the harm that is being done by causing money to be sent abroad that could be kept here, and pay some penalty for so doing, an import duty of £2 per ton, equivalent to 2.2d. per gallon, be imposed on bitumen. I can for my company guarantee that our present base price of 8d. per gallon for distilled tar in bulk at the distillery would not be increased because of any import duty that might be placed on material that competes with it.

11. I realize that placing an import duty on bitumen would *bring* emphatic protests from roads boards, road engineers, and motorists, but it seems to me that there are economic reasons, perhaps necessities, which more than outweigh protests that may be made, and my suggestion is made in all seriousness for we have a large investment in plant and equipment used only for spraying bitumen, and we have, except for a relatively short period during the past six years, been able to dispose of all of the tar produced at the steel works, Newcastle, for road construction and maintenance purposes.

My company has supplied the tar for, and supervised the construction of, two sections of road in the Federal Capital Territory of retread or mixed-in-place surface. *One section of about three-quarters of a mile* on the Queanbeyan-road was laid down in January. The metal, preferably of about one inch gauge, is spread to a depth of 2½ inches and sprayed with three-quarters of a gallon of tar to the square yard. The tar and metal are worked to and fro with a grader until thoroughly mixed, and the consistency of the tar has stiffened sufficiently to allow it and the metal to consolidate under the roller. After the surface has been levelled with the grader and consolidated by roller, it is sealed with one-third to half a gallon of tar to the square yard and blinded with screenings. Penetration macadam is not mixed on the road. Metal of 1½-in. to 2½-in gauge 3 inches to 4 inches thick is penetrated with a heavy tar, which could not be mixed in place. After penetration the road is rolled and blinded in the same way as a retread. The retread method permits of the use of a lighter or thinner layer than penetration, and usually costs less. I was in the tar business in the United States of America for 25 years, and Mr. Hill, the Commonwealth Director of Works, will support me in saying that there tar has been used as successfully as bitumen. Indeed, there are engineers in New South Wales who during the shortage of tar on account of the coal dispute have postponed their road works because they say that bitumen does not give as good a result as tar. The municipal engineers at Parramatta and Auburn are amongst those who prefer tar. *Normally my company produces about 3,500,000* gallons of tar per annum: we are building new coke ovens, and when the coal industry is in full swing again we shall produce 4,000,000 gallons per annum. During the last six years, except for a relatively short period, we sold the whole of our product. Probably during that period the steel works have burned up to 1,000,000 gallons of tar. I have said that an import duty on bitumen would bring emphatic protests from road boards, road engineers and motorists. The reason for that statement is that I believe that those engineers who prefer bitumen would object to any impost that would increase its price. Motorists also are well organized, and generally protest strongly against any proposal that will increase the cost of road construction and motoring. Left to themselves they would not find any fault with tarred roads, but they would be prompted by the importers to complain that roads could not be built as well or cheaply if a duty were imposed on bitumen. In addition to the Broken Hill Proprietary Company's Steel Works at Newcastle the large gas companies in the capital cities are producing tar which can be economically used for road purposes. *Those engineers* who prefer bitumen should be forced to use Australian tar in the general interest of the community, or pay a penalty through the customs tariff. The freight on tar to South Australia is 1½d. per gallon when carried by the Broken Hill Proprietary Company's vessels. The regular shipping companies would charge about 32s. 6d. per ton on tar in casks, and to Western Australia about 45s. Freight is charged on a measurement basis at the rate of 133 gallons to the ton. Notwithstanding that, and the fact that bitumen, being imported free of duty, is costing less than Australian tar, some engineers in Perth are using tar. The Port Adelaide Corporation insists on using tar instead of bitumen. I have examined portion of the route of the proposed federal highway. My company supplied and sprayed the bitumen on a section of the road being constructed by Mr. McDonald along the shores of Lake George. If gravel is available along the route of the federal highway and is suitable for surfacing with tar it should be used and allowed to consolidate. Later, after all pot holes and gullies have been levelled, it should be surfaced with tar and maintained in that way. Relatively little gravel in the Canberra area is suitable for *surfacing* with tar, because of the excess of clay and fine material in it, and if a suitable gravel cannot be found convenient to the federal highway the surface should be constructed by the retread method. Porphyry rock would be suitable for retread or mixed-in-place surfacing. That method was used on the Queanbeyan section, and my company has recently received an order from the Federal Capital Commission for tar to construct a further 2½ miles of that type of surface. In the United States of America, where suitable gravel is available, roads are maintained by surfacing with tar or bitumen. *Next in order* comes the retread or mixed-in-place type, which has come into vogue very rapidly during the last three or four years. A report by the Highway Research Board, Washington, emphasizes the economic value of that type of construction and goes so far as to say that nothing as costly as penetration macadam is warranted where the traffic does not exceed 1,500 vehicles per day. So far as I could learn, no retread work had been done

in England when I was there three years ago; the larger part of road construction there is done by premixing slag from the steel furnaces, or crushed metal, with tar. Most of the maintenance is done by surfacing with tar. During the last six months the Main Roads Board in New South Wales has invited tenders for the construction of several lengths of road, and the specifications have provided for alternative tenders for penetration with tar or bitumen and sealing with bitumen. Unfortunately, there are no standard laboratory tests that do not tend to prove that tar is almost worthless for road purposes, the range between melting point and brittle point, and the evaporated losses being greater than in bitumen; but conditions in the field are different from those in the laboratory. The temperatures used in the laboratory to determine the evaporated losses are very much higher than those to which the materials are subjected on the road. It is not true that during hot weather tar has a greater tendency than bitumen to come to the surface. That fault can be obviated by adjusting the quantity used, according to the quantity and character of the blinding material. Eight miles of the road from Maitland to Newcastle was constructed and maintained entirely of tar. A section of 26½ miles on the Great Western-road, between Blaxland and Mount Victoria, was surfaced with tar three years ago. It was merely a temporary improvement, but the results have been far beyond the expectations of those who carried out the work. Some portions have been resurfaced, but generally the road has served all the requirements of traffic. The Maitland-Newcastle-road was constructed four and a *half years ago, and where the sub-soil conditions and* drainage had been properly cared for has been very efficient. Sections of it are not as it should be, but that is due to faulty engineering. Drainage is a most important factor, but the degree of safety required in road construction is not nearly so high as in connexion with buildings. It would be much more economical to have 1 per cent. of a road fail and expend 5 per cent. of the total cost in repairing defects than to increase the total cost by 10 per cent., 15 per cent., or 25 per cent. in order to ensure against any failure. Drainage should be taken care of when a road is first constructed; but the bearing strength of the road can be improved later, often at less cost than by ensuring against a defect of that character at the outset. The cost of tar surfacing on suitable gravel or water-bound macadam ranges from £200 to £400 per mile. The depth of gravel placed on the road does not affect the cost of surfacing; the cost of the surface will be the same, regardless of the cost of grading and filling. The depth of gravel to be employed depends on the bearing strength of the natural soil. Where a road passes through gravel country that has naturally a good bearing strength shaping is all that is required. But through soft, wet country from nine inches to twelve inches of foundation is necessary. A gravel or water-bound macadam road should have a surface of about three-eighths of an inch of tar and blinding. The annual cost of maintenance will be from £100 to £200 per mile. In many instances it has been less, but £100 would be a fair estimate. All the tars produced in the Commonwealth are suitable for road construction at a price. Those which are the product of the gas company retorts are not as suitable as that produced by my company, but their uses are regulated by the cost at *which they can be made available to the* road engineer. The by-product coke ovens have a total output of about 3,500,000 gallons annually. The imports of bitumen total about 65,000 tons; assuming 216 gallons to the ton, that is equivalent to 14,000,000 gallons. I estimate that about 25,000,000 gallons of tar is made in Australia. With tar, as with bitumen, it is necessary to have good conditions to get the best results. I have had results from tar which the Main Roads Board of New South Wales will admit are as good as the results obtained from bitumen. I think tar can be satisfactorily and economically used where it is impracticable to use bitumen. When making a penetration macadam road the metal need not be as clean, free from dust, or dry to get good results from tar as is necessary when using bitumen. Tar can be used under lower temperature conditions than would be desirable for bitumen. Tar will bind better with a dusty surface than will bitumen, and it is common practice, even when the final surface is to be of bitumen, to prime the road with tar.

106. *To Senator Reid.* My company has done work for the Main Roads Board of New South Wales; we have supplied and sprayed tar on the roads, and have done similar work for shires and municipalities, the Main Roads Board paying portion or all of the cost. The board honestly believes that bitumen is very much better than tar and cheaper in the long run, and I have never been able to upset that conviction. The board's engineers think that bitumen lasts longer and is less liable to disintegrate under traffic and varying atmospheric conditions. They are convinced that the upkeep of a tar surfaced road is much heavier than the upkeep of a bitumen surface. I have endeavoured to get experiments in regard to this matter carried out. So far, only two tests have been made under comparable conditions. One was on a section of the Great South-road at Liverpool, which we penetrated and sealed with tar about three years ago. The seal coat did not last nearly as long as I expected, or as the bitumen lasted on an adjoining section; but except that the *tarred section required another seal coat, the road is in* every respect as good as the adjoining section. The other test was completed the week before last at Wyong, on the Sydney-Newcastle road. At my suggestion, the Main Roads Board arranged for four sections of 20 chains each of penetration macadam—the first to be penetrated and sealed with my company's tar; the second to be penetrated with our tar and sealed with bitumen; the third to be penetrated and sealed with tar from vertical retorts; and the fourth to be penetrated with tar from vertical retorts and sealed with bitumen. These various sections have been constructed under identical conditions, and the results will be comparable. The difference in cost between sealing with tar and sealing with bitumen, using one-third of a gallon of bitumen to the square yard, was about 10s. a chain. On some works the price of our tar would be higher than bitumen; but when we can send tar in railway tank wagons, and so avoid cooperage charges, our price is 1d. to 2d. per gallon below the cost of bitumen. I think tar will prove as economical as bitumen, and I am anxious that many tests be made to prove or disprove that opinion. The term "gravel" covers a great variety of materials, and I rarely advise surfacing any considerable length of road without first making tests of a few chains and allowing that section to stand through a winter and summer to see if there is any sign of peeling. Decomposed granite and other gravels which have not too much mica are good anywhere; that is true also of certain quartz gravels, but ridge gravel is an uncertain quantity, and river gravel usually requires something to be mixed with it otherwise it will not consolidate under the roller. My tar mixes well with the screenings from stone-crushers, but it is the practice to use with tar a type of blinding that would not be suitable with bitumen. The better the blinding the better the results. I prefer good clean grit or metal chips free of dust, but I have advised the use of relatively fine sand from the river when it can be obtained for 2s. 6d. a yard rather than pay 15s. a yard for metal screenings. The superiority of the latter does not warrant the additional expense. If we were to spray a gallon to 8 or 10 square yards, it can be blinded with almost anything; but if

we *spray a gallon to 4 square yards the blinding should* contain some ¼ or even ½ inch material. All our spraying is done by machines. One ton of coal treated for coke yields only about 7 gallons of tar; therefore, tar cannot be produced commercially as a primary product. *It can only be produced economically as a by-*product of the coke ovens. The supply of tar will depend on the demand for coke. We have sold for road construction purposes 90 per cent. of the tar we *have produced in the last six years, and I believe that* we could sell all of it; but I am *pleading also for the* tar produced by the gas companies, which I think also should be used on the road. Improvements have been effected in the process of producing gas tar, and further *improvements are possible*, but at the present time most of the municipal *engineers in the Sydney metro*politan area prefer Broken Hill Proprietary tar at 3d. per gallon more than they would have to pay for the product of the vertical retorts. They consider it *economical to pay a higher price for the superior* article; but if they could get gas tar for 4d. or 5d. per gallon less than our tar they would probably use it. A tar surface will not be sticky if the consistency and *quantity of tar used is adjusted to correspond with* the quantity and *character of blinding used*. We sprayed 26½ miles between Blaxland and Mount Victoria, and after the tar had been blinded fat spots were discernible for a week or two. *They required immediate attention*, but after the first few weeks *not a sticky spot could* be found. Tar surfacing, if properly laid, shows no inclination to become soft so that traffic will cut it into ruts and ridges.

107. *To Senator Sampson.*—Most engineers believe *that the vertical retort tar does not last so long as our* horizontal retort tar, or bitumen. *The reason is that* the vertical retort tar is produced under different conditions. A vertical retort recovers seventeen to twenty gallons of tar per ton of coal, whereas our horizontal *retort and coke ovens will recover only about* seven gallons. Many municipal *engineers about Mel*bourne are using extensively the by-product of the gas works, but they are gradually turning to bitumen, be*cause they believe that it gives better value.* Probably the same engineers *would buy a road roller made in* England rather than one made in Australia if there were no import duty, because the imported article at 30 per cent. to 40 per cent. less cost would be better value.

108. *To Senator Reid.* There is no material difference between *the coal burnt for coke and coal burnt* for gas. Coals from certain mines or seams will produce more cubic feet of gas per ton than coal from other seams. Similarly, coal from certain mines will *produce coke that will stand up better under the load* of the blast furnace than will *the coal from other mines.*

109. *To Senator Sampson.*—In Sydney we charge for our tar spread *on the road approximately* 3d. per gallon more than the gas companies charge for their product. Until five years ago my company delivered the tar in barrels to the different municipalities, but *I was of the opinion that we were not getting the best* value from the use of it. Too often the *engineers used* too much rather than too little, and that caused sticky and bumpy roads. My company provided mechanical sprayers *and now most of the tar used in the metro*politan area, except for *patching and small jobs*, is supplied by our machines. Members of my staff frequently inspect work in progress unless we are satisfied that those in charge are sufficiently experienced in the *use of tar to obtain satisfactory results.*

110. *To Mr. Cameron.*—I understand that three-*quarters of a mile of tar penetration on the Quean*beyan road, which was *done early in January* of last year, is standing up very well, notwith*standing that about 2,800* vehicles per day use the road. Another section *was put down two months* later, and from the fact that we have received an order from the Commission to supply and spray tar on another 2½ miles, I assume that that section also is *giving satisfaction.* We test samples from every tank wagon to see that the tar *complies with the specifica*tions, but it has not been found practicable to eliminate anything from horizontal retort tar except oil. The quantity taken out depends on the consistency of *the tar we have to supply. Neither* has it been found practicable to add anything to *improve the quality of* the tar. It is used as it comes from the retort, except for distillation to get the necessary consis*tency or viscosity.* We remove nothing except *a percentage of distillate oil.* Tar on the road disintegrates or wears off exactly like a coat of paint on a building. As the oil evaporates, the tar loses its life. A tar surface requires a certain *amount of traffic.* It will last longer if 300 to 500 vehicles per day *are using it than if only 50* vehicles use it. The principal difference between horizontal retort tar and vertical retort tar is that the latter contains certain waxes. A tar surface will need re-conditioning *after a year, or two years, or three years, according* to the conditions of the *traffic on the road. I have said* that the initial cost of tar surfacing is from £300 to £400 per mile. That covers two coats of tar, each of ¾ to ¾ gallon per square yard. The first coat is not *blinded; the second is. In time* the road must be resurfaced, using not more than ¼ gallon to the square yard and blinding. If the initial treatment of two coats costs £350 per mile, the subsequent treatments *will cost about £225 per mile. Large quantities of* tar are being burned. *In America, tars are distilled to* pitch and used for roofing and for the *making of* briquettes. Large quantities of pitch are sent to Europe for briquette-making.

111. *To Mr. Gregory.*—Sharp, clean, river sand is not as good as crushed metal for top dressing, but I *would rather* use sand at 2s. 6d. than pay 16s. for clean metal chips. For blinding purposes I would prefer a rock that crushes to cubes rather than into flakes. The blue metal about Sydney tends to become flaky. The porphyry rock at Canberra is cubi*form, and I saw some white quartzite which gave a* very good fracture. *My firm has made no representa*tions in regard to cheaper freights on tar. The nearer a commodity like tar is used to the source of production, the more economical it is. My aim is to have *all the tar that is produced in Newcastle used in New* South Wales. Adelaide, Perth and *Melbourne would* be dependent on the product of the gas retorts. I doubt if there would be enough of that to meet require*ments if tar were to replace bitumen on the road; but* I am of opinion that *all the tar now produced should* be used before bitumen is admitted free of duty. When a country is committed to a protective policy it should carry it out logically, and a duty on bitumen *is just as logical as any other duty in the tariff. I* believe that the *imposition of a duty on bitumen would* be harmful to my company; but I am *advocating it* for the general good of Australia. A big enterprise like the Broken Hill Proprietary Company has a *greater interest in placing Australia on a sound in*dustrial basis *than in any profit it might make from* the small by-product I am *handling.*

112. *To Senator Reid.*—The containers in which our tar is *distributed are drums which originally con*tained lubricating oils or barrels that *held grease.* We have to send them to Newcastle and recooper them. This involves additional freight and greater cost of *handling.*

(Taken at Sydney.)

FRIDAY, 7th MARCH, 1930.

Present:

(Sectional Committee)

Mr. GREGORY, in the Chair.

Senator Reid	Mr. M. Cameron.
Senator Sampson	

Hugh Hamilton Newell, Deputy-President of the Main Roads Board of New South Wales, sworn and examined:

113. *To Mr. Gregory.*—The proposed Federal Highway is a continuation of the road being constructed by the New South Wales Main Roads Board from Goulburn to Canberra. The scheme was first promul*gated by the board as a result of an investigation made* by me. Following a conversation between *the members* of the board and Mr. Hill, Director-General of Works, it was thought better to find a better and shorter route *to Canberra*, and we decided on one which would reduce the *distance twelve miles below that of the previous* shortest route. It follows the Hume Highway from Sydney, through Goulburn to Yarra, about six miles beyond Goulburn where it turns off to *Collector*, and follows the line of a reserve road along the *eastern foreshore of Lake George to Geary's* Gap. From that point to Canberra it is practically a new road. The Main Roads Board anticipates complet ing its section by the end of 1930. Special monetary *provision has been made for this road.* As the result of the conference between *representatives of the board* and Mr. Hill, the then Commonwealth Minister for Works and Mr. T. Hill, then Commonwealth Chief Engineer, the Commonwealth under*took to pay two-thirds* of the cost of this road, independent of the Federal Aid Roads Agreement. We have let contracts for practically the whole of the length from Collector to the Federal Capital Territory, and the whole of the earthworks, one of the largest bridge *structures and many culverts* are almost complete. Tenders are now in the office for gravelling the last fifteen miles. We have also made arrangements to carry out the necessary works between *Collector and the take-off* from the Hume Highway. We anticipate that *whilst that portion may not be* finished, it will be available for traffic by the end of the present year. We have adopted stage construction. The road as far as Collector was of gravel formation *and we purpose reconditioning it with gravel of a* quality that will take a tar or bitumen surface. Beyond Collector we experienced difficulty in getting material for the first five miles, and there we had to put down a gravel base not of quality to take tar surfacing. We *laid a 6-in. gravel base and a 3-in. wearing course of* bitumen penetration for the first five miles. From that point onwards we decided to carry out the whole of the earth-works and call for tenders for the paving *later, because there seemed to be a possibility of finding* good gravel *as we went along. That road will con*stitute a base for an improved wearing surface to be provided as traffic requires. It will be sufficient for the traffic in the immediate future so far as we are *able to forecast it. At a later date it will be surfaced* with either tar or bitumen. We are *putting down* nine inches of gravel, and we anticipate about two inches of wear. If necessary, we shall lay down premixed bituminous macadam; but we do not think that *any further improvement will be needed for two years.* The present estimate of the traffic is 200 vehicles per day, but that is a mere guess. We are not getting that traffic over the Tarrago road at the present time. In my opinion some time will elapse before the traffic exceeds 200 vehicles per day. Much will *depend on* the growth of the capital city. For the six miles of *road within the Federal Capital Territory*, I would recommend the same type of *construction as the board* is using on the other section. The gravel base will be suitable for subsequent covering with an improved pav*ing.* The first obligation of a road engineer is to *ensure proper location and gradients*, suitable curvature, and efficient drainage. I have *seen swampy* country dealt with by deep drainage on either side and it has become dry and hard in a very short time. The *treatment of ground depends on the location.* If the ground is high, *drainage perhaps will be sufficient.* On the first section of our road we had to use *crushed* metal, but now we are experiencing no difficulty in getting gravel. We have let tenders for ridge gravel *for a length of fifteen miles. It is our intention to use* the best ridge gravel *that is procurable. Screening is* not necessary; if the gravel were screened, the bitumen would have to be applied immediately. As a matter of *fact we do not apply bitumen to gravel without first* using *tar as a primer.* If we intend to use any seal coat we subject the road to wear; *afterwards the larger* stones become exposed and most of the dust is blown away. Then by sweeping we get a fair surface to *which the tar will adhere.* I believe that No. 0 grade of tar has a better *chance of adhering to a dusty road* than has bitumen. We are now experimenting in the laboratory with road oils and tars. Gravels are concentrated in boxes, penetrated, and surfaced with *different preparations* and tested at varying tem peratures. Road oil is *an imported by-product of* petroleum. If we can get tar to respond to our tests we shall prefer to use it. We are already using it *fairly extensively as a primer.* We have found that *coke oven tar is superior to gas tar*, which is the product of the vertical retort. It is *generally recognized that* coke oven tar has more body and consistency and, therefore, should have better wearing properties. We *have used both types of tars for final surfaces*, and have not *experienced any difficulty with it during* the hot weather. When the board first *came into exis*tence we did have trouble, through the melting of both tar and bitumen during hot weather, but we have over*come that by reducing the quantity applied.* The first specification submitted *to us by an earlier authority*, provided for 2¼ gallons of bitumen to the square yard; we have cut that down to 1½ gallons for penetration, and ¼ gallon for finishing. Now we are free of *bleeding and corrugation during the summer months.* With tar we have had both *failures and successes.* Some of the tar produced by the B.H.P. By-Products Proprietary was down for two and a half to three years without further treatment, but I believe that *the material used in the road lent itself to tar surfac* ing. Our first experiment was to lay down, *on the* Hume Highway near Liverpool, three sections carry ing exactly the same traffic. One was in the Australian Gaslight Company's tar, another in the Broken Hill Company's tar, *and a third in bitumen.* The Australian Gas Company's section failed in four and a half months, and the other tar at the end of seven months. The bitumen did not require attention for eighteen *months. Even* Mr. Sibley, manager of the B.H.P. By-Products Proprietary Limited, *admits that where tar* is used for penetration purposes, the road should be sealed with bitumen, which is more waterproof than tar. With both tar and bitumen trouble is experienced through capillary action; water is drawn up and *through the paving, causing disintegration.* In one instance that fault was very extensive. *Despite the* provision that is made for drainage, springs break out where they are least expected. In this instance a spring appeared on the summit of a hill, although there was no record of any trouble of that kind having occurred *before. Where we have known of the possibility of* encountering difficulties of *that kind, we have incurred*

the higher cost of cement concrete. An instance of that is the Murwillumbah to Tweed Heads road. We put down eight miles of bituminous penetration, but through the swamp area we laid the pavement in cement concrete, which has a bridging effect. I am sure that the bituminous penetration would not have stood up to the work in that area. Always one must lay the paving that is most suitable for local requirements and conditions. I do not believe that corrugation is caused by using a heavy roller instead of a harrow on the loose metal. It is true that a heavy roller can create incipient corrugation which would become accentuated by the subsequent traffic. But instead of rolling the metal longitudinally we use a light tandem roller diagonally and finish off with heavy longitudinal rolling. While the metal is loose it is liable to move ahead of a heavy roller. We have not done in New South Wales any real cement penetration; but we did a short section on the sandwich system, and we are now arranging for Mr. Craig, the chief engineer to the board, to carry out another experiment. At Ryde, a little cement penetration has been done, but sufficient time has not elapsed to prove whether or not it is entirely satisfactory. We would not repeat the sandwich method because the costs were not much below those of pre-mixed cement concrete. The average costs per square yard on the Collector road have been as follows:—On Fowler's contract for gravel paving on the section from 3 miles 3,800 feet to 6 miles 800 feet, the whole job including the earthwork is costing £3,953 per mile. The gravel, 6 inches thick, is costing 8.77d. per square yard, and we are applying a 3-in. seal coat at a cost of 1s. 7¾d. per square yard. The culverts, principally of pipes, are costing 13s. to 14s. 11d. per lineal foot. Box culverts are costing £6 13s. 1½d. per cubic yard. On another section, where we used crushed metal, the cost was £9,424 per mile, but the earthworks were very much heavier. The gravel in the base cost 2s. 9d. per square yard, and the 3-in. penetration 7s. per square yard. On another section of 5 miles, let to the same contractor, the earthworks alone cost 9s. per square yard. We have to combine that cost with the price of the gravel paving for which we have just received tenders; that contract, plus another for 10 miles, will be £5,235 per mile, exclusive of surfacing. We shall probably leave that road for a couple of years until it has consolidated, and is in a suitable condition for surfacing; then it will probably need a priming of tar and a seal coat of bitumen. I do not anticipate that the maintenance will be heavy. On Prince's Highway, from Sydney to the Victorian border, we are working an ordinary horse-drawn drag, and the grading is costing about 2¾d. per chain for each treatment. A month may elapse between treatments. Graders and drags are working continuously over the 300 miles of this highway, and the cost of maintenance is not excessive. Because of the scarcity of material the cost of laying down a highly improved road would be tremendous. When the Main Roads Board came into existence the highway was in a bad condition throughout, so much so that service cars, which left Moruya at 5 a.m. failed at times to catch the 2 p.m train at Nowra. Since the road has been improved the cars leave Moruya at 7.30 a.m., allow the passengers a rest of three-quarters of an hour at Milton, and arrive at Nowra in ample time for lunch at 1 o'clock. This improvement is entirely due to progressive maintenance of the road by drags and graders. On the road to Canberra, maintenance will not be excessive for a year or two, and when the traffic and wear warrant, we shall go in for further improvement. The drag does not tend to accentuate the dust nuisance unless it is working in a very fine flour-like material. Where gravel contains a fair percentage of dust the grader brings the stone to the surface, thus forming a carpet of metal which tends to keep the dust down. The cost per mile of maintenance on various sections of the Prince's Highway pavement has been from £15 to £30 per mile per annum. The price we pay for 2½-inch metal depends upon the availability of the material. At Kiama, we are buying 2½-inch metal for about 5s. 3d. per ton at the quarry and 1½-inch metal for about 6s. It is columnar basalt. Supplies used in the metropolitan area have to be transported not less than 70 miles, and the cost works out at not less than 13s. per cubic yard. When the board first came into existence it was paying 7s. for 2½-inch metal at the quarry, but keen competition has developed; quarries are better equipped, and they have large breaking-down machines that will handle even a 5-ton spall. Because of freight charges the cost to us on the job is fairly heavy, being as high as 23s. at distances up to 170 or 180 miles. On the North Coast and about the northern rivers the cost is 25s. to 25s. 6d. per cubic yard; within a hundred miles radius of Sydney it is 15s. to 18s. per ton On the western and southern lines, where competition is not so keen, 2½-inch metal costs about 8s. at the plant. We use either sandstone or basalt—the former for the base course. It would not pay us to bring basalt spalls from the distant quarries, so we use sandstone in an 8-inch Telford base. Better results are obtained from basalt than from porphyry At the present time, on account of the trouble in the coal industry, we experience difficulty in getting supplies of the better grade tar. The gas-works are still able to supply up to about 17,000,000 gallons. We think the price of tar is too high. One company told us that it is consuming 2,000,000 gallons per annum for fuel; it estimates the fuel value at ¾d. per gallon and is receiving 2¾d. per gallon for tar used as fuel by other consumers. I was assured, however, that the profit to the company on the distilled tar is only ¾d. per gallon more than the profit it obtains from the sale of crude tar for fuel purposes. When the board wants tar for road purposes, it is asked to pay 7d. and 8d. per gallon. Although the tar-producers are objecting to the importation of bitumen they are not prepared to bring down the price of tar to a reasonable figure. One representative of the tar-manufacturers said that if the board would let him know what it was paying for bitumen he would quote a better price for tar. We have had quotations for local tar which are actually higher than the price of imported bitumen, the figures being 10¼d. for bitumen and 10½d. for Newcastle tar. The price of bitumen is now approximately 8d. at the ship's side. Only recently representatives of the Broken Hill Proprietary Company conferred with the Minister for Local Government regarding the use of tar; representatives of the board were present, and said that the future use of tar would be governed by the price. The companies said that they would get together and consider the price, but nothing has been done. I am certain that an import duty on bitumen will not help to bring down the price of local tar. The Federal Highway should be built in progressive stages and, as the traffic grows and the foundations become consolidated, it should be improved to the extent that the traffic warrants. That is in accordance with the advice given by the then Chief Engineer, Commonwealth Department of Works, Mr. Hill, after his trip abroad. On the Goulburn side of Collector the gravel is very clean, and we are spraying it immediately. Where the gravel has a considerable clay content the road will be allowed to carry the traffic for a year or two before further treatment, otherwise we might lose the tar or bitumen. On the Great Northern-road we have put down cement concrete to the Hawkesbury River and from Belmont to Newcastle, the two heavy traffic sections, but on the two intermediate sections are confining ourselves to

gravel. At one part we are using gravel with a heavy clay content; we do not propose to surface it immediately, but have made arrangements for periodical treatments of sand. We anticipate that in a couple of years the clay will have been killed. From Moonee Creek into Gosford gravel has been laid and a contract has been let for tar surfacing it. North of that we are adopting either penetration, or pre-mixed bituminous macadam to Belmont. From north of Wyong to Catherine Hill Bay there is a conglomerate gravel, and the laboratory experiments suggest that we should use an asphaltic oil as a primer and one of the local tars for sealing, applying a bitumen surface later. In the metropolitan area, where the roads are traversed by tram-tracks, we are putting down a 2-inch carpet coat of bituminous concrete over a 6 to 8-inch cement base. Where there are no tram-tracks, we lay down bare cement concrete, which, so far, is not showing any undue wear. We did anticipate five years of use before we need do anything to these roads, but they are likely to last longer. They are subject to a little steel-tyred traffic. Portion of the Botany-road was put down in bare concrete just prior to the board coming into existence That road is traversed by trams and there is only a slab 12 feet wide on either side of the tracks. On one side the heavy iron-tyred traffic going loaded to the tanneries has cut definite grooves in the concrete In fact, after two years, the reinforcement is showing. One of our greatest problems is to deal with that type of traffic, but we are now treating the road with a 2-in. bituminous carpet coat, and we believe that it will be effective. We have allowed the gas company to put down tar to its own specification. Hitherto we used bitumen, but now we are trying a new material, Duratenax, a mixture of gas-pitch and bitumen. Some of the experiments show that it has held effectively, and we do not anticipate any further difficulty with the Botany road. On the opposite side of the tram-tracks, which is subject to only the lighter return traffic, the indications of wear are very slight. Apart from that one road, we have had no trouble with the concrete. There is no publication of a Federal character on the subject of road engineering, but the Main Roads Board of New South Wales, realizing that something of that character was needed, is publishing a monthly paper called *Main Roads* in which we set out the results of our experiments, and the testing of materials. In every possible way we let the local governing bodies know the results of our experience and we have asked the municipal and shire engineers to contribute to the journal letters and articles, dealing with their problems, failures and successes. At present the articles are contributed mainly by officers of the Main Roads Board, but the columns of the journal are open to the shire engineers. By means of this publication we hope that the shire engineer in the south will be able to help his brother in the north, and vice versa. The Blue Mountains road was in a fearful condition when the board first came into existence. Remedial action had to be taken immediately and we employed a fleet of eight rollers and scarifiers. We scarified 31½ miles of road and treated it with a light addition of material and tar. We did not anticipate a lasting success, but the results were most gratifying. The road stood fairly well for about eighteen months, then it commenced to corrugate, due to the fact that in parts new material had been placed over old material that had been somewhat pulverised. When we spread our seal coat of tar it slipped over the face of the metal and set up corrugation. We have overcome that by using the Killifer Disc, an implement somewhat like the disc plough; it passes over the road and cuts off the ridges and corrugations. The result is that the road is again in good condition. Each year we endeavour to do five miles of reconstruction.

114. *To Senator Reid.*—We did not set up our laboratory until last year, and our testing engineer has only been at work since June. His experiments with different oils and tars commenced about two months ago. So far no material has been discovered in Australia that can be mixed with tar to improve its value for road purposes. I see no reason why something of the kind should not be produced later. In fact at one of the Federal Aid Roads Conferences we formed a technical committee, representative of various commissions and road construction authorities, and Mr. Kemp, of Brisbane, urged that the Commonwealth Bureau of Science and Industry be requested to investigate the possibility of making more use of Australian tar by giving it more elasticity. A suggestion was made that we might experiment in the use of discarded motor tyres. These have only scrap value, and if the rubber in them can be treated and added to the tar, so as to give it more the consistency of bitumen, it will have a great value for road-making purposes. The gas companies have their own spraying waggons. These are filled at the works, and the gas is sprayed on to the road at about 1s. 2d. per square yard. The price of the tar is from 7d. to 8d. per gallon. I realize that refining costs something, but there seems to be too great a margin between the price of ¾d. per gallon for tar as fuel, and 8d. per gallon in the companies' waggons on the roads. We think the companies might reasonably reduce their price, because the refining is a simple and inexpensive process. The price quoted is practically at the works, but the companies will carry the tar a little distance and spray it on the road. Our price at the depot, 14 miles from the city, is 9¾d. per gallon. We received alternative quotations for tar and bitumen, delivered at Rosehill depot, and the price of the coke oven tar exceeded those of bitumen. The local gas company's tar at that time was 9¾d. at the depot, or slightly less than bitumen. The margin was not sufficient to justify the use of tar, having regard to the better quality of the imported material. We would be glad to arrive at a stage when it was no longer necessary to import one gallon of bitumen. In Sydney about four or five companies are operating in bitumen, but their quotations are almost identical; we think the price is regulated by arrangement. There is no competition except in regard to quality. Some time ago we discovered through a failure that occurred quickly that some bitumens have a greater ductility at low temperature than others. The Mexican bitumen is the better; the Californian bitumen is without the required ductility at 34°. We discontinued using it last winter, until other shipments of better quality were brought out, but we were able to carry on with mexphalt. There is a tendency here as in other parts to place the bulk of the orders for bitumen with the Shell Company. The competition should be with tar, and it is to this extent, that when the board started and it is to this extent, that when the board started bitumen ranged from £9 to nearly £10 per ton, whereas to-day it is about £7 12s. per ton. We find that whilst the price of bitumen gradually dropped the price of tar did not decrease correspondingly. The gas companies were formed at the outset for the purpose of selling and manufacturing gas. Tar was a mere by-product, but with the use of it for road-making they found a new source of profit, and apparently they intend to exploit it to the maximum. As tar is merely a by-product of the main industry of gas production, it should be sold at a minimum profit. The position is much the same with slag. The Broken Hill Proprietary Company cannot help accumulating slag at its Newcastle works, and five years ago had mountains of it, which had to be blasted, carted, and removed. We inquired into the possibility of using it for road-making purposes. Probably it would be worth 1s. per ton to quarry it out of the dumps and load it into trucks. But the company charged us 7s. and 8s. per

ton, practically the same price as we had to pay for blue metal. We set out to build the Newcastle-Maitland road with Newcastle slag and tar, but as we approached Maitland it was cheaper to carry metal some distance from the quarry than to use slag from the furnaces at Waratah. We have been offered thousands of tons *of open-hearth slag from Port Kembla, but it is only* blast furnace slag that we can use. It has a French co-efficient as low as 4, and the best of it from 6 to 6.4, as against 10 to 13 in the basalts at Kiama. In the United States of America it is found that a softer stone can be used with bitumen, and soft rocks with a co-efficient of about 6 have been used. We took a risk at Maitland, because we wanted to use local material and keep the money in the district. The road is standing up fairly well. Mr. Sibley has advised us not to use an excessive quantity of tar, and although it is his business to sell that material he has urged upon shire engineers the wisdom of restricting the quantity. It should be possible for the companies to put crushed slag on the trucks for 3s. 6d. per ton. One of the difficulties experienced in the laboratory with tar was the time it requires to penetrate consolidated gravel. It takes longer than oil, and consequently may hold up traffic to some extent, but our testing officer, Mr. Mack, is persisting with his experiments, and using different grades of tar oils. We shall use tar more extensively if we possibly can. At the end of seven months, *the tar-surfaced road leading from St. Mary's became* partly disintegrated, probably because during the winter months the clay was forced up through the tar, but we treated it with bitumen and further screenings, and so overcame the trouble. The failure on the Hume Highway at Liverpool was in the nature of surface *damage due to the tar having become lifeless.* The more elastic material supplied by the Broken Hill Proprietary Company lasted longer than the Gas Company's tar. It was clearly evident that the latter had dried up, and that the mere addition of screenings would not help; we had to apply bitumen. I have read that on Fifth-avenue, New York—a sheet asphalt surface on a concrete base—the caterpillar tracks of military tanks and heavy guns, one weighing 80 tons, made indentations to a depth of ¾ inch, and within 24 hours they were ironed out by the rubber-tyred motor traffic. I do not believe that statement, but it is true that the indentations in a bitumen surface, caused by ordinary steel wheels, will be ironed out within a week by rubber-tyred traffic. That result would not be obtained with tar. Both tar and bitumen bleed under the influence of summer heat, but that can be obviated by using the correct quantities. We think we have approached the correct proportions by using one and a quarter gallons of bitumen for 3-inch penetration, and one-third gallon for the seal coat. In regard to roads within the city of Canberra, the earlier you treat them the *better. You have established there a garden city.* While you have dusty roads you will not get full value from your plantations. I saw many trees that are dying, partly as a result of the accumulation of dust on their foliage; they cannot breathe. These garden plots must be protected against the action of dust. We shall ultimately treat the whole of our road, but we propose to allow sufficient time for the coarser material to work up so that when surface treatment is applied it will be more lasting than it otherwise would be. In Canberra, tar or bitumen treatment is undoubtedly justified for the sake of minimizing the dust.

115. *To Mr. Cameron.*—We are using gravel throughout, and putting down the full depth of 9 inches immediately. We anticipate getting a certain amount of wear from it, and when necessary we can add a 2-in. carpet coat of pre-mixed or penetration bitumen macadam. I am fairly confident that a tar seal coat will overcome the dust. As Canberra is not likely to be an industrial centre, we need not anticipate anything but fast light traffic on the roads leading to it. One would not attempt to penetrate the gravel with bitumen; the penetration would be in the 2-in. or 3-in. coat of metal. Proper penetration cannot be obtained with gravel, but the retread method can be adopted. The gravel would be scarified and then penetrated. It would then be worked into windrows with a grader until every stone became coated. After being levelled it would be consolidated with a roller. We have just finished a section of this type of road out of Tamworth. This construction is particularly adapted to stream gravel. From the Yass river bed we could probably get a water-worn gravel which would enable us to do some retread work in that locality. While gravel contains clay the dust nuisance will not be great, and when we have got rid of the clay the road is ready for surfacing. I do not think anything could be taken from tar to give it longer life, but something might be added to it. Where metal can be obtained and gravel cannot, and where *traffic is not heavy enough to justify further treatment,* we shall put down macadam roads. Such places are few and far between. When you get beyond the gravel stage you must jump to a surfaced road. There is no intermediate stage, except on a developmental road which is carrying a great proportion of iron-tired *vehicles. Our standard provides 10-ft.* streams for heavy traffic and highways. In the metropolitan area we increase the road width to 60 feet between kerbs. On the trunk roads in the country the width is 18 feet, and on minor main roads 16 feet for two-way traffic. On fast roads with a highly improved surface a width of not less than 20 feet is necessary. We do not believe in reducing to 12 feet, because that tends to concentrate the traffic and increases the cost of maintenance. If the last 6 miles of the Federal Highway is given a primer of tar or asphaltic oil, and sealed with bitumen, probably it will require a small dressing at the end of twelve months; then it should last for two years, and after the next treatment it should last three or four years. Each treatment adds to the road more bitumen and screenings. The Broken Hill Proprietary Company and the Australian Gaslight Company *have spraying plants, and will tender for the* supply and spraying of tar. The board also has a steam waggon spraying plant, with which the bulk of its maintenance is done. We find it more convenient to use our own plant, and we believe that we benefit by the experience of the men who operate it.

(Taken at Canberra.)

SATURDAY, 15TH MARCH, 1930.

Present:

MR. LACEY, Chairman;

Senator Reid	Mr. Curtin
Senator Sampson	Mr. Gregory.
Mr. M. Cameron	

Thomas Hill, Director-General of Works, recalled and further examined.

116. *To the Chairman.*—When I last appeared before the committee I recommended bitumen penetration surfacing for the Federal Highway. The Federal Capital Commission has since recommended mixed-in-place bitumen. At the time that I gave my evidence previously the research work in connexion with suitable paving material had not been completed. It appeared then that the best available material would be crushed rock from Mount Ainslie. However, the

geological and other researches did not disclose a suitable bed of metal there. Later I accompanied the committee to the foot of Black Mountain where there are extensive gravel deposits. This has been found to be the best available material to use. I saw the suggestion made by Mr. Potts, with whom I have conferred, and we decided upon the gravel, and to apply a bitumen surface in due course. The gravel will be sprayed and mixed in position. I have no hesitation in recommending this procedure, for it will make an excellent road, eminently suitable for the nature and extent of traffic which can be reasonably expected. The final surface will be screened gravel, blade-spread, and mixed *in situ*, and then rolled. That is not what is commonly called a retread road. I would call a retread road a semi-penetration road. The type of road that I propose to put down would be just as durable as what is called a retread road, and the construction will be simpler. The difference in the expense of construction for the actual surface would be between 2s. and 4s. a square yard. The maintenance under traffic would be the same. Very little retreading is done abroad. The majority of the country roads are treated with what is known as the bitumen sprayed *surface. Retreading is practically the reconditioning* of an old road which has already a good foundation. The construction of the road from Goulburn to join this highway is being actively carried out. It is expected that the final stages will be broken through about October. I refer to the last ten miles which join up with the Federal Territory. I do not *mean to say* that the surfacing will be completed by that time, but the earthworks and probably the gravel portion will be available for traffic. It may take another two years to complete the surfacing. I am interested by the following paragraph which appeared in the Melbourne *Herald* on the 13th March:—

> The Country Roads Board to-day made arrangements to lay down shortly a portion of the Prince's Highway near Gardfield, for a distance of one mile, with the All-Australian bituminous compound "Nabitco," a product of local oil shale This compound is the result of long experiments by Mr F G Renow, an Australian engineer and roads expert. He determined to discover an efficient local substitute for the natural asphalt which Australia has been forced to import, at great cost, and at the rate of approximately 100,000 tons a year.

I do not know the particular compound referred to in that paragraph, but various compounds of that nature are being experimented with. This represents a genuine effort to invent an all-Australian material for road surfacing by distillation from our shales and rocks. At present our products of that nature are limited to the by-products of coke ovens and gas works. We are using all the material of this nature that we can obtain, *but the quantity of it is limited.* I estimate that the deficiency is, roughly, 50,000 tons a year. Unless we can develop some new source of supply from coal or distillation, we shall have to continue heavy importations of this material. Mr. McCormack is pushing on with the idea of assisting Australian industry, and he has an experimental *stretch of a mile in length down.* The particular road where the experiment is being made is of the sand clay type. The material with which he is experimenting is sprayed on and surfaced with screenings. It will make practically the same type of road that Mr. Potts calls a retreaded surface. The full value of that experiment will not be known for at least another year. It will need to have the round of the seasons upon it, both winter and summer. The gravel road that is being put down on the Federal Highway will need to be consolidated before it is surfaced. I would prefer at least six months of consolidation to take place, including a winter season. It might be even better in some circumstances if twelve months' consolidation occurred. A good deal would depend upon the season. Between Canberra and Goulburn the maximum grade of the highway is one in twenty, and the maximum radius of the curves one in *300. That will enable an ordinary motor car to* travel the whole distance in top gear without any trouble. I do not anticipate any trouble from heavy rains, for the road has been properly culverted. The only thing that could possibly cause serious damage, so far as I can see, would be a serious cloud burst or floods. It is proposed to use Australian tar on this road, with possibly some addition of bitumen to bring it up to a certain constituency. I should say that the first spray coat will contain a very large percentage of Australian coke oven tar. The final coat will be of bitumen. The kind of road that we propose to put down will cost in respect of the surfacing 2s. a yard less than the retread road, and it will be perfectly satisfactory in the circumstances.

117. *To Mr. Cameron.*—I do not agree with statements that have been made to the effect that properly distilled Australian tar is not as durable as bitumen. In certain circumstances it is better than bitumen. The first spray coat of Australian tar, under present conditions, may be a bit weak in asphaltic content, but if it is stiffened with the addition of some imported bitumen it gives excellent results as a first penetration coat. The results that we have had from using our tar in that way have been quite satisfactory. To use Australian tar for a final coat it must be properly distilled. We are conducting experiments along these lines, and have been doing so for some time. By using this *material we have been able, by competitive tenders, in* some cases to get prices for the Australian material as low as half the cost of the imported article. We have laid down areas of metal treated with Australian material at half the cost of imported bitumen. Some of these experimental roads have been down for twelve or eighteen months, and, so far as we can see, they are wearing as well as roads made with wholly imported material. I make it quite clear that these roads have only been down for twelve or eighteen months, and I can only speak to that extent. It is only within about that period that research has been applied to the use of our local products. I am speaking of roads constructed under my own supervision and carrying a fair amount of traffic—in fact, heavy traffic. Of course, unless we can discover some new sources of supply it will not be possible for us to produce sufficient of this Australian article to meet all our requirements. I am speaking now of by-products from coke ovens and gas works. Even when we use all we can get of this, it appears to me that under present conditions we shall still have to import about 50,000 tons of bitumen annually. We are aiming at getting the same kind of *a surface with this local material as bitumen gives* us; and, up to date, the experiments have given us very favourable results. If we do not reach the stage where we can use this Australian material for the final coat, we certainly can use it with very great advantage in the first penetration coat. A road made with this *material and surfaced with bitumen would have just* as long a life as a road made wholly with imported bitumen. As a matter of fact, the materials are much the same. You cannot class all tars in one category. To be effective for road work, tar must be properly distilled. It must be produced according to a definite specification. The tar of which I have spoken has been prepared to this definite specification.

118. *To Mr. Curtin.*—There is practically no difference in chemistry between properly distilled tar and bitumen. Ordinary tar as it leaves the gas retort or the coke oven contains a lot of paraffin and carbolic oils. If these and other deleterious substances are distilled out of it, and certain other by-products of the first distillation are put back into it afterwards, you get a product practically the same as bitumen.

119. *To Mr. M. Cameron.*—Bitumen has greater adhesive properties than ordinary tar, but even some bitumens are not suitable for use where the temperature falls below freezing point. Their elasticity is low, and they char and powder below freezing point. The addition of some tar may improve bitumen in cold climates, for it increases the elasticity of it. Certain engineers are now specifying that they will not take bitumen for their work from certain portions of the United States of America because of the practical absence of elasticity below freezing point. Extensive laboratory work is going on now in connexion with all these matters. I do not anticipate that there will be any difficulty from seepages on the Federal Highway. I would prefer a full winter to be included in the consolidating period. We shall probably not be doing any bitumen surfacing until November or December. That would give us about nine months of consolidation. There are odd spots where seepage may occur in the hills five or six miles out from Canberra, but we have a good system of side drains, and we do not anticipate any difficulty at all. Spraying is preferable to pouring for the penetration coat. It gives a more even distribution of material, and the machine makes for more effective work. With hand pouring you are always likely to get a thick layer in places.

120. *To Mr. Gregory.*—I do not consider that hand-pouring is equal to machine spraying. We are able to get an ample supply of Black Mountain gravel of the kind you saw at the pit near the entomological block some little time ago. We can also get ample and suitable material for the top-dressing. It is proposed to screen some of the fines and dust to get it. That will make excellent top-dressing material. We will not surface the highway until after it has been properly consolidated. Actual cases have occurred through tendering, in which we have got a local product for the penetration coat at half the cost of the imported article. This may have been due to the fact that the gas companies were anxious to introduce their product in order to break down a prejudice which exists against it. These tars are being properly distilled. There is no doubt that although the committee may have heard from one or two engineers that they have no prejudice against the Australian article, a prejudice does exist among many engineers. Perhaps it would be truer to say that it was a lack of confidence rather than a prejudice. Undoubtedly the tars that were used years ago were unsuitable. They were taken straight from the tar pit and their percentage of moisture and oils was not considered. They were put on to the roads raw, and of course, they could not stand up to the work. At present the gas companies are distilling their tars according to a proper formula, and this is building up confidence in them. I realize that you get sixteen or seventeen gallons of tar to the ton from the gas works and only seven or eight from the coke retorts. That is why some of the tars have to be refined so much. The paraffins and other oils have to be removed. As I have said, we are continually conducting experiments with the object of using our local products for a final coat. We are doing a lot of work in our own laboratories, just as the New South Wales Country Roads Board is working in theirs. We are also definitely testing out sections of roads under working conditions. In my opinion we have been able to bring our tars up to the same formula as the imported bitumen, but the tests that we have made so far have been limited to eighteen months at the most. To that extent they have been satisfactory. The Footscray Gas Company in Melbourne is doing a lot of distillation work, and a good many of the Footscray roads are being treated with material from those works. A good deal of this kind of work is being done in England. Very largely they are using locally distilled tars there, but they are adding a small percentage of imported bitumen. So far, most of the work that has been done in Australia with the local article has been for primary coat, but we are now trying if we can use it equally well for secondary work. I want the experiments to be continued for some time longer before I can speak definitely on that point. The New South Wales Roads Board has had cases where it has had to be careful of the kind of bitumen used. Mexican bitumens are preferable where frosts are likely, and these are chosen before bitumens from the southern States. I would not recommend concrete for this highway. The traffic would not justify it. A Black Mountain gravel road with a bitumen sprayed surface mixed *in situ* will be perfectly satisfactory. One coating will probably be put on at the end of this year, and the second coating in the following year. By the time the second coating is put on, any faults or defects in the surface will have developed. For the first spray we shall use from one-third to half a gallon of material to the yard. For the second spray we shall use a quarter of a gallon to the yard.

121. *To Senator Reid.*—Bitumen has a slight percentage of natural oil. The amount is determined by what you want the asphaltic content to be. If you want a low asphaltic content you have to add more oils to bitumen. There is only about 2 per cent. of oils in bitumen with a high asphaltic content. The amount of manufacturing it needs depends upon the purpose for which it is to be used. We are doing our utmost to use the maximum quantity of Australian material. The road to which I have referred, which is surfaced with Australian distilled tar, is not showing any weaknesses up to date. But unless we can obtain additional supplies by means of the distillation of our shales and coals, I estimate that we shall still have to import about 50 per cent. of our surfacing material. The quantity would vary, of course, according to the amount of roadwork we put in hand each year. The only possible source of supply of this material of which I know anything, is the distillation of it from shale and coal. Several companies are experimenting in this direction in Tasmania at present. I hope that it will be possible to produce a material at approximately the same cost as bitumen. This would need to be got down to about 9d. per gallon at the distillery. Any other by-products that might be obtained from the distillation could be sold otherwise. We would only need the distilled tar. In my opinion, the reason why Mr. Newell was so definite that tar would not stand up as well as bitumen is that raw tar has been used at some time or another direct from the works, with perhaps only a slight heating to drive off some of the excess moisture. In England you can buy all varieties of tar. The elasticity of some of the bitumens from the south coast of the United States of America at no degrees Centigrade is nil. It becomes exceedingly brittle. When the distilled tar is used for the top-dressing instead of bitumen the process is exactly the same. The tar mixes just as well, and only an analytical chemist could tell the difference between tar and bitumen. When we come to top-dress this highway we shall slightly scarify the surface to 1 inch or 1½ inch, and then spray and mix it in position with graders and bladers and thoroughly roll. Afterwards the road will be spread with some fine screenings. We will probably use 100 yards of screenings to the mile, but it will need to be screening of excellent wearing qualities. It is advisable to use good screenings for this final surface even if you have to pay a little more to get them. The whole of the gravel is being put into the road now; but, as I have said, the top-dressing will not be done until the road has had proper time to consolidate.

By Authority: H. J. Green, Government Printer, Canberra.