1927.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

REPORT,

TOGETHER WITH

MINUTES OF EVIDENCE,

PLANS, AND APPENDICES,

RELATING TO THE PROPOSED PROVISION OF

WHARFAGE FACILITIES, DARWIN.

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F.4132/25.

MEMBERS OF THE PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

(Fifth Committee.)

Appointed 22nd January, 1926.

GEORGE HUGH MACKAY, Esq., M.P., Chairman.

Senate.	*House of Representatives.*
Senator John Barnes.	Malcolm Duncan Cameron, Esq., M.P.§
Senator Patrick Joseph Lynch.†	Robert Cook, Esq., M.P.
Senator Herbert James Mockford Payne.‡	The Hon. Henry Gregory, M.P.*
Senator Matthew Reid.	Andrew William Lacey, Esq., M.P.
	David Charles McGrath, Esq., M.P.
	Alfred Charles Seabrook, Esq., M.P.

* Resigned 2nd March, 1927. † Resigned 30th June, 1926. ‡ Appointed 1st July, 1926. § Appointed 24th March, 1927.

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EXTRACT FROM THE MINUTES OF THE VOTES AND PROCEEDINGS OF THE HOUSE OF REPRESENTATIVES, No. 14, DATED 11TH FEBRUARY, 1926.

6. PUBLIC WORKS COMMITTEE—REFERENCE OF WORK—WHARF IMPROVEMENT, DARWIN.—Mr. Marr (Minister representing the Minister for Home and Territories) moved, pursuant to notice, That, in accordance with the provisions of the *Commonwealth Public Works Committee Act* 1913–1921, the following work be referred to the Parliamentary Standing Committee on Public Works for investigation and report thereon, viz.:—The Improvement of Wharf Facilities at Darwin, Northern Territory.

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

Debate ensued.

Question—put and passed.

LIST OF WITNESSES.

PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

WHARFAGE FACILITIES, DARWIN.

REPORT

The Parliamentary Standing Committee on Public Works, to which the House of Representatives referred, for investigation and report, the question of the provision of wharfage facilities at Darwin, has the honour to report as follow:—

INTRODUCTORY.

1. In July, 1923, at the request of the House of Representatives, the Parliamentary Standing Committee on Public Works investigated a proposal submitted by Engineer Vice-Admiral Sir William Clarkson for the construction at Darwin of a new wharf.

2. The work contemplated was a solid wharf running south-westerly from the point of Stokes Hill, and a few feet shorewards from the edge of the mudbank between Stokes Hill and Fort Hill.

It was suggested that there should be steel sheet piling along the face of the wall, with 12 inches of concrete on the face of the wall and 3 feet behind it to just below low-water level, the remainder of the structure to be filled in at the back with material obtained from Stokes Hill. The decking of the wharf was to be of reinforced concrete. It was proposed that the structure should be 130 feet wide and 600 feet long in the first instance, to be later extended to a length of 1,200 feet.

It was proposed to provide a railway to the wharf by the construction of an approach round the eastern side of Stokes Hill, and to give vehicular approach round the western side of Stokes Hill by removing the railway lines on the existing railway approach and constructing a road from the shore end of same to connect with Mitchell-street. Necessary railway tracks were to be laid on the wharf, on which would also be erected a bond store and a sorting shed 50 feet wide.

3. The estimated cost of this work as submitted to the Committee was set down at :—

	£
Dredging 257,000 cubic yards at 1s. 6d. per cubic yard	19,300
Taking bucket dredge to Darwin	1,200
Concrete, 4,700 cubic yards	28,200
Sheet piling, 1,036 tons at £30 per ton	31,100
Railway	6,000
Sheds	1,500
Filling, 75,000 cubic yards at 5s. per cubic yard	18,750
New road	14,000
Total	£120,050

4. After taking exhaustive evidence in the matter, the Committee, in February, 1924, recommended that the proposal to construct a concrete wharf at Darwin as put forward by Sir William Clarkson be not approved.

5. Although the Committee could not see its way to recommend the proposal submitted, it stated in its report to Parliament that with the re-opening of the Meat Works and the adoption of a progressive policy for the systematic development of the Northern Territory, it was of opinion that the existing wharfage facilities would prove wholly inadequate for the efficient and economical handling of goods to and from Darwin. It further recommended that the Government should forthwith instruct a harbour engineer to make a full and detailed examination of Darwin harbour, and submit a scheme of harbour improvements or utilization of the existing wharf, which would provide efficient and economic transport of imports and exports.

6. In June, 1924, Cabinet approved of a recommendation by the then Minister for Home and Territories (Senator Pearce), that a report on harbour improvements, Darwin, should be obtained from Mr. J. F. Ramsbotham, M. Inst. C.E., M. Am. Soc. C.E., Director, Commonwealth Lighthouse Service, and this report was furnished in October of the same year.

7. On the 18th February, 1925, His Excellency the Governor-General in Council referred to this Committee for investigation and report a proposal for the erection of a wharf at Darwin on the lines of Mr. Ramsbotham's recommendations.

8. On the 24th September, 1925, before the Committee was in a position to submit its report, Parliament adjourned, the House of Representatives being then dissolved as from 3rd October, 1925.

Prior to the adjournment, a statement was made in the House of Representatives on 23rd September, 1925, by the then Chairman of the Committee (Honorable H. Gregory, M.P.), in the following terms :—

> "The House early in this year referred to the Public Works Committee for report the construction of a wharf at Darwin. The Committee has not been able to make a report, and I wish to make a short statement explaining why the report is not ready for presentation. On behalf of the Committee, I desire to inform the House that, owing to the inability of the Committee to obtain all the evidence necessary, it has not been possible to present a report in regard to the proposed construction of a new wharf at Darwin. On the 16th March, 1925, the Committee commenced its inquiry, and took a large amount of evidence in regard to the proposition submitted by the Government for the construction of a concrete wharf in accordance with designs submitted by J. F. Ramsbotham, M. Inst. C.E., M. Am. Soc. C.E., Director of Lighthouses. During the course of the investigation, the Committee learned of the arrival in Australia of Sir George Buchanan, and decided to ask him to give evidence in the matter. On approaching him, however, it was ascertained that he also had been asked by the Government to submit, *inter alia*, a proposal for the provision of wharfage facilities at Darwin. He expressed his disinclination to give evidence on the proposal while at the same time formulating a scheme of his own, and intimated that his ideas on the subject would not be available until embodied in a report which he intended to prepare on his return to England—which report might be expected to reach the Government towards the end of this year. Under these circumstances, the Committee feels that it would not be fair, either to the House or to itself, to submit its report until the views of Sir George Buchanan could be obtained. The evidence already taken by this Committee will, of course, as provided in the Act, be available for use by any subsequent Committee dealing with this matter."

A new Committee was appointed on the 22nd January, 1926, and the matter was referred to that Committee by the House of Representatives on 11th February, 1926.

EXISTING ACCOMMODATION.

9. The existing accommodation for shipping at Darwin consists of a jetty 575 feet long and 32 ft. 6 in. wide, situated at the eastern end of the bay at the foot of Stokes Hill. It was built by the South Australian Government in 1904, with cast-iron piers filled with concrete, and with steel bracings and a timber deck. In 1916, this jetty was widened by an addition of 11 feet on timber piles.

10. An outer and an inner berth are provided for shipping, the former being the more popular, but neither is free from objection, as the alignment of the jetty is not parallel to or abreast of the current, and consequently trouble is experienced in berthing at and leaving the jetty at certain states of the tide.

11. The jetty is approached by an embankment on the shore end and a viaduct 350 feet long and 20 feet wide, of similar construction to the jetty. This viaduct, with the jetty, forms a structure the shape of the letter L. A turntable, worked by a steam engine and capable of accommodating two trucks at a time, serves to convey trucks on to the jetty from the viaduct and vice versa.

PROPOSAL SUBMITTED.

12. The scheme submitted by Mr. Ramsbotham is designed to give improved facilities to meet present day shipping needs at Darwin, and aims at the systematic development in successive stages of the bay lying between Fort Hill and Stokes Hill, to provide sufficient wharfage accommodation to meet any probable development of the port for many years to come.

13. The first stage of development provides for the construction of a solid wall from the toe of the L in a north-easterly direction to the shore, the resultant triangle to be filled in solid with spoil from the adjacent Stokes Hill and paved with concrete. This wall gives, in addition to the 575 feet provided by the existing jetty, Quay A, with wharfage accommodation in sheltered water to the extent of 530 feet, as indicated on Sheet A attached.

14. By progressive development, further quayage as shown by Sheets B and C attached may be provided as required, giving accommodation as under :—

Existing jetty	575 feet
Quay A	530 „
„ B	450 „
„ C	1,000 „
„ D	515 „
„ E	1,335 „
„ F	450 „
„ G	1,335 „
Total	6,190 „

METHOD OF CONSTRUCTION.

15. It is proposed that the quay walls shall consist of reinforced concrete caissons or tanks 96 feet long, 26 feet wide, and 36 feet high, which may be built on shore, launched and floated into position, then filled with concrete and sunk. The concrete wall will then be built on the top of the tanks in the dry by tide work, earth filling placed at the back, and the whole covered with reinforced concrete.

ESTIMATED COST.

16. The estimated cost of the project as submitted to the Committee was set down at :—

Quay A.	£
480 lineal feet of caissons at £167 per foot run, including *mooring posts, &c.*	80,160
Marrying quay wall into jetty at head of dock, 30 feet x 25 feet = 750 square feet at £4 per square foot	3,000
Marrying quay wall into existing jetty, triangle area, 25 feet x ½ feet, = 250 square feet at £4 per square foot	1,000
224,360 cubic yards spoil, at 5s. per cubic yard, for filling in, from Stokes Hill	56,090
28,070 cubic yards, stone pitching, representing 17,319 cubic yards solid stone, for slopes, at 18s. per cubic yard	15,587
Dredging—soft, 535,000 cubic yards, at 1s.	26,750
Dredging—rock (schist), 49,600 cubic yards, at 5s.	12,400
Enbankment on tongue between branch docks, to hold mud up, 15,640 cubic yards, at 5s.	3,910
Retaining wall at back of existing jetty, 520 lineal feet at £9 per foot run	4,680
	203,577
Add 10 per cent. Contingencies	20,357
Cost of Quay A.	223,934

and the time estimated to complete this first section is set down at 26 months from date of commencement.

Quay B.	£
450 feet x 44 feet = 19,800 square feet ferro-concrete wharf, at £3 per square foot	59,400
67,000 cubic yards filling at 5s. per cubic yard	16,750
3,000 cubic yards pitching, representing 1,851 cubic yards solid stone at 18s. per cubic yard	1,665
	77,815
Add 10 per cent. Contingencies	7,781
Cost of Quay B	85,596

In later evidence, it was recommended that caisson construction should be used instead of reinforced concrete piles, and the estimated cost was increased to 90,042

Quay C.	£
1,000 lineal feet of caissons, at £167 per foot run	167,000
Marrying end of quay wall into quay at end of dock	3,000
260 lineal feet of caissons at end of dock, at £167 per foot	43,420
296,950 cubic yards of filling at 5s. per cubic yard	74,237
	287,657
Add 10 per cent. Contingencies	28,765
Cost of Quay C.	316,422
So that the total estimated cost of completing the branch dock ABC, including quays outlined, together with all reclamation and filling in, would be ..	630,398

COMMITTEE'S INVESTIGATIONS.

17. In investigating Sir William Clarkson's proposal in 1923, a considerable amount of evidence was taken as to conditions in the Northern Territory, the disabilities said to exist in connexion with the present jetty, the increased charges for which it was blamed, &c., while a section of the Committee visited Darwin, inspected the jetty, and acquainted itself with local conditions on the spot. These inquiries were not duplicated in the present investigation, but inspections were made of various wharfs, particularly those constructed of concrete, in use in Queensland tropical waters, and evidence was taken as to the type which might be considered most suitable to meet the peculiar conditions obtaining at Darwin.

Sir George Buchanan's Report.

18. During the progress of the Committee's investigations, the Government, on the 30th March, 1925, asked Sir George Buchanan, a prominent British engineer who was visiting Australia in connexion with other matters, to advise in regard to the provision of up-to-date shipping facilities at the port of Darwin.

19. Sir George Buchanan, before beginning his investigations, was supplied with a copy of Mr. Ramsbotham's scheme, this Committee's previous report in regard to the proposal and other information, and in submitting his report dated 30th April, 1926, which was made available to the Committee in July of the same year, he made the following comments :—

Paragraph 39. "I have studied Mr. Ramsbotham's scheme with care, and submit the following observations thereon :—

(i) the lay-out is on the right lines, but keeping in view the length of quay designed (2,555 feet), I am of opinion that the cargo area (i.e., space on which inward and outward cargoes will be handled) is hardly sufficient ;

(ii) For the following reasons, I doubt if Mr. Ramsbotham's scheme can be carried out for the figures quoted, having regard to certain of his estimated prices. His unit cost for reinforced concrete at Port Darwin is £7 15s. per cubic yard, which is based on the cost of a work done by his Department, apparently under specially favorable conditions, many miles away. The price of reinforced concrete in a work now being carried out by contract under the supervision of my firm in Scotland is £10 8s. per cubic yard, and a similar work in India cost £14 3s. per cubic yard. It may be doubted whether, under present conditions, work can be done cheaper in Port Darwin than in either of the above cases, and I have thought it safe to assume a maximum price of £21 12s. as a basis of estimating for reinforced concrete work of a quality similar to that executed in the instances quoted above ;

(iii) It is obvious, for many reasons, that construction at Darwin should be of the simplest nature, with the number of skilled men required reduced to a minimum ;

(iv) The stability of the wall proposed by Mr. Ramsbotham, in my judgment, is open to question. The question of stability has been carefully investigated by the recognized methods, and in the light of experience, and under water-borne conditions, such a wall would not, in my opinion, be stable. I consider that the width should be increased by 3 ft. 6 in., or 18.4 per cent., to obtain a section of wall that would be stable under water-borne conditions.

In view of the foregoing observations, a revision of Mr. Ramsbotham's prices, in my view, would be inevitable, if his project were adopted. In a later paragraph, in discussing projects of my own, prepared at the invitation of the Government, I have for comparative purposes applied to Mr. Ramsbotham's quantities the prices I have used in my own estimates."

20. These comments were transmitted to Mr. Ramsbotham who answered the objections seriatim, *vide* Appendix 2.

21. Sir George Buchanan stated that at a conference of the Chiefs of the General Staff, both Naval and Military, the opinion was expressed that accommodation should be provided for one 10,000-tons warship drawing 26 feet of water, with facilities for taking oil on board at all

states of the tide and under all circumstances. It was, however, suggested that a graving dock for naval purposes would not be required, and that the establishment of any Naval quarters or repair workshops was not contemplated.

22. The full text of Sir George Buchanan's suggestion for improvements at Darwin is attached—Appendix 1. Briefly, he suggested two schemes :—Scheme A, to comprise a deep-water wharf and a tidal dock. The wharf recommended was to be 1,800 feet long, of which 1,200 feet would be built at once—the balance in later stages as required. Scheme B was designed to comprise portion of Scheme A and a wet dock.

23. He suggested that the design should be of steel cylinders filled with mass concrete, and a steel superstructure of substantial construction, well braced longitudinally and transversely. The decking would be of steel troughing filled with mass concrete, the railway and crane roads being laid thereon.

24. He furnished the following summary of estimated costs :—

	£
Scheme A.—	
Stage 1, with 1,200 feet of quay, two sheds, railway connexions, and roads	587,657
Stage 2 adds 600 feet of quay to the above, and provides an inner quay 1,100 feet long, three cargo sheds, railway connexions, and roads	767,788
Stage 3 adds 1,300 feet of quay, two sheds, railway connexions and roads, includes dredging, and completes the tidal dock	560,534
	£1,915,979
Scheme B.—	
Stage 1 as above, 1,200 feet of quay, two sheds, railway and road connexions	587,657
Stage 2 adds 750 feet of quay to the above, one shed, and railway and road connexions	256,184
Stage 3 completes the wet dock, adding 2,700 feet of quay, six sheds, and railway and road connexions	1,056,379
	£1,900,220

and added :—" It should be noted that whichever proposal is adopted, Stage 1 would provide ample quay and storage space for the port of Darwin for some years to come."

Quays or Wharfs.

25. After carefully studying all the aspects of the case, the Committee is convinced that to a very great extent the future prosperity of the port of Darwin will depend on the type of quay provided. The problem is by no means an easy one, and has given the Committee no small amount of anxiety. The present trade at Darwin is small, and at first one is tempted to provide the cheapest type of quay possible. The future trade is an unknown quantity. That there are possibilities must be admitted, and the port is the key to the future prosperity of the Territory. It has been determined to provide at Darwin an oil depot for the use of the Navy, and if the wharf is to be used by warships, that indicates one justification for the building of a first-class quay. A timber quay is out of the question on account of the teredo in the water and the white ant above water level. The choice is then limited to mass concrete, ferro-concrete, or metal, and the particular type resolves itself into a solid wall or a piled braced structure.

Solid Quay Wall.

26. The evidence obtained by the Committee shows that this particular type of quay is very common and prevalent in Europe, but is practically never used in Australia. It is admitted that its first cost is high, but at the same time it is claimed that its subsequent maintenance is nil. Its use means that a solid earth quay is formed behind the wall, and consequently there is no limit to loads, and engines, trucks, and cranes, &c., can be used and placed without any limitations being imposed. This is a point of considerable moment. It is also practically indestructible by gun-fire, as was witnessed at Zeebrugge. It lends itself to assist ships when the weather conditions are unfavorable, as ships can come alongside with the knowledge that they can do it no damage.

Piled Braced Structure (Ferro-Concrete).

27. The natural floor of the harbour is about 28 feet 6 inches below low-water level. That being so, it would be useless to dredge the floor of the docks below that level, as if this were done a sump would be supplied for detritus to fill up. So, assuming that a depth of 28 ft. 6 in. at low-water level is desired, and the dock level is taken at 31 feet above low water (the existing jetty level), then piles at least 65 feet in length would be required. Such piles would weigh about 7½ tons, and would be exceedingly difficult to handle; and if the strata is the same as was found at the present jetty, extreme caution and experience would be necessary when driving. The structure in cross section would require at least four piles, and the decking would be 44 feet wide, a pitched slope of 45 degrees being adopted, and a small wall being used above low water for retaining the filling. This type of structure has been extensively used. The objections to it are:—(*a*) Liable to damage from shipping, and difficult and costly to repair; (*b*) subject to corrosion, with subsequent maintenance; (*c*) extreme care required during construction and special plant required; (*d*) difficulty in holding up the slope, the surface of which has been pitched; (*e*) if there is any slide, considerable damage will be done to sheds, railways, &c.

Steel Cylinders.

28. The type of structure suggested by Sir George Buchanan is very similar to that used at Singapore, although the tidal change at Singapore is not as great as at Darwin. A somewhat similar construction was used in connexion with the Hawkesbury Bridge (New South Wales).

Although some corrosion is liable to take place from a little above high water to a little below low water, this can be dealt with, and the structure kept in good condition by giving it a coating of bitumen as required.

Dredging.

29. This will play no small part in the scheme. From the borings put down and the information obtained by the Committee, it would appear that a modern dredger would do all the work rapidly and economically. A powerful bucket dredger built and designed for dredging rock or hard material would preclude any necessity for blasting. The Western Australian dredgers *Parmelia* and *Fremantle* are said to be capable of dredging to a depth of 40 feet with an output of 70 cubic yards per hour; so that, working two shifts of eight hours each and allowing 25 per cent. for lost time, an output of 840 cubic yards per diem could be relied upon. The tides would make it difficult and costly to use the spoil for reclamation purposes, and therefore it would be best to send all dredgings to sea. In any case, it would be inadvisable to deposit the spoil obtained by dredging until the quay wall had been built, if that class of structure were decided upon. In this event, it is recommended that all spoil for filling should be obtained by means of a small navvy or steam excavator from Stokes Hill, and the area released and made available for commercial purposes. It has been emphasized to the Committee that for Mr. Ramsbotham's scheme A alone 252,430 cubic yards of material will be required, and as the figure is large it is essential that mechanical power should be used, and a face of at least 8 feet is required for working the navvy. The source of supply recommended fulfils these conditions, and has the additional advantage of being adjacent to the new dock; and further, useless ground is made available for other purposes.

Silting and Maintenance Dredging.

30. From the information placed before it, the Committee is satisfied that some silting has taken place in the bay between Fort Hill and Stokes Hill in the past, and what effect the tipping of stone alongside the viaduct will have on future siltation it is impossible to say. It is, however, surmised that it may result in a limited deposit of silt; but as very few harbours are free from maintenance dredging, this question would have to be faced. In any case, a small grab dredger would not be expensive; on the other hand, if the amount of silt were small and the accretion took a long time to form, possibly a dredger could be sent periodically from Fremantle.

Requirements.

31. In the course of the Committee's investigations, it has been pointed out that adequate shipping facilities at Darwin should provide:—

(*a*) accommodation at the wharf for at least two vessels about 500 feet long;
(*b*) storage shed accommodation on the wharf;
(*c*) vehicular access to these sheds;
(*d*) railway access to the sheds and ships without the intervention of a turntable.

The schemes put forward by Sir George Buchanan and Mr. Ramsbotham both fulfil these requirements, but at a high cost, and the Committee made an endeavour to ascertain whether at least some of these requirements could not be obtained at a less expenditure.

Alternatives.

32. The Committee is of opinion that two berths could be made available at the existing jetty by a certain amount of dredging, and inquiries were made as to the possibility of bringing trains alongside ships without the intervention of the turntable.

33. A statement made in evidence that at Liverpool, England, trains negotiated curves of 120 feet radius led to inquiries being made as to whether it was possible to fill in the interior angle formed by the existing jetty and the viaduct, with the object of bringing the railway road on to the wharf by means of such a sharp curve.

34. Evidence obtained by the Committee indicated that it was possible to negotiate a curve of this radius with 3 ft. 6 in. rolling stock, with special shunting engines, and possibly some alterations to the wagons; but it was stated that there would be little if any saving of time as against the turntable; a section of about 100 feet of the wharf would be rendered unusable; even if it were safe to work, which was doubted, it would not be economical because of the heavy wear and tear and additional shuntings; the alterations entailed to the sidings on the wharf would make shunting more difficult; and generally, the disadvantages incidental to a sharp curve would outweigh the inconveniences and costliness of the turntable.

35. The alternative plan of erecting a goods shed on the existing jetty and constructing a dray road approach was considered, and the estimated cost of same was put down at £29,500.

The construction of this shed would entail the closing of the inner berth at the jetty, with the exception of about 150 feet at the western end; but it would enable goods to be handled direct from the ships' slings, would expedite loading and unloading of ships, and reduce handling charges by approximately 3s. per ton. As against this, however, consignees would have an additional half-mile to convey their goods to and from the town. Taking 10 per cent. on the cost of this proposal as representing interest and depreciation, the annual additional charge may be set down at £3,000. To justify this additional impost, the tonnage to be handled would require to be in the neighbourhood of 20,000 tons per annum. During the last two years, large quantities of railway construction material have been handled over the wharf; but taking the average for the three previous years, the annual tonnage dealt with may be set down at approximately 6,000 tons. On completion of the present railway construction period, it was stated that the quantity of loading would revert to that tonnage and probably remain at that figure until there is some marked progress in the Northern Territory, such as would be caused by the extension of the railway system or the re-opening of the meat works, or some development in the mining industry.

CONCLUSION.

36. The Committee, therefore, found itself faced with the problem that while Darwin is provided with a magnificent water-way—discounted by the fact that it has a rise and fall of the tide of 26 feet—there is a population in the township of only about 1,250 whites, and in the whole of the Northern Territory of about 4,000. The suggested improvement schemes for the first section only would cost in one case £223,934, and in the other £587,657, while the goods handled over the wharf approximate on an average about 6,000 tons per annum. Added to this are the facts that the meat works at Darwin are now closed, and the principal export trade of the Territory is live cattle, which is adequately dealt with under existing conditions; and that the Commissioner, Commonwealth Railways, who control the wharf, insists that the present jetty is capable of handling all the trade that goes into the port, and that he is unable to recommend any expenditure on the wharf at the present time other than for maintenance.

37. Summarized, the position is that although existing wharfage accommodation is not modern, it meets all present-day requirements. There is nothing to show that a better wharf would encourage development, and the spending of money to provide greater facilities is not justified until increased trade calls for it. When development reaches such a stage as to warrant any considerable expenditure on wharfage improvement, a definite scheme should be adopted and proceeded with in successive stages as required.

38. The Committee carefully considered the proposal outlined by Sir George Buchanan in his report of 30th April, 1926, but was handicapped by the fact that many details were not available, and there was no opportunity of obtaining evidence from Sir George Buchanan, as while he was in Australia, he had intimated that he had not given sufficient thought to the matter at that stage to enable him to formulate any scheme or supply any definite information.

From the information available, however, the Committee is of opinion that while the accommodation suggested by him would be more than sufficient to handle any trade likely to pass through the port of Darwin for very many years, the cost at which it is proposed to provide the facilities is much higher than the Committee considers warranted.

39. Under these circumstances, the Committee, after giving the matter most careful consideration, agreed to recommend that while, in its opinion, the first stage of the scheme submitted by Mr. Ramsbotham would eliminate all the disabilities complained of in respect of Darwin Jetty, and could be progressively extended as the business of the port expanded, it is not considered that the existing or immediately prospective trade of the port warrants any additional wharfage construction at the present time.

G. H. MACKAY,
Chairman.

Office of the Parliamentary Standing Committee on Public Works,
Federal Parliament House, Canberra,
13th May, 1927.

LIST OF APPENDICES AND PLANS.

APPENDIX 1.

SIR GEORGE BUCHANAN'S SCHEME.

The most favorable site for port development at Darwin is undoubtedly within the area between Fort Hill and Stokes Hill, and after a perusal of the evidence, and studying the scheme previously prepared, I have formed the opinion that a deep water quay, either as an extension to the present jetty or in a position further back, is the first step to be taken. To widen the present jetty to give quay space for sheds, and to make the necessary alteration to the lead on to the jetty (in order to abolish the turntable) is an expensive proposal, and such a scheme does not lend itself to easy expansion. After careful consideration, therefore, I have prepared two alternative schemes, A and B (*vide* plans attached):

Scheme A.—This proposal comprises a deep water wharf and a tidal dock. The wharf to be 1,800 feet long, of which 1,200 feet would be built at once; the balance in later stages as required.

The wharf is shown to commence at a point on the approach to the existing jetty, about 300 feet back from the face line of the jetty, and extending in a south-westerly direction generally parallel to the low water mark for a distance of about 1,800 feet, where it ends in a round head forming one side of the entrance to the tidal dock.

The tidal dock is shown extending north-eastwards from this entrance for a distance of about 1,150 feet into the bay behind the deep water wharf, the quay line of the dock making a small angle with the face line of the wharf.

The width of the dock is 300 feet. This width is a good general average for such a dock as is now proposed, and gives ample space for the berthing and unberthing of ships. A wider dock would be more costly, without any compensating advantage. The length of quayage provided is 290 lineal feet per acre; which is also a good general average.

To allow of economical extension to meet the future development of the port, a stone-pitched slope is provided, instead of a quay, at the end of the dock.

Vessels berthed alongside the deep water wharf and dock quays will be subject to the rise and fall of the tides, which during spring tides will amount to from 22 to 24 feet. This entails the wharf and quays being 61 feet in height from the dredged level to the deck of quays.

It is proposed to carry out this scheme in three stages, each stage being a definite part of the whole, and a complete unit in itself.

Stage 1.—This stage is shown on plan D, and comprises:—

(*a*) a wharf 1,200 feet long and 50 feet wide to the face line of the transit sheds, and having a depth alongside of 30 feet at low water and 55 feet at high water ordinary spring tides;

(*b*) two transit sheds 400 feet long by 100 feet wide, with crane rails; and

(*c*) three lines of railways on the wharf side and two lines of railway on the landward side of the sheds, with their extensions and connexions to the existing railway; and

(*d*) roads on quays.

The line of this wharf is sufficiently far behind the existing jetty to permit of its construction without interfering with the berthing of ships. On the completion of Stage 1, the existing jetty would be removed.

Stage 2.—This stage is shown on plan D, and comprises the extension of the wharf for a distance of 600 feet to the round head, forming one side of the entrance to the tidal dock, and the construction of the south quay of the dock, for a length of 1,100 feet. The extension of the dredging into the dock to a width of 200 feet to form the ships' berths and the stone protection of the dredged slopes is also included.

The arrangement of the sheds, railways, and their connexions and roads is similar to that for Stage No. 1.

Stage 3.—This stage is shown on plan D, and comprises the construction of the north quay of the tidal dock and the completion of the dredging to form the dock; sheds and railway connexions and roads arranged as in the previous stages.

The quays to be constructed of steel cylinders 5 feet in diameter, filled in with mass concrete and strongly braced together. The decking to be of steel girders with steel troughing filled in with concrete.

The completed scheme will give:—

Length of quays	...	4,200 lineal feet
Minimum depth of water alongside	...	30 feet
Number of sheds	...	7
Floor area of sheds	...	30,000 *square yards*
Miles of wharf railway	...	4¼

Scheme B.—This scheme comprises the deep-water wharf, Stage 1, and part of Stage 2 of Scheme A, and a wet dock.

The outline and position of the dock is generally similar to the tidal dock of Scheme A, but it is provided with two pairs of entrance gates to retain the water. The entrance to the dock is situated under the south-east corner of Fort Hill as shown on plan E.

The dock is 1,350 feet long by 300 feet wide between the quay walls, with available space for a further 300 feet extension.

The depths from coping level to the bottom of the tidal dock and wet dock are 61 feet and 48 ft. 6 in. respectively, that is to say, the wet dock bottom is 12 ft. 6 in. higher above datum than that of the tidal dock, and consequently the excavation is correspondingly of less amount and the dock walls less costly.

The entrance and quay walls of the dock are of mass concrete construction. The maximum height of the walls from foundation level to quay level is 56 ft. 6 in.

The entrance gates to be of steel construction and the transit sheds of steel framing and corrugated steel sheeting construction.

The minimum depth of water in the wet dock would be the level of high water neap tides, and docking and undocking of ships would take place for about an hour before and after high water.

The advantages and disadvantages of a tidal dock and wet dock respectively are that, in the case of a tidal dock, there is on the one hand the inconvenience of working cargo on a constantly rising or falling tide, but on the other hand vessels can be berthed at the wharfs at any time of the day or night.

In the case of a wet dock there is the convenience of having the water in the dock at a constant level and the inconvenience of only being able to berth ships for, say, two hours on every tide.

The complete Scheme B will give:—

Length of quay—Wharf	..	1,950	
Dock	..	2,700	
			4,650 lin. feet
Minimum depth of water alongside—Wharf	..	..	30 feet
Dock	..	..	30 feet
Number of sheds	..	..	9
Floor area of sheds	..	..	32,700 sq. yds.
Miles of wharf railway	..	..	4¼

Provision of Roads for Vehicular Traffic on Wharf and from Wharf to Town.—I had taken, whilst in Darwin, some additional surveys and levels to enable me to form an opinion as to the best arrangement for the new road, and, after consideration, I decided that, in view of the necessity for crossing the railway line at rail level, the best route would be from the east end of the wharf on the west side of Stokes Hill, via the southern end of Wood-street and finally connecting with Bennett-street, as shown on Plan E. This gives a uniform grade of 1 in 31 and a total length of 900 yards. The estimated cost of this road is £31,500.

Estimates.—The estimates have been based on the following unit prices which are intended to be schedule prices, i.e., rates at which contractors would carry out the work complete in every respect. They include all plant, staging, and other temporary works, accommodation for staff and workmen, overhead charges, supervision and contractors profits:—

Prices used for Darwin estimates—

6 to 1 concrete	.. ..	c. yd. 80s.
Steelwork in place	.. ..	ton £45
Reinforced concrete	.. ..	c. ft. 16s.
Filling material	.. ..	c. yd. 5s.
Rubble in place	.. ..	c. yd. 20s.
Dredging soft—including hire of plant, &c.	.. ..	c. yd. 3s.
Dredging hard or rock	..	c. yd. 12s. 6d.

If it is considered in Australia that the rates are too high or too low, the estimates can be modified accordingly.

Before coming to a decision as to the best and most economical form of construction, the following types of wall to be built without cofferdams were considered:—

1. Concrete blocks.
2. Reinforced concrete caissons.
3. Steel screw piling.
4. Steel cylinders.
5. Reinforced concrete—

and 4 was ultimately decided on as being the most suitable and economical design for Port Darwin. The design is of steel cylinders, filled in with mass concrete, and steel superstructure of substantial construction, well braced longitudinally and transversely.

The cylinders are spaced 25 feet centre to centre longitudinally and transversely. The bottom or foundation length is 6 ft. 6 in. diameter, and is reduced by a taper length to 5 feet diameter. These cylinders would be placed in position and sunk by grab cranes excavating the materials inside until the cylinders reach a hard foundation.

As the whole of the steel work would be prepared in the makers' works ready for erection at site, a large number of skilled craftsmen would not be required at Darwin; a few good erectors and intelligent labourers only would be necessary for its erection.

This type of structure is not unusual, and no difficulty is experienced in sinking the cylinders in their correct positions and joining up with the various other parts of the steel work.

The decking would be of steel troughing filled in with mass concrete, the railway and crane roads being laid therein.

The following is a summary of estimated costs:—

Scheme A—

Stage 1, with 1,200 feet of quay, two sheds, railway connexions and roads	£587,657
Stage 2 adds 600 feet of quay to the above, and provides an inner quay 1,100 feet long, three cargo sheds, railway connexions and roads	767,788
Stage 3 adds 1,300 feet of quay, two sheds, railway connexions, and roads, includes dredging and completes the tidal dock ...	560,534
	£1,915,979

Scheme B—

Stage 1 as above, 1,200 feet of quay, two sheds, railway and road connexions	£587,657
Stage 2 adds 750 feet of quay to the above, one shed, and railway and road connexions	256,184
Stage 3 completes the wet dock, adding 2,700 feet of quay, six sheds, and railway and road connexions	1,056,379
	£1,900,220

It should be noted that whichever proposal is adopted, Stage 1 would provide ample quay and storage space for the port of Darwin for some years to come.

On the basis of the unit prices quoted and used by me in estimating, Mr. Ramsbotham's estimates will need revision as follows:—

	Mr. Ramsbotham's *Original Estimates.*	Mr. Ramsbotham's Scheme based on Prices used by me.	Mr Ramsbotham's Scheme with Thicker Wall and Prices used by me.
	£	£	£
Quay A ..	223,934	363,820	418,760
„ B ..	85,596	97,955	97,955
„ C ..	316,422	484,373	549,270
	625,952	976,148	1,065,985

As has been noted already, Mr. Ramsbotham's scheme does not provide for sheds, railways, and roads. These, if provided on the lines laid down in my own scheme, would cost an additional £200,000 at least. Further, it must be borne in mind that the old wharf probably will need reconstruction within the next 20 years, and in the meantime will need increasing and heavy charges for yearly maintenance. Finally, to recall an objection raised earlier in this Report, the cargo handling area appears to me to be inadequate.

APPENDIX 2.

Wilton, Bell, and Ramsbotham,
Chartered Civil Engineers,
Westminster, S.W.1,
19th January, 1927.

The Secretary, Parliamentary Standing Committee on Public Works, Federal Parliament House, Melbourne, Australia.

Dear Sir,

I have pleasure in responding to your minute of the 7th December, 1926, in which you ask to be favoured, for the information of your committee, with any remarks I may desire to make in regard to the comments contained in the report by Sir George Buchanan on "The Ports of North and North-West Australia," as affecting my reports of the 17th October, 1924, 12th March, 1925, and the 20th January, 1926.

I would remind you that all these reports have been read and discussed by the committee. Sir George Buchanan's criticism, as affecting my proposals, can be condensed into—

(1) Insufficient cargo space for inward and outward cargoes.
(2) Insufficient money allowed for reinforced and plain concrete.
(3) Stability of wall is open to question.

With regard to (1)—Insufficient cargo space for inward and outward cargoes—this is a point about which the committee will have no difficulty in coming to a decision.

Shortly prior to my leaving Australia, I was asked by the committee of the Interstate Harbour Conferences (Australia) to submit a report on the conclusions which I had arrived at after visiting ports between Sydney and Liverpool via Canada. On the 31st July, 1926, I had pleasure in submitting from Montreal my report dealing with everything up to that stage. I later submitted a supplementary report from Liverpool dealing mainly with grain handling at Liverpool, the port of destination.

This very question of width of piers received my most careful consideration.

Auckland.—I ascertained that the width of the Princess (double sided) pier at Auckland is 281 feet.

Honolulu.—The width of the main double-sided pier at the port of Honolulu is 120 feet. (Bigelow, chairman of the Harbour Commission, stated that their next double-sided pier would be 400 feet wide.)

Vancouver.—La Pointe (double-sided) pier is 300 feet.
Ballantyne (double-sided) pier is 341 feet, and a new pier about to be built will be 400 feet.

Width of Quays at Other Ports

Liverpool—Gladstone Dock, 311 feet.
Seattle.—Smith's Dock Terminal, 365 feet.
San Francisco.—Mission Rock Development, 350 feet.
Portland (Ore).—New Terminal, 480 feet.
Kobe.—No. 2 Pier, 336 feet.
Genoa.—Victoria Emmanuelle III. Basin, 426 feet.
Vancouver.—Ballantyne Pier, 341 feet.
Marseilles.—President Wilson, 426 feet.
Philadelphia.—300 feet.

The width I proposed at Darwin was 388 feet. I am not prepared to increase that dimension, unless the Commissioner of Railways specifically states that he desires to have three lines of rails between the shed and the quay, in which case the increased size will be limited to a few feet.

If this dimension of 388 feet were contrasted with the sizes at present adopted in Australia, I fear that it would be considered that I was excessive in my requirements, and was wasting valuable space and involving large sums of money in unnecessary maintenance.

In deciding on this figure of 388 feet, I was guided to some extent by comparison with the port of Liverpool. Undoubtedly, the tendency will be for Australian ports to work up to this dimension, and as the volume of traffic increases, it will be found that more freedom is required at peak periods.

In my opinion, to go beyond this width simply means the wastage of valuable space, particularly if additional water area and additional quayage could have been provided if restraint had been shown.

(2) *Insufficient money allowed for reinforced and plain concrete.*

I would refer you to a paper read by Ramsbotham, Jackson, and Mehaffey before the Institute of Civil Engineers in 1921. At my instigation Mr. Jackson gave, on page 34, a summary of costs, on page 35 the cost of concreting materials, and on page 36 the cost of concrete work in both the Cape Don Lighthouse tower quarters and other buildings.

It is hardly necessary for me to say that these costs were faithfully kept, as obviously there was no reason for doing otherwise, and further, as they would be used by our own officers for estimating purposes afterwards, there was every inducement and intention to keep them accurately. It must, however, be realized that notwithstanding the disadvantage of the site for Cape Don towers, we paid nothing for the sand, stone, and water used, as they were all contiguous to the station.

This station was built at the very peak of the war period. Our workmen were returned to Melbourne two consecutive seasons during the rainy season, as it would have been impossible to do ferro-concrete work for a tower like Cape Don Lighthouse during that period. All cement plant gear had to be carried by boat from Darwin to Cape Don (a distance of 105 miles), then transported on a tramway for 3 miles, so that, weighing everything up, I came to the conclusion that the price for Cape Don should be taken as a basis, and I reduced the cost of £7 14s. 11½d. for ferro-concrete to £7 10s. per cubic yard, this embracing all materials, including steel, all moulds, providing conveyors, concrete machines, &c.

I note that Sir George Buchanan, in paragraph 44, in his prices used for Darwin estimates, takes for 6 to 1 concrete 80s. per cubic yard. That being so, I am still satisfied that the ferro-concrete work which I propose could be done for an additonal £3 10s. per cubic yard, as it simply means increasing the strength of the concrete from 6 to 1 to 4½ to 1 (an increase of 25 per cent.), and providing approximately 1 per cent. for steel, the moulds being common to both estimates. It will be noted that my price, however, is 87.5 per cent. more than that allowed by Sir George Buchanan for 6 to 1 concrete.

(3) *Stability of wall is open to question.*

Though there may be some divergence of opinion over the width of base necessary for a wall of a given height, the dimensions of a wall are a matter of calculation. If all the forces acting on it were known with exactitude, this would be a simple matter. Unfortunately, they are not, and the magnitude of some of them must be a matter for judgment and knowledge of local conditions.

It is, of course, an easy matter to "play for safety" by adding a large margin of width to a wall which is already shown by calculation, after a proper consideration of local conditions, to be safe, but I do not consider this justifiable, as to do so is tantamount to a waste of money.

For purposes of comparison, it may be noted that the ratio of base of wall to height given in my proposals of the 17th October, 1924, was approximately 0.4. The walls at the docks at Liverpool, designed by the late Mr. Anthony George Lyster, Engineer-in-Chief to the Mersey Docks and Harbour Board, President of the Institution of Civil Engineers, to whom I was a pupil and assistant for thirteen years, work out at approximately the same figure, and these walls have stood for many years, and never shown the slightest sign of failure. This, I think, may be taken as supporting the soundness of my contentions.

In my proposals of the 17th October, 1924, I gave the base of the wall as 24 ft. 6 in. I subsequently increased this in my proposals of the 20th January, 1926, as I desired to increase the buoyancy of the caisson after launching, and decrease the toe pressure, the unit loading on the base of the latter being 5.578 tons per square foot.

In my report of the 12th March, 1925 (page 8), I stressed the importance of weep holes, stating, "6-in. weep holes, staggered at the end at 10-ft. centres horizontally, and 5-ft. centres vertically, must be provided above low-water mark."

I further emphasized the desirability of having a hand-packed rock drain placed at the back of the wall, connecting all weep holes, both vertical and horizontal, stating that it should not be less than 24 inches wide. On page 11 I further allowed a sum of £250 for weep holes and hand-packed rubble drains for completing a length of 96 feet, thus emphasizing the importance which I attached to giving relief to any water accumulating behind the wall.

I would refer you to *Kemp's Engineers' Year-Book*, page 404 (my edition, 1914). This, of course, does not take into account factors incident to the location of a wall.

In my first proposals for a wall, I rather made a point of having two cutting edges under the base of the wall, as I wished to ensure a good grip of the ground, and prevent any tendency for the wall to slip when filling was deposited behind. After further very careful consideration, I came to the conclusion that it would be wise to omit these cutting edges, as in the event of hard rock being encountered in one place, and not in others, difficulties might arise. Any tendency of the wall to slip will be dealt with more satisfactorily by a modification suggested by my partner, Professor T. R. Wilton, M.A., M.Inst.C.E., that is, to provide a space in the centre of each pocket, or box, for driving, say, a 4 in. by 4 in. steel grip, or pile, into the ground, after the caisson has taken up its correct position, then concreting in the extra thickness of floor already allowed for in my design. This is a very simple proposal, and should be adopted. It will not only keep the caisson in its position in the early stages, but will subsequently prevent any tendency for the wall to slide on its base when the filling is tipped behind the wall. (*Vide* appendix for all data.)

As to the virtual loss of weight of wall by upward water pressure on the base, I maintain that very little loss of weight will take place, as stated on page 10 of my report of the 12th March, 1925. In my calculations I allowed for 10 lb. per cubic foot of wall in this direction. I am not prepared to go any further, and I very much question if I should have allowed even that amount.

I must differ from Sir George Buchanan on this point, as I adhere to the view taken by the late Mr. Lyster (who is acknowledged to be one of the greatest authorities on the subject), the soundness of which is proved by miles of quay built and completed satisfactorily as the basis of the design of which a similar theory to that on which I have worked was adopted. I can only say that if an increase of 18.4 per cent. had been adopted, say at the Port of Liverpool, it would, in my opinion, represent a useless expenditure of a capital sum running into many hundreds of thousands of pounds.

Since I was before the committee in April, 1926, I have been fortunate enough to see, at the Port of Montreal, some walls built by this systems of caissons. The result of my visit has been to influence me considerably, as at Montreal they fill their caissons from top to bottom with stone. I am not prepared, however to go as far as they have gone.

In work carried on in Java, it has been found of some advantage to have three pockets in the cross-section instead of two, and I rather favour the adoption of this, and the use of stone and sand filling in partial substitution of concrete. It would mean increasing the thicknesses of the walls beyond the 7 inches for which I have provided, as there would not be a solid concrete filling inside to be depended upon, and it would not be safe to depend upon 7 inches, in the event of any cracks developing, or in the event of the structure suffering from shock from vessels berthing, &c.

The committee will no doubt realize that if dumplings of sand and stone are introduced, instead of having a solid concrete wall from top to bottom, a loss of weight is inevitable, and consequently the centre of gravity of the wall is changed, and the position of the resultant thrust is moved, so much so, that the only way to overcome the new position of affairs is to increase the width of the caisson.

I have given the matter some thought, and whenever I have had any spare time, I have proceeded with an amended design on these lines Unfortunately, I have not as yet been able finally to complete my proposals, but everything points to the width of the caisson (if the back pockets are filled with sand and stone) being increased from 28 feet to about 32 feet The thickness of the walls will be about 12 inches throughout, and pockets 8 feet square will be provided for, 2-ft. toe being provided at each side.

It is interesting to note that if this method is adopted, and £200 is allowed for making and driving fifteen steel grips, or piles, into each caisson, the cost per foot run of the wall will run out at £161 3s. 7d., as against £167 allowed for in wall No. 2, as per my estimate of the 20th January, 1926. I have taken exactly the same unit price, notwithstanding that it will be an easier type of caisson to build. The saving effected really results from using stone and sand as a filling, instead of a concrete core.

I freely admit that there is a difficulty in estimating costs, particularly at a place like Darwin, where the human factor and climatic conditions are uncertain quantities, in addition to which, every variation of the tariff upsets calculations, and uncertainty and unrest are world factors over which the Commonwealth has no control. Nevertheless, they all contribute to increased prices in both wages and materials.

I am in agreement with Sir George Buchanan's provision:—"If it is considered in Australia that the rates are too high or too low, estimates can be modified accordingly."

Yours faithfully,

(Signed) J. F. Ramsbotham, M. Inst. C.E.,
M. Am. Soc. C.E.

Appendix.

No. 2 Dock Wall, Darwin.

Surcharge taken at one-third of a ton per square foot.

Concrete in caisson before launching taken at 150 lb. per cubic foot.

Concrete in wall taken at 140 lb. per cubic foot.

Filling taken at 104 lb. per cubic foot.

Resolved horizontal thrust against wall 17,000 tons.

Total effective weight of wall, counterforts and backing, 79,779 tons.

Resultant thrust on foundations, 81,570 tons.

Overturning moment about outer edge of toe, 383,911 feet tons.

Moment of stability about outer edge of toe, 1,133,808 feet tons.

Factor of safety, 2.979.

Eccentricity of resultant thrust 3.542 feet.

Average intensity of pressure per square foot on foundation, 3,068 tons.

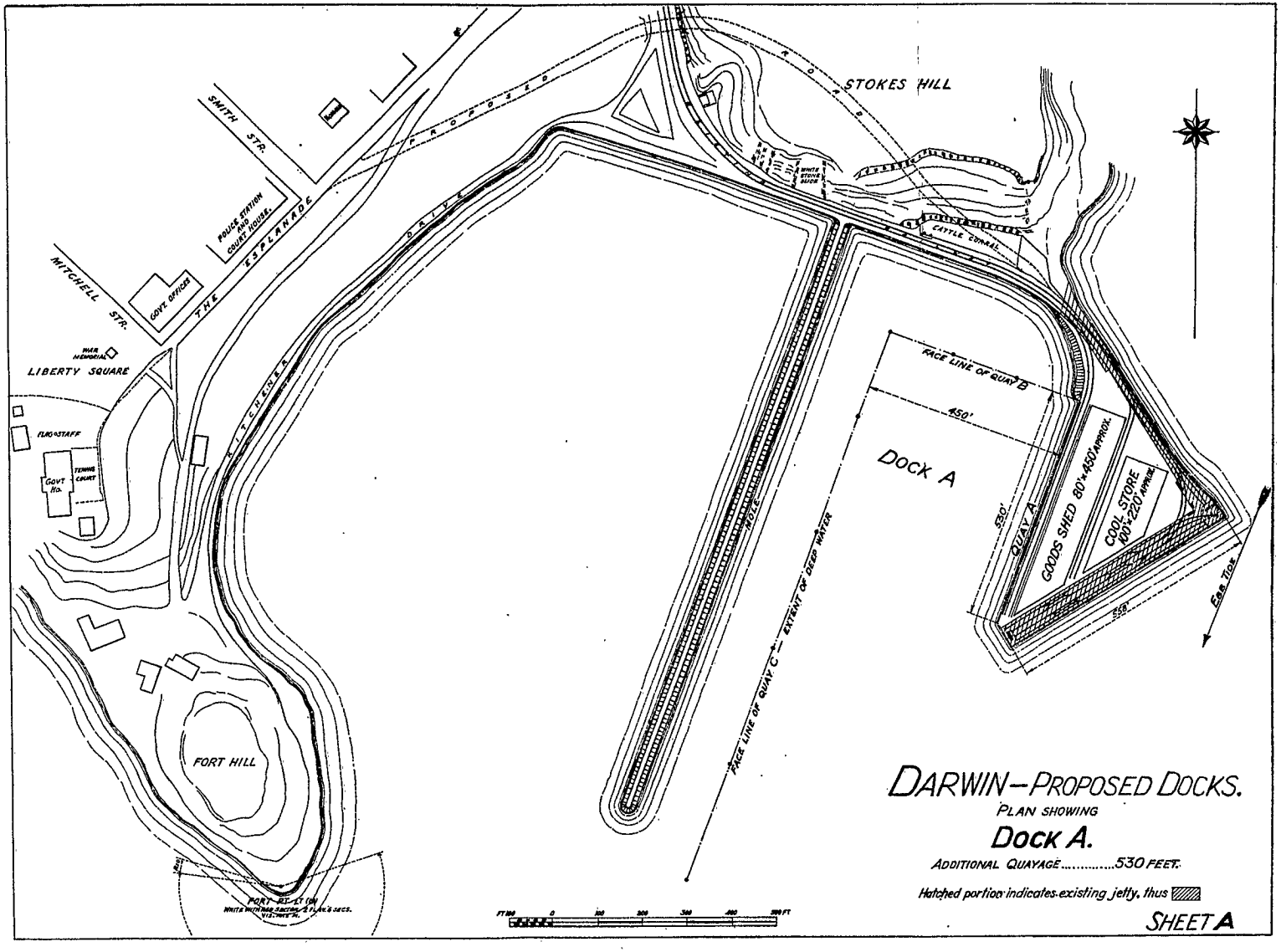
Maximum intensity of pressure per square foot on foundation, 5.578 tons.

Factor of safety for sliding on wet clay, 1.5.

Factor of safety if taken on sand, 1.86.

With regard to the two latter items, sand was provided for in the design, and any assistance from the schist in front of the toe of the wall was disregarded.

PLAN A.



DARWIN—PROPOSED DOCKS.

PLAN SHOWING

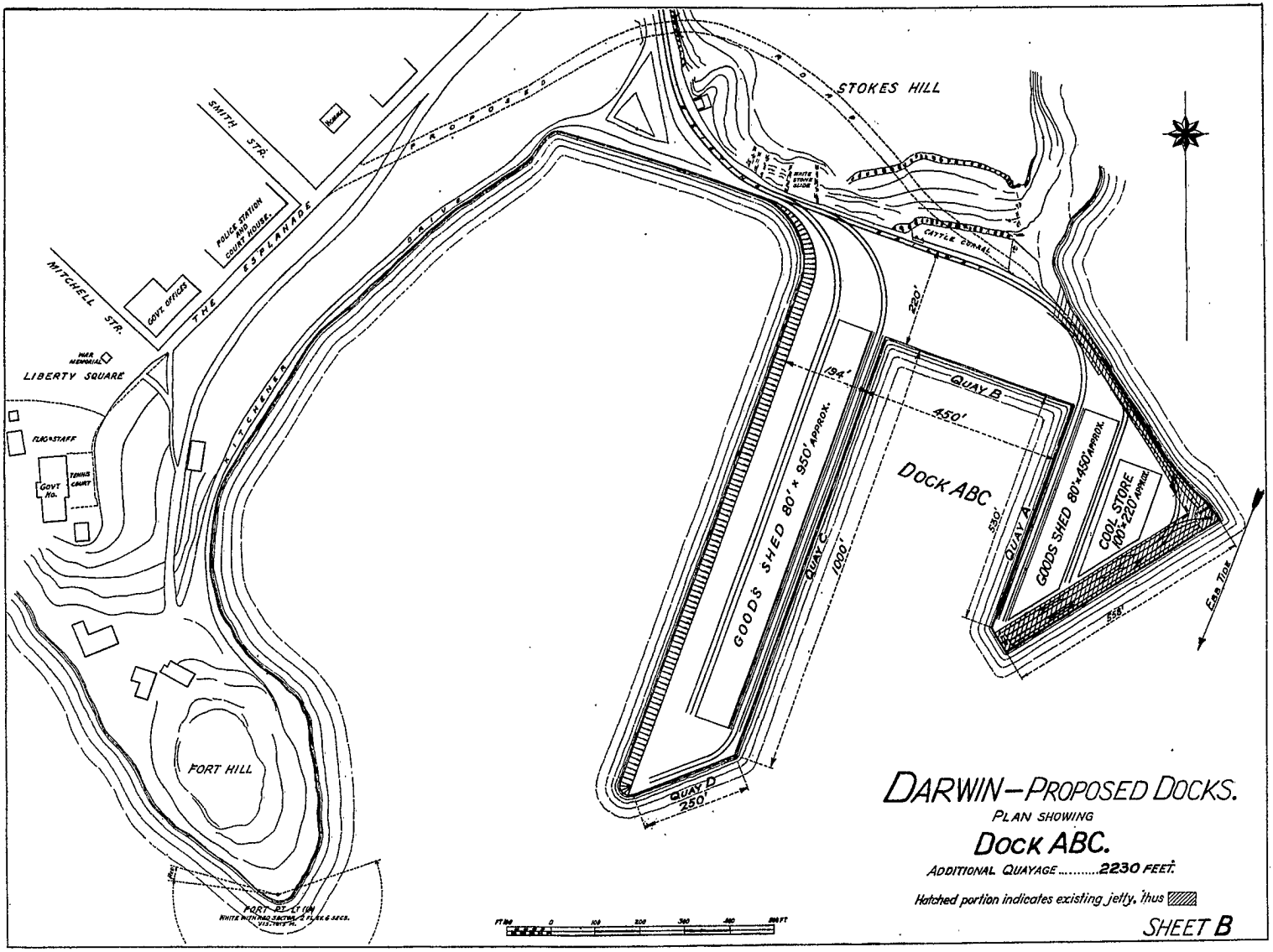
DOCK A.

ADDITIONAL QUAYAGE.....530 FEET.

Hatched portion indicates existing jetty, thus ▨

SHEET A

PLAN B.



DARWIN—PROPOSED DOCKS.

PLAN SHOWING

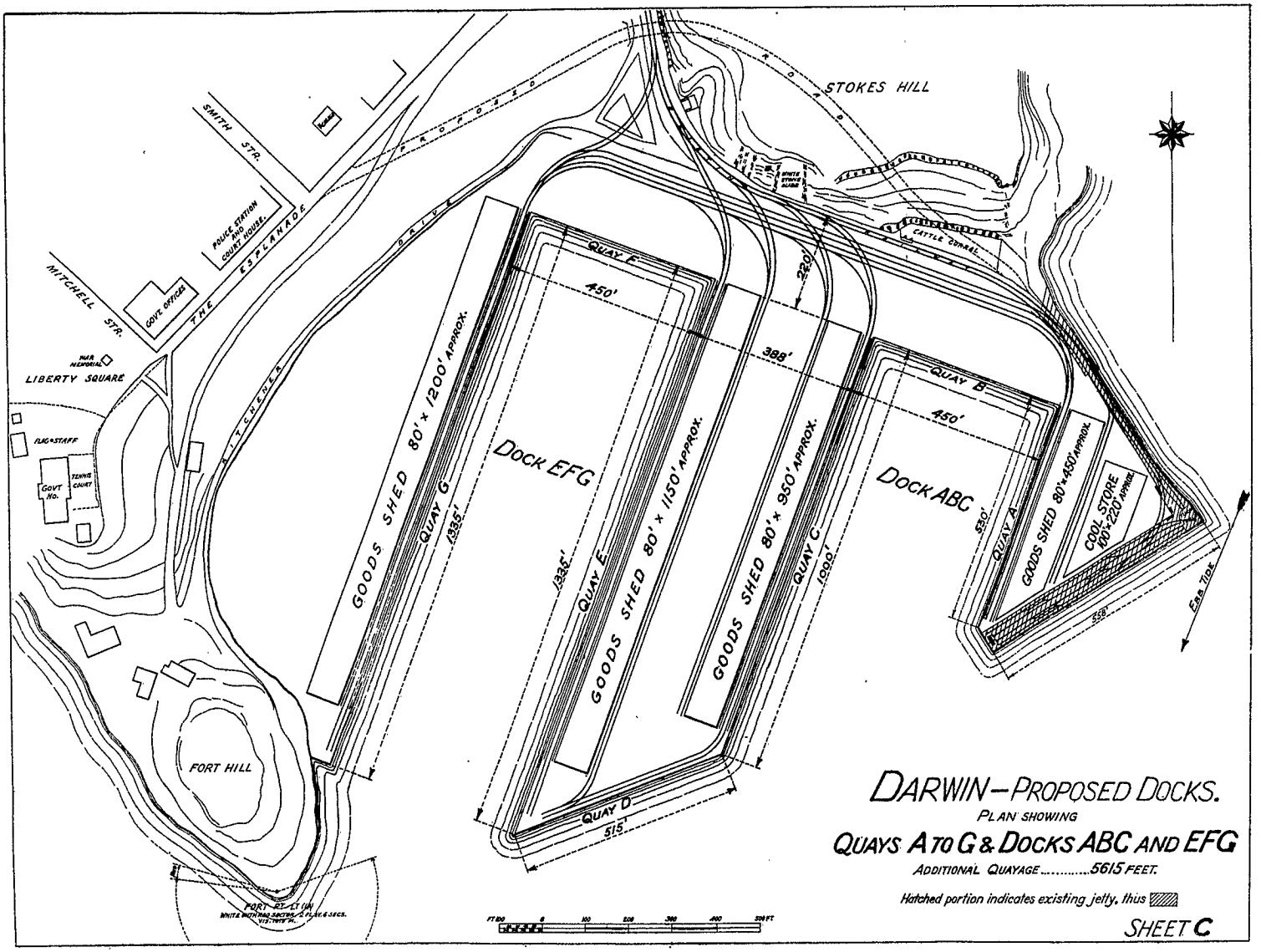
DOCK ABC.

ADDITIONAL QUAYAGE.....2230 FEET.

Hatched portion indicates existing jetty, thus ▨

SHEET B

PLAN C.



DARWIN—PROPOSED DOCKS.

PLAN SHOWING

QUAYS A TO G & DOCKS ABC AND EFG

ADDITIONAL QUAYAGE.....5615 FEET.

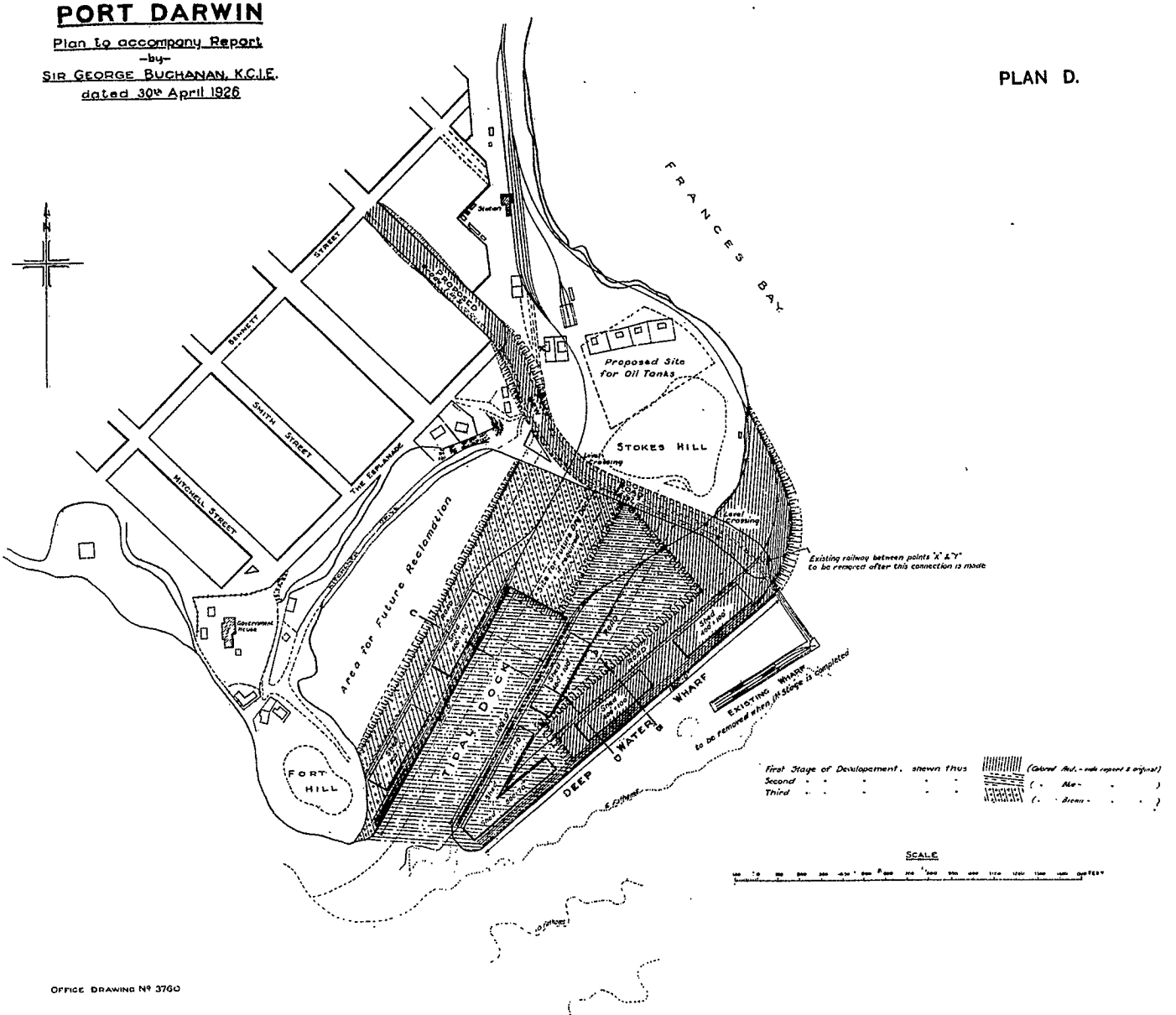
Hatched portion indicates existing jetty, thus ▨

SHEET C

PORT DARWIN

Plan to accompany Report
-by-
SIR GEORGE BUCHANAN, K.C.I.E.
dated 30th April 1926

PLAN D.

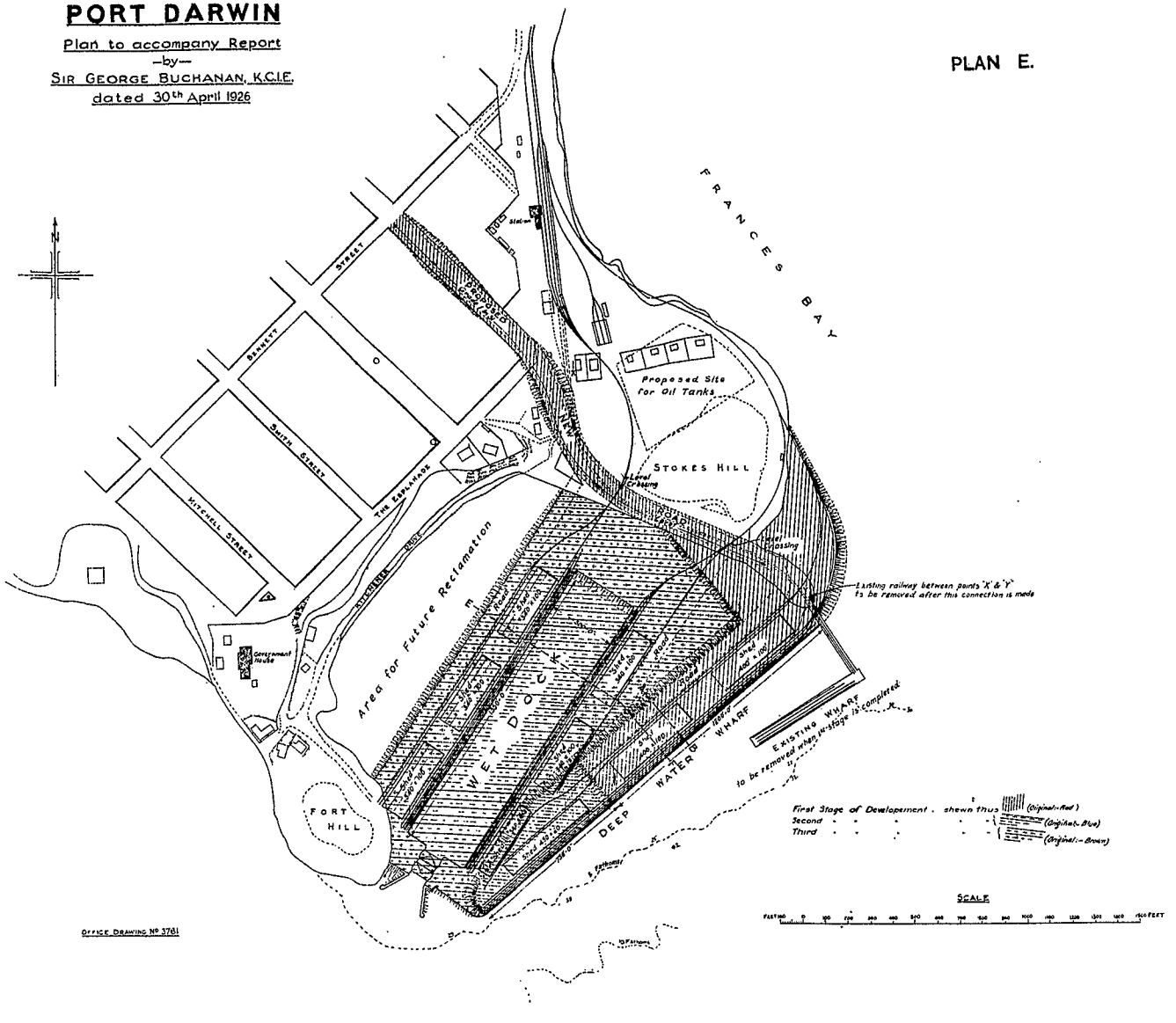


OFFICE DRAWING Nº 3760

PORT DARWIN

Plan to accompany Report
—by—
SIR GEORGE BUCHANAN, K.C.I.E.
dated 30th April 1926

PLAN E.



OFFICE DRAWING No 3781

MINUTES OF EVIDENCE.

(*Taken at Melbourne.*)

MONDAY, 10TH MARCH, 1925.

Present:

Mr. MACKAY, in the Chair;

Senator Barnes	Mr. Cook
Senator Reid	Mr. Jackson
Mr. Blakeley	Mr. Mathews.

Joshua Fielden Ramsbotham, M.Inst. C.E., M. Am. Soc. C.E., Director of Lighthouses, sworn and examined.

1. *To Mr. Mackay.*—I served my articles from 1896 to 1899 as civil engineer to the late Anthony G. Lyster, Esq., past president of the Institution of Civil Engineers, for many years Engineer in Chief to the Mersey Docks and Harbours Board, Liverpool, and towards the latter end of his life in partnership with Sir John Woolfe Barry, Lyster, and partners, London. My training was of a thorough character, embracing all phases in dock and harbour engineering. In 1899 I was assistant resident engineer on the building of the Prince's cattle jetty (ferro-concrete structure), Liverpool. In 1899-1901 I was assistant resident engineer throughout the construction of the Stanley Dock tobacco warehouse, Liverpool, a building of fourteen floors, 125 feet high, with a floor area of 36 acres. The cost entailed was £318,000. In 1901-2 I was resident engineer in charge of the new North Carriers' warehouse, Liverpool, a structure built on green-heart piles driven into a rock bottom, barge traffic being conducted underneath. In 1903-5 I was resident engineer in charge of construction of the new Brocklebank Graving Dock, Liverpool, the dock being 805 feet long, with an entrance of 135 feet, the depth from coping to sill being 44 feet, in addition to which I had charge of the underpinning of the old South-east Brocklebank dock walls, the total cost being £175,000. In 1906 I was in charge of the underpinning of the walls of Canada Tongue in Canada Dock, Liverpool, the cost being £14,000. In 1906-7 I was in charge of the construction of a three-story warehouse, South Sandon Dock, Liverpool, for the accommodation of the largest liners afloat, cost £60,000 (ferro-concrete warehouse). In 1907-8 I was in charge of the Brunswick Dock extension works, entailing the building of a new 100-ft. passage, gates, and swingbridge, and equipping the new dock walls with sheds, railways, &c. Extensive dams had to be used on these works at both ends, the cost of the work being £222,000. In 1909 I was in charge of the underpinning of South-west Brunswick Dock wall, costing £12,000. In 1910-11 I was appointed by the Western Australian Government to design and carry out by day labour the Fremantle Dock. On taking up duty I recommended the Government to either abandon the dock or place a floating dock in the area already dredged. On my advice the Government decided to further investigate the bottom for the inner side wall and were thus enabled to have a more thorough examination made of the conditions that prevailed. Subsequent examination under cover of dams indicated caves of an extensive size, and in view of the uncertainty it was decided to abandon the site. In 1912-13 I reported to the Western Australian Government on future extensions and improvements to the ports of Fremantle, Albany, Bunbury, and Geraldton. I was appointed to my present position in August, 1913. Since the inception of the service over £300,000 has been expended on additional aids to navigation and improvements to existing lights. I was instructed on 11th June, 1924, to prepare a scheme for the improvement of shipping facilities at Port Darwin, and I submitted the following report to the Minister on 17th October, 1924:—

THE PORT OF DARWIN, AND PROPOSED SCHEME FOR ITS IMPROVEMENT.

With reference to the minute of 11th June, 1924, from the Right Hon. G. F. Pearce, P.C., Minister for Home and Territories, stating that Cabinet has approved of his recommendation that I should be asked to report on the question of harbour improvements for the port of Darwin, I have pleasure in submitting my report, together with recommendations, estimates of cost, and plans, showing the proposed scheme. The latter shows the extreme limit or capacity of the port in the bay, bounded by Fort Hill on the west side and Stokes Hill on the north-east side.

Material assistance has been gained from reading the report, together with the minutes of evidence as presented and printed by the Parliamentary Standing Committee on Public Works. I should like to record that their report enables me to omit any references to trade and facilities of the present port, as they so clearly demonstrate that the present equipment of the port is not only unsatisfactory, but that it precludes the future development of the Territory, and before any great scheme or policy of development is put in hand it will, in my opinion, be necessary to commence modernizing the present port. If this is not done, all development such as railways, roads, and bridges, in the Territory, must be done at enhanced costs.

PRESENT PORT AND PREVAILING CONDITIONS.

The port consists of a jetty 575 feet long, 44 feet wide, and served by four lines of rails. An outer and an inner berth are provided for shipping, the former being the most popular, but neither is free from objection as the alignment of the jetty is not parallel to or abreast with the current, and consequently trouble is experienced in berthing and leaving the jetty, due to the flow and ebb of the tide. The jetty is approached by an embankment on the shore end, and a viaduct forming the shape of the letter L. A turntable worked by a steam engine, and capable of carrying two trucks, serves to convey trucks to and from the jetty to the viaduct. The statement of John Hargreaves Millican, Officer-in-Charge, Northern Territory Railways, is accepted, that if this turntable was dispensed with and cargo landed from the ship direct into a sorting shed, a saving of 3s. 2d. per ton in handling would be effected.

COST AND LIFE OF JETTY.

The valuation of the jetty, given by Mr. G. A. Hobler, Chief Engineer for Ways and Works, Commonwealth Railways, is accepted. In his evidence Mr. Hobler stated that "the estimated cost of the jetty is £100,445, and I should say that another 25 years will be the limit of its life." This statement is of supreme importance, and has materially affected my proposals, as the necessity of dove-tailing the existing jetty into the proposed scheme of extensions and improvements to the

port is realized. The sum of £100,445, together with the prospects of a life of 25 years of the jetty, should not be thrown aside unless its retention would adversely affect the future extensions of the port.

Tides, Current and Wind.

Very little data is available with regard to the tides at Darwin. Mr. Mehaffey, during the limited period he was at Darwin, obtained some data, but it is thought that steps should be taken to generally collect and collate such information, not only at Darwin, but throughout Australia, and possibly the hydrographer could be induced to undertake this important work. The highest level of a spring tide that took place during the time Mr. Mehaffey was at Darwin was 22 ft. 6 in. above low-water mark, and the lowest recorded depth was 2 ft. 6 in. above low-water mark. At the same time, the evidence of Mr. William Scott Brownless, C.E., has been accepted, and everything has been provided for a spring tide of 26 ft. 3 in. above low-water mark.

The greatest velocity obtained by Mr. Mehaffey in the vicinity of the jetty was two knots on the ebb tide and 1¾ knots on the flood. It must not, however, be taken that these are the highest velocities that occur, but at the same time it indicates clearly that good seamanship is required when approaching Darwin jetty, and at certain times of the tide there is a danger to both ships and jetty when a vessel is berthing. It is most satisfactory and reassuring to note that Mr. Mehaffey found "dead water" in the area covered by the abutment from which the viaduct springs, notwithstanding that a 2-knot current was running under the viaduct. This means that "dead water" at all states of the tide will be found in the proposed docks. The port is well sheltered, and rough weather is only experienced during the equinoxes.

Nature of Ground.

Mr. Mehaffey did valuable work in ascertaining the nature of the ground, particularly in relation to the proposed scheme under consideration. At the same time, he used data already obtained, and by co-ordinating the two results he has been able to indicate with some certitude as to what the strata consists of and their respective volumes. The strata consists of mud, clay, and schist. I am satisfied that all can be economically dredged, at a reasonable cost, provided a suitable dredger is used.

A good sound foundation or bottom is assured for carrying any loads that may be imposed—a point of considerable value, as uncertainty in this direction means enhanced costs. At the same time, there is a doubt about the wisdom of driving piles for a piled wharf structure. The probabilities are, however, that this could be overcome with care; but I wish to emphasize that it is preferable to have a hard bottom than a soft one, as one rather gathers, after reading the evidence in the report of the Parliamentary Standing Committee on Public Works, that the finding of a hard bottom was a source of regret rather than otherwise.

I am satisfied that silting has taken place in the port, and will continue. It is hard to see how it can be prevented, as if detritus is carried in suspension it must be deposited at some stage of the tide.

Conditions to be Observed when Designing a Port.

It is by no means an easy matter to design and lay out a port, as unless your scheme conforms to the requirements of shipping and the subsequent handling of goods on the quay by transport, such scheme (whilst it may be an engineering success) will be an absolute failure from a utility stand-point. The engineer must not, on the other hand, allow his scheme to be sacrificed from a cost point of view by these interests, but should endeavour to combine these three essentials, viz.: security and safety of shipping, traffic facilities, and first cost of scheme. These points have been studied, and after I had drawn out a tentative scheme I consulted Captain Mortimer, master of the Royal Mail s.s. *Marella*, who has traded at Darwin for many years and who, besides being an experienced mariner, knows the local conditions. In addition to this, I have shown the proposals to Mr. N. G. Bell, M. Inst. C.E., Commissioner of Commonwealth Railways. Both gentlemen consider that the scheme will suit admirably and serve their respective interests.

Berthing of Ships at Darwin.

The range of tide (26 feet springs) at Darwin is a disadvantage, not only to the handling and safety of the ship, but also to economical working of cargo. At the same time, the position must be faced as it is found. The remedy, i.e., forming enclosed docks and providing dock gates and possibly a lock, is obviously, on account of the prohibitive cost, out of the question at present, unless it were decided to form a naval base of considerable magnitude there. From this it can be seen that there is no alternative but to build open or tidal docks or quays. That being so, it is most essential that every consideration should be given to the handling and safety of the ships when berthed. Ship-owners naturally object to their ships being knocked about, and if a port gets a bad name in this direction they either cut out calling at the port or increase their insurance and freights to that port. From this one sees at once that the alignment of the wharf is of paramount importance, and, consequently, the direction of the current must be studied. At the same time, it is necessary to remember that modern steamers present a large surface to the wind; and this factor, whilst secondary to the current, must not be forgotten. The alignment or direction of the wharf must, therefore, be parallel to the current, so that steamers can use their full engine power and steam direct into the current or with it. This being accepted, then obviously one must dredge and form the dock inside, and take advantage of the natural protection afforded by the coast. The direction or alignment of the docks or wharfs having been settled, it is necessary to determine what the width of the docks should be. It is essential to remember that no tugs will be available at Darwin, and further that Darwin is subjected to cyclonic disturbances, and therefore there is every justification for increasing the ratio of water area to quay space beyond the usual practice. It is, after careful consideration, recommended that the width of the branch docks should be 450 feet. This allows ample room for the largest size of vessels to berth without the assistance of tugs, work their cargo (taking in coal from a collier alongside at the same time), and still leaves ample room for other vessels to enter or leave another berth in the dock.

After having drawn out my proposed scheme I had a general discussion with the Hon. H. Gregory, M.P., Chairman of the Parliamentary Standing Committee on Public Works, and was advised by him to see the various schemes proposed by other engineers, particularly the schemes submitted by Mr. Settle. It is highly satisfactory to note that the alignment of the wharf as proposed is very similar to one outlined by Mr. Settle, although the scheme differs otherwise.

Shed Accommodation.

Whatever is done in this direction should be done to suit both the inward and the outward trades. The latter will be most important, particularly if cotton becomes an everyday factor in the life of the Territory. Comparatively few people grasp the possibilities in this direction, but if only cotton-growing in the Territory could be established I feel certain that the future of the Territory would be assured. The type of shed required is important. I recommend that before anything is decided in this direction a conference be held between the Commissioner of Railways, traffic manager, shipping representatives, merchants, and those interested in a large way in the future of the Territory, including those engaged in the cattle and meat industry and mining, and also cotton-growers. Between the present jetty and the proposed new wharf A there is room for a cold storage chamber 220 feet long by 100 feet wide, and conveyors overhead would carry meat, &c., to the ship.

It is purposed only to discuss in general terms the type of shed favoured. It is recommended that the sheds be constructed of ferro-concrete columns and floors, with brick panels for the walls and continuous sliding doors on the quay side; that they be two stories, but that only the quay floor be constructed first; that they be 80 feet wide and divided into compartments, no compartment to exceed 300 feet in length, as by this means some check can be held on fire; that the quay floor be capable of carrying a load of 5 tons to the square yard, and the upper floor 30 cwt. to the square yard; that the height from the ground floor to underside of the first floor be 18 ft. 6 in., and the upper floor 12 ft. 6 in.; that the roof be flat, with the requisite fall for clearing rain water, and be designed to carry a load of 25 cwt. per square yard.

The advantages of making the shed several stories are that it increases the value of the quay, and at the same time it speeds up the unloading and loading of ships. The former needs no further comment; and with regard to the latter, it enables the outward cargo to be assembled beforehand in the upper stories before the arrival of the steamer, and it is then possible, under certain conditions, to both load and unload a steamer simultaneously. At a port of call like Darwin, this is an important factor.

A portion of the quay floor of the shed could, if required, be made available for cold storage purposes, in addition to the proposed storage already referred to, and serve both the old jetty and the new quay A.

Cranes, Transporters, and Conveyors.

The first cost of an electric 3-ton crane on gantry would be about £6,200, erected Darwin. The lighthouse service has long felt the want of a 10-ton crane for handling the Clarence Straits buoys, and no doubt other interests would welcome such provision. It is recommended that a conference of interests concerned should determine the requirements in this direction. A 3-ton electric crane should be able to hoist 3 tons at a speed of 165 feet per minute; 1½ tons at 330 feet per minute. The height of the lift would be 70 feet above rail level, and the radius for the 3-ton lift 60 feet, and for the 1½-ton lift 65 feet.

A new type of locomotive, suitable for shunting and worked by petrol, was shown in the *Engineer* (London) of 10th August, 1923, Vol. CXXXVI., No. 3528. It is thought that it would be very suitable for a port like Darwin, as it dispenses with coal and water and can be used or laid idle at will.

The belt conveyors used on the construction of the wall would be available and would very soon demonstrate their value. They are built in sections, which can be coupled together, and, with a belt speed of 300 feet per minute, will handle 200 tons in eight hours. It is suggested that they be used permanently, and it is thought that they would form an asset, particularly for handling coal.

Water, Oil, and Electric Power Mains.

A 4-inch main is provided for in the pipe trench or tunnel, with stand pipes every 100 feet, for supplying water to ships or for fire. An oil main is provided for, with stand-pipes in suitable places, for supplying oil fuel to ships. It will be laid in the pipe trench or tunnel. Electric power mains will be laid also in the trench or tunnel in the dock wall, and plugs will be provided every 100 feet.

Railways.

The scheme I submit lends itself to railway communication, there being ample room for sidings and no trouble with any curves. The new railways readily working into the existing railway system will be advantageous, as it means that past expenditure in that direction becomes an asset. From previous experience, I am satisfied that a curve of 120 feet radius would serve the end of the jetty, and thus dispense with the turntable, which is a source of expense and delay. This radius is used at the port of Liverpool for a 4 ft. 8½ in. gauge railway, permanent-way trucks, and locomotives with a wheel base of 9 ft. 8½ in. The provision of two lines of rails, together with lines for an electric crane or transporter, is recommended on the wharf. This will mean that the face of the shed will be about 29 feet from the face of the wharf. The above is the Fremantle practice, but, of course, it can be varied to suit the particular trades. I do not advise that this distance should be increased, unless it be decided to allow for a gauge of 4 ft. 8½ in., as it increases the trucking distance between the sheds and the ship. Decisions on matters of this kind should be in the hands of those who have to operate the traffic. It will be noticed that I have allowed 170 feet between the two sheds on the tongue. This area will be found invaluable for cargo stacking purposes, both for inward and outward cargo, the provision of railways being simply a matter of determination.

Road.

It is recommended that a road be built to the wharf, and the determination of it left in the hands of the Commissioner of Railways.

Quays or Wharfs.

To a very large extent the future prosperity of the port will depend on the type of quay provided. The problem is by no means an easy one, and has given me no small amount of anxiety. The present trade at Darwin is small, and at first one is tempted to provide the cheapest type of quay possible. The future trade is an unknown quantity. That there are possibilities must be admitted, and to my mind the port is the key to the future prosperity of the Territory. It has been determined to make Darwin an oil depot. That being so, presumably the source of supply will be availed of by the Navy; and if so, there is justification for building a first-class quay. A timber quay is out of the question, on account of the *teredo navalis* below water and the white ant above water level. The choice is then limited to mass concrete or ferro-concrete, and the type resolves itself into a solid wall or piled braced structure.

Solid Quay Wall.

This particular type of quay is very common and prevalent in Europe, but is practically never used in Australia. It is admitted that its first cost is high, but, at the same time, it is claimed that its subsequent maintenance is nil. Its use means that a solid earth quay is formed behind the wall, and consequently there is no limit to loads, and engines, trucks, and cranes, &c., can be used and placed without any limitations being imposed. This is a point of considerable moment. It is practically indestructible by gunfire, as was witnessed at Zeebrugge. It lends itself to assist ships when the weather conditions are unfavorable, as ships can come alongside with the knowledge that they can do it no damage.

Piled Braced Structure (Ferro-concrete).

If the most recent chart of soundings is studied it will be seen that the natural floor of the harbour is about 28 ft. 6 in. below low-water mark. That being so, it would be useless to dredge the floor of the docks below that depth, as if this were done, a sump would be supplied for detritus to fill up. Thus, assuming that a depth of 28 ft. 6 in. at low water is desired, and the deck level is taken at 31 feet above low water (existing jetty level), then piles at least 65 feet in length would be required. Such piles would weigh about 7½ tons, and would be exceedingly difficult to handle; and if the strata is the same as was found at the present jetty, extreme caution and experience would be required when driving. From the borings and evidence collected, I am satisfied that a good foundation will be assured, capable of withstanding a statical load of at least 10 tons per square foot. This relieves any anxieties with regard to settlement. The structure in cross section would require at least four piles, and the decking would be 44 feet wide, a pitched slope of 45 degrees being adopted and a small wall being used above low water for retaining the filling. This type of structure has been extensively used. The objections to it are—(*a*) liable to damage from shipping, and difficult and costly to repair, (*b*) subject to corrosion (subsequent maintenance), (*c*) extreme care required during construction, and special plant required, (*d*) difficulty in holding up the slope, the surface of which has been pitched, (*e*) if there is any slide, considerable damage will be done to sheds, railways, &c.

Dock Wall.

The advantages of the solid wall outweigh the jetty type of structure. The former is recommended, and it is proposed to deal with it in some detail.

The requisite height of the dock wall will be at least 61 feet, taking the average rise of tide, or ordinary spring tide, at 23 ft. 6 in., and an extraordinary spring tide at 26 feet. This would enable a vessel drawing 28 feet to berth at any stage of the tide. The wall could be built in mass concrete under cover of a single skin dam, but as the dams would, I estimate, add possibly £80 per foot run to the cost of the wall, this method need not be further considered.

It consequently resolves itself into either building the wall with blocks keyed together and handled by a Titan crane, or the building on shore of large caissons or tanks, the height being only 6 feet above low-water level, launching, floating, and then sinking them in position, filling the tanks with stone and finishing in order to obtain additional weight, the portion of the wall on the top of the tanks then being built in the dry by tide work. Putting aside, for the moment, the important factor of cost, the merits of the two proposals can be summarized thus:—

Caissons or Tanks—(*a*) The unit cost should be low, as they would be built in a depôt under favorable conditions. (*b*) They are the best method of constructing a wall on a bad or doubtful foundation. (*c*) By the time the body of the dock is dredged out a large number of tanks would be ready for launching, and consequently the wall would make rapid progress under construction. (*d*) Provided the tanks are properly designed and constructed, no fear need be anticipated from launching. I am aware that the usual practice has been to build them in graving docks or to have special appliances constructed for handling purposes. (*e*) No tanks should be launched during the hurricane season. (*f*) When once in position, provided adequate means have been taken, they can rapidly be filled with stone and concrete, the same remarks applying to the construction of the remainder of the wall.

Concrete Blocks.—This method has been used for both break water and dock walls all over the world. The principal objections can be summarized thus:—(*a*) First cost expensive, on account of having to provide a Titan crane for handling and placing blocks; (*b*) handling and setting of blocks costly; (*c*) dependence on diver for sound work; (*d*) any subsequent settlement of wall might be disastrous to the stability of the wall; (*e*) method of construction must be slow, and no setting of blocks should be done during the hurricane season; (*f*) easily destroyed by gun-fire.

From the above it can at once be seen that the evidence is in favour of the tanks, and that particular type of wall is recommended.

Construction of Wall.

The dimensions of the caissons or tanks used at Zeebrugge and the Port of Musel were:—Zeebrugge—Length, 82 feet; width, 24 ft. 7 in.; height, 20 ft. 8½ in. Port of Musel—Length, 65.01 feet; width, 49.21 feet; height, 37.07 feet.

The dimensions that I have in my mind are—length, 96 feet; width, 24.5 feet; height, 36 feet. The length has been fixed quite arbitrarily. The width has been determined by calculation based on past experience. The height has been arbitrarily fixed, the object being to get as high above low water level as is consistent with the safety and buoyancy of the caisson, thus enabling the caisson to float and be deposited in the final position. The launching weight of the tanks will be 1,260 tons, and their draught will be 24 ft. 6 in.

In the design it has been arranged that as soon as the caisson has been sunk in the final position, suitable staging should be erected and conveyors (worked electrically) be used for carrying the dry mixed concrete and stone to its position, water being added when the materials pass down the shoot.

By this means the minimum labour will be engaged, and a relatively cheap job should result. The conveyors can be worked in sections, and about 200 tons of material can easily be handled in eight hours. It is essential that the caisson should be filled as soon as possible after having been placed *in situ*, as otherwise there is a danger of it moving, particularly if bad weather arises. Inlet or sluice valves will be provided in the compartments at each end of the caisson, and there will be inter-communication between each compartment. A small centrifugal pump, worked by a motor, will be provided.

Dredging.

This will play no small part in the scheme. From the borings taken by Mr. Mehaffey, and the details collated and given in the report of the Standing Committee on Public Works, I am satisfied that a modern dredger would do this economically and rapidly. A powerful bucket dredger, built and designed for dredging rock or hard material, would not require any blasting to be done. The Western Australian dredgers *Parmelia* and *Fremantle* are capable of dredging to a depth of 40 feet with an output of 70 cubic yards per hour; working two shifts, of eight hours each shift, and allowing 25 per cent. for lost time, an output of 840 cubic yards per diem could be relied upon.

The tides would make it costly and difficult to use the dredged spoil for reclamation purposes, and therefore it would be best to send all dredgings to sea. In any case, it would be inadvisable to deposit the spoil obtained by dredging until the quay wall has been built.

All spoil for filling should be obtained by means of a small navvy or steam excavator. A train of side-tip wagons would be required, together with a locomotive. Ten men and two horses would complete the gang. The gang would be working an eight-hour day, with an output of about 700 cubic yards; and allowing 25 per cent. for climatic conditions, certainly 525 cubic yards should be realized per eight-hours' day.

It is recommended that spoil be obtained from Stokes Hill, and the area released and made available for the oil depôt. It is, however, emphasized that for scheme A alone, 252,430 cubic yards are required, and as the figure is large it is essential that mechanical power should be used; and a force of at least 8 feet is required for working the navvy. The source of supply recommended fulfils these conditions, together with the additional advantage of it being adjacent to the new dock; and further, useless ground is made valuable and put to commercial use.

Alternative Scheme.

I can see no reason why a small but powerful steam navvy should not be used to obtain filling from Stokes Hill and conveyors used to fill in the spoil for reclamation. The main belt drive would be 1,000 feet, and it is quite practicable. This would be economical, and it would be practicable to maintain the traffic on the railway when required.

Silting and Maintenance Dredging

I am satisfied that silting has taken place in the past. What effect the tipping of stone alongside the viaduct will have it is impossible to say. It is, however, surmised that it may result in a deposit of silt; but as very few harbours are free from maintenance dredging, this question would have to be faced. In any case, a small grab dredger would not be expensive; or, on the other hand, if the amount of silt was small and the accretion took a long time to form, possibly a dredger could be sent periodically from Fremantle.

A sloped embankment should be tipped on the inside of the bay adjacent to Stokes Hill and along the viaduct, and continued along the inside cast-iron pile portion of the present jetty. The latter will enable the portion of the jetty which was widened during the war to be discarded, as when the stone slope is finished it will be filled in solid with tipped spoil. A small retaining wall will be required to hold up the spoil, as otherwise it would be necessary to increase the width of the jetty decking, which is undesirable. Simultaneously, dredging should be commenced on branch dock ABC, the bottom of the dock being 28 ft. 6 in. below low-water level.

At the same time, launchways should be laid down and caissons or tanks be built at Carl's Beach, their dimensions being about 90 feet by 30 feet and not less than 24.5 feet in width. The foundation level for the new wall will be 18 inches below the floor of the dock, or 30 feet below low-water mark. A cut 33 ft. 6 in. wide will, however, be dredged to 31 ft. 6 in. below low-water mark, and 18 inches of sand deposited and levelled on the bottom will form the bed for the caisson. This work must be accurately and faithfully performed, as the stability of the wall will depend on its taking a uniform settlement, and as the bottom of the cassion is 18 inches below the floor of the dock, there will be no fear of the wall sliding, and in addition a grip on the foundation will be obtained. Possibly it would be found advantageous to pack between the toe of the wall and the side of the cut with concrete. After being launched and deposited in position, the quay wall will be continued on the top, the height being 61 feet and the weight being 50 tons per foot run. The total length of the new quay wall will be 630 feet. Some ferro-concrete piles and decking will be required for marrying the new quay wall into the existing jetty, and also into the quay at the head of the dock. A berth 450 feet long can be made at the end or head of the dock, and it is suggested that if such is required it be made available for the coastal trade, in which case a depth of 14 feet below low-water mark should suffice. This should be determined by the Commissioner of Railways after a conference with the interests concerned.

From the above it will be seen that the reclamation and tipping of stone along the viaduct and jetty, dredging, and building of the caissons or tanks would go on simultaneously. If it is not proposed to construct the west quay wall or quay C of branch dock ABC, it will probably be found necessary to tip a stone bank, in order to prevent the tide washing the mud into the branch dock. This should, however, be a matter of subsequent determination.

The quay walls having been completed, the filling-in would be proceeded with with energy and determination. It should, however, be possible to do some filling-in remote from the quay walls before they are finished. The filling-in having been completed, the railways, roads, and sheds would be built, and such essentials as electric power and lighting, water and oil mains, and cranes would be erected and finished.

The scheme presents no great engineering difficulties, and resolves itself into one of organization and ability to handle labour. The latter is a factor which must not be overlooked. At the same time, a first-class resident engineer will be required, with experience in dock work and in shifting large bodies of spoil. Labour-saving appliances should be used wherever practicable, as not only is the cost of labour high at Darwin, but the efficiency is low when compared to places in the south. It is claimed that the scheme not only permits expansion but dovetails itself into the existing port facilities; and, further, that it will remove many of the objections to the present jetty. The ebb tide will be prevented from tearing under and diagonally across the jetty, thus making it easier for ships to berth and lie there. The objections to the right-angle bend on the jetty, necessitating the use of a turntable for the railway, will be removed, and a curve of 120 feet radius can be put in on solid ground and railway trucks enabled to approach or leave the jetty without any interruption.

It is hard to estimate the time required for completing the scheme for quay A without knowing the class of dredger to be used, but if the proposals were being handled at the port of Liverpool, where unlimited plant and suitable experienced labour are available, it would certainly be completed within twelve months. On the other hand, allowing for the climatic conditions and the remoteness of Port Darwin, I estimate that it would take about 20 months.

It is claimed that the scheme will meet the requirements of shipping for many years to come, and that what is now proposed is only a small portion of the ultimate scheme which, when completed, will provide 5,615 lineal feet of additional quay. The first consideration in the scheme has been for the safety of ships, together with the efficiency for handling cargo. The latter consideration should be studied in every detail, and from the evidence given before the Standing Committee on Public Works it is clear that this point has not been lost sight of. Lastly, I am satisfied that the alignment of the quay walls will allow the Commissioner of Railways to so arrange his railways as to suit the traffic requirements, and will result in a marked improvement on the present position.

There is an enormous quantity of suitable plant, including locomotives, wagons (both end and side tip), steam navvy, cranes, rails and fastenings, &c., lying at the Henderson Naval Base, Fremantle. It would seem to me that before they are disposed of a decision should be reached as to whether or not the scheme under consideration is to be proceeded with.

Contract or Day Labour.

The scheme lends itself to either a lump-sum contract for the work, or being done by day labour. That, however, is a question of policy with which I am not concerned. The undesirability and folly of splitting up the work and attempting to introduce both policies is emphasized, and, as already pointed out, the various features of the job, viz., reclamation, dredging, and building of quay walls, railways, and sheds, are interwoven and must go on simultaneously; and that being so, to try to introduce two policies of construction must end in trouble, and possibly in litigation.

Estimated Cost of Scheme.

The following are particulars of the estimated cost for providing additional quayage at Port Darwin:—

Quay A.—This includes providing a solid quay wall, the coping level being 31 feet above low-water mark, dredging out the body of the dock to 28 ft. 6 in. below low-water mark, and reclaiming and filling in the area behind the new quay wall and adjoining the existing railway to a level of 31 feet above low-water mark, the portion behind the existing jetty, viaduct, and railway at the head of the dock being pitched

with rubble, assisted by a small retaining wall, in addition to which an embankment will be tipped behind Quay C in order to prevent mud falling or washing into the new dock.

480 lin. ft. caissons or tanks at £158 per ft. run. Including mooring posts, &c.	£75,840
Marrying quay wall into jetty at head of dock, 30 ft. × 25 ft. = 750 s. ft., at £4 per s. ft. ..	3,000
Marrying quay wall into existing jetty triangle, area, 25 × ½ = 250 s. ft., at £4 per s. ft. ..	1,000
224,360 cu. yd. spoil, at 5s., for filling in from Stokes Hill	56,090
28,070 cu. yd. stone pitching, representing 17,319 cu. yd. solid stone, at 18s. for slopes ..	15,587
Dredging—soft, 635,909 cu. yd., at 1s.	26,750
Dredging—rock (éclust), 60,000 cu. yd., at 5s. ..	15,000
Embankment on tongue between branch docks, to hold mud up, 16,040 cu. yd., at 5s.	3,010
Retaining wall at back of existing jetty, 520 lin. ft., at 20 per ft. run.	4,680
	£201,857
Add 10 per cent. contingencies	20,185
Cost of Quay A ..	£222,042

Quay B.

450 ft. x 44 ft. = 19,800 s. ft. of ferro-concrete wharf, at £3 per s. ft.	£59,400
67,000 cu. yd. filling, at 5s.	16,750
3,000 cu. yd. stone pitching, representing 1851 cu. yd. solid stone, 18s. per cu. yd	1,665
	£77,815
Add 10 per cent. contingencies	7,781
Cost of Quay B ..	£85,596

Quay C.

1,000 lin. ft. caissons or tanks, at £158 per ft. run.	£158,000
Marrying end of quay wall into quay at end of dock	3,000
260 lin. ft. caissons or tanks, at end of tongue, at £158 per ft. run.	41,080
296,950 cu. yd. filling, at 5s.	74,237
	£276,317
Add 10 per cent. contingencies	27,631
Cost of Quay C ..	£303,948

Branch Dock ABC.

Estimated cost of making branch dock ABC, including quays outlined, together with all reclamation and filling in, is £611,586

In conclusion, I wish to thank Norris G. Ball, Esq., M. Inst. C.E., Commonwealth Railways Commissioner, who gave me the benefit of his experience and knowledge of local conditions in the Territory. In addition to this, Mr. J. H. Millican, Officer-in-Charge, Northern Territory Railways, rendered material assistance in obtaining data. I was unfortunately prevented by unforeseen circumstances from proceeding to Darwin in order to obtain first hand the prevailing conditions, particularly in relation to the currents and the nature of the ground. I was, however, fortunate in being able to arrange for Mr. M. W. Mehaffey, B.E., Assoc. M. Inst. C.E., Assistant Lighthouse Engineer, to visit Darwin in order to obtain the necessary information and data. His report is submitted hereunder, and I have much pleasure in placing on record my appreciation of the valuable assistance he has rendered.

In my report of 17th October, 1924, to the Minister for Home and Territories, I very carefully and purposely did not go into full details of design or costs, as it was undesirable to do so at that stage. At the same time I committed myself to definite recommendations as to what should be done and the type of structure I advocated. At one time I thought of including the details I now propose to give, but I came to the conclusion that it would make the report unduly long and serve no useful purpose. As, however, the Public Works Committee has been instructed to examine and report to Parliament on the proposals, I desire to submit the following details for the information of the Committee:—

In my report I suggested dredging the floor of the dock to 28 feet 6 inches below low-water mark. I now advise that this be altered to 27 feet below low-water mark, until it is found necessary to deepen the dock to 28 feet 6 inches below low-water mark to suit the requirements of shipping. My reasons are:—(1) Vessels trading to Darwin draw only 22 feet, so that no useful purpose would be served by having an excess depth now, which will probably silt up in course of time. (2) By having the table or floor of the dock at a higher level it will tend to reduce the silting up or, at any rate, retard it. (3) Dredging at this depth is expensive, and it is essential to spend only what is absolutely necessary. The saving effected will be £2,600. (4) It will be advantageous, at any rate, in the initial stages of the building of the wall, to have the toe of the wall resisted by a 3-ft. cut instead of a 1-ft. 6-in. cut of schist. (5) The floor of the dock can be deepened to 28 ft. 6 in. at a later stage if found necessary.

In my report I suggested building the caissons or tanks on Carl's Beach. I wish to alter that to the head of branch dock ABC. My reasons are:—(1) The concrete mixer can then be used as an auxiliary to the one required for building the wall on the top of the caisson, which will also be used for filling in the caissons with concrete. The desirability of doing this with rapidity is obvious. (2) Good foundations are assured for the launchways. (3) Deep water will be assured for launching the caissons. (4) it is desirable to have the caissons in protected waters, and consequently it will be wise to avoid towing them from Carl's Beach to the site of the wall. (5) All the work done in connexion with the dredging and filling in for launchways is common to the general scheme, and must thus result in economy. The only objection that I can see is that it will relegate the building of quay B to the last, or, in other words, the launchways should be retained until the caissons have been built for quays A and C.

The design of the caissons I have made, and on which I have estimated the cost, is admittedly expensive. At the same time I am not prepared to say that I could not reduce the cost by cutting out some of the diaphragms and concrete shores, substituting wooden temporary shores instead. However, before attempting anything in the nature of working drawing or finished design, it is imperative to know what the unit weight of the concrete will be. After further very careful consideration I have slightly modified the design of the caisson by adding stiffeners on the inside of the floor and filling in solid from the top of the bottom shore to the floor. Small holes, however, have been introduced for drainage purposes. In addition to this I have further increased the volume of the concrete in the two end bays, as it is desirable that they should be able to withstand a certain amount of shock, particularly when being assembled in position Further, I have introduced two important cutting edges on the base of the wall. Referring you to the model which I exhibit this shows, you will note, that 2-ft. spaces have been left at intervals of 10 feet in the cutting edges to permit any sand being squeezed out when the wall takes a grip on the foundation. Although this can be considered a detail it is of very great importance. The above will increase the cost of the caissons by £1,080, or £11 5s. per foot run. I refer members to my report, and the instructions I gave to Mr. Mehaffey. I requested him to obtain the unit weights of stone, and sand, and schist. This has been done, with the following results:—

Locality.	Spec. Grav. at 60° Fah.	Weight per cu. ft.
Surface rock for Darwin ..	2.40	110 lb.
Rock from 42 miles ..	2.75	171.87 lb.
Rock from Mount Carr ..	2.66	166.25 lb.
Schist from Darwin ..	2.73	170.62 lb.
Sand from Adelaide River ..	2.65	165.62 lb.
Sand from Tale Head ..	2.64	165 lb.

From the above there is every indication that a very exceptionally heavy concrete will be made. This is

advantageous, but at the same time great care will have to be exercised, or the caissons may draw too much water and not have sufficient freeboard. In my design for the caissons I took the unit weight for the ferro-concrete at 150 lb. per cubic foot, but there is every indication from the above that it will be more than this figure. There is only one thing to do, and that is to obtain sufficient quantities of stone and sand to make samples, say, 12-inch cubes, gauging them to the correct proportions, and obtain the weights after the samples have matured for a month.

A minor alteration is proposed on the base of the wall. Instead of having the footing the same as the toe, it will be made level but contain the same amount of concrete so as to ensure the caisson trimming properly. This shelf will allow almost 3 tons of earth, &c., to assist the wall, and will be of material advantage to the design.

The estimated weight of the caisson before launching is 1,520 tons. The draught, when launched, is estimated to be about 29 ft. 3 in., which leaves a freeboard of 6 ft. 9 in. The design will allow the caisson to float on an even keel, and there will be no fear of overturning. The sides of the caisson are tapered, and the average weight required to lower the caisson 1 foot is about 50 tons. A freeboard of 6 ft. 9 in. will permit the building of staging for carrying the conveyors and the placing of a light railway on the top of the caisson.

In the event of the unit weight of the concrete being increased as a result of the determination by weighing, then it will be necessary to increase the volume of the caisson. At the same time I am not prepared to say that it would not be possible to make some minor cuts on the weight as at present designed, as I have purposely, at this stage, been liberal in the thickness of walls of the caisson, floor, &c.

As already mentioned, the weight of the tank on the launchway is 1,520 tons. Of this 224 tons approximately will be steel, and the remainder concrete. I have allowed for a rich mixture of concrete, viz., 4½ of aggregate to 1 part of cement. The price allowed is £7 10s. per cubic yard, which embraces all materials, including steel, all moulds, providing conveyors and concrete machines, &c. There are 841 cubic yards in the floating caisson, and this makes the estimated cost of the caisson on the slip to be £5,227.

During the years 1916-17 the Lighthouse Service built a ferro-concrete tower at Cape Don, 105 miles from Darwin. Materials (except sand and stone) and workmen were sent from Melbourne to Darwin, and then freighted by a departmental vessel to Cape Don jetty, and then carried on a tramway for 3 miles to the site of the light. That ferro-concrete tower, 92 feet high, including all steel, moulds, &c., cost £7 14s. 11½d. per cubic yard, the mass concrete foundations costing £3 17s. 7½d. per cubic yard.

The placing of the caissons or tanks *in situ* will be interesting, and will demand care. The lighthouse steamer might possibly be made available, or better still, possibly the Department of the Navy could be prevailed upon to lend a hand. The inside edge of the foot of the caisson should be marked by a pile, the dock-side face of the quay being marked by suitable back-leading marks on shore. Very slowly the caisson should be towed to the site, a very heavy steel cable having been placed right round the top of the caisson for towing purposes. Two powerful winches should be used on the shore end in order to restrain the caisson from going seaward, and if the towing operations are conducted with caution no great strain should come on these winches. Two light winches should be used on the shore, the wire ropes being attached to each end of the caisson, both on the same side of it, and merely used for keeping the caisson in position. The small towing steamer would, when the caisson was in position, act in a similar capacity on the other side of the caisson at the seaward end. A 16-inch x 16-inch oregon log, 60 feet long, should be used for keeping the caisson in position after having been sunk.

There are two schemes either of which could be safely adopted for proceeding with the work at this stage, viz.:—(*a*) Pumping out caisson and working tidal work for filling in the caisson and then building the wall on the top. (*b*) Erecting flitch dams on the top of the caisson and then filling in with concrete, and subsequently building the wall on the top under cover of the dam. The advantage of (*b*) over (*a*) is that the work would be uninterrupted and quite independent of the tide, whereas (*a*) would take longer, but the considerable cost of dams would be obviated. The model submitted provides for scheme (*a*) being adopted, and in the event of scheme (*b*) being accepted then the shores in the caisson should be placed at different centres, as the pressures, when pumping out, would be very much in excess of those in the caisson without a dam on the top. It is submitted, however, that the Commonwealth Public Works Committee would leave the choice of such details to the contractor or Commonwealth engineer after they have satisfied themselves about the feasibility of both proposals.

It is essential that the caisson should be subdivided with temporary timber planking into compartments, as if this is done the water can be very much more quickly pumped out and concrete placed in. There will be about four hours available for work each tide. A 12-inch centrifugal pump would empty one compartment in 8.4 minutes, a 34.5 B.H.P. motor or engine being required. I have photographs of similar flitch dams used on works of which I was resident engineer, and they are submitted for the Committee's information.

The sources of supply of concrete will be the belt conveyor on the gantry at the top level, and a 3-ft. 6-in. gauge railway with 2 cubic yard side tipping trucks on the top of the caisson. The former will deliver 200 tons of concrete in eight hours, and the latter the same amount, but it would be mainly used for carrying rock displacers. The total concrete filling required is 1,558 cubic yards. The object of having holes in the diaphragm for every 2 feet is now evident, as it allows the pump to unwater the caisson when required, and care should be exercised in stopping the concrete just below the level of a hole so that the water is readily got rid of by pumping. A weak concrete of 10 to 1 will be used for filling-in purposes, as many displacers or "plums" being used as possible; £3 per cubic yard has been allowed for this concrete. If practicable the wall on top of caisson should not be commenced until the last caisson has been placed, as when it is commenced it will mean doing away with the light railway on the top of the caisson. In order to ensure a good bond, railway metals have been provided projecting at least 18 inches into the new wall. In addition to this the entire surface of the caisson should be scabbled all over with rock picks. The total quantity of concrete required is 1,002 cubic yard, which, at £4 per cubic yard, gives a cost of £4,008. A concrete of 8 to 1 will be used, and as many "plums" put in as is consistent with good work. Before recommencing the work each day the skin on the old concrete should be removed as already mentioned. Six-inch weepholes staggered, and at 10 feet centres horizontally, and 5 feet centres vertically, must be provided above low-water mark. Earthenware pipes are the most suitable for this purpose. A hand-packed rock drain must be placed at the back of the wall, connecting all weepholes, both vertically and horizontally. It should not be less than 24 inches wide. A pipe trench 3 feet 6 inches x 3 feet has been shown. The bottom is 26 feet 6 inches above low-water mark, and it is connected with the drain into the dock. Manholes will

be provided every 50 feet. The "Teddy Bear" type of bollard used at Fremantle is advocated. Their weight is 17 cwt., and cost £20 f.o.b. The electric light and power cable will be placed in the pipe trench. I can see no reason why oil and water pipes should not be provided in the same trench. It is essential that they should be as near the quay face as is practicable.

The history of dock walls and retaining walls is interesting, as it is marked with many disastrous failures. A very eminent engineer once remarked, after expending much thought on a design for a dock wall, that he preferred to depend on his own judgment and experience, and he tore up the design, substituting one that he considered would best adapt itself to the unusual conditions that prevailed. I am satisfied that a good foundation can be depended upon, but it must not be overlooked that this particular type of construction is admirable for a bad foundation, as the caisson becomes a deep girder and will bridge over any inequalities of ground. The main forces requiring consideration are the lateral pressure due to earth pressure at the back of the wall. Any outward pressure from water at the back of the wall is negatived by the usage of weepholes. The above earth pressure is augmented by a surcharge of cargo on the quay. The mass or weight of the wall resists this earth pressure and provides a downward force. The resultant force passes well within the inner third of the base of the wall. It is desirable that the wall should obtain a grip on its foundation, and for this purpose two cutting edges already alluded to have been provided on its base. It is assumed that they will cut through the sand which has been deposited to ensure the caissons having a level bed.

The only other main force which requires consideration is that due to the upward lift due to water underneath the base of the wall. What should be allowed for in this direction is doubtful, and is a disputed point among engineers. At the Port of Liverpool it is neglected entirely, and having myself underpinned four old quay walls there, I confidently say their contentions are correct, as these walls were severally founded on a stratum of sandstone rock, red sand, boulder clay, and gravel for a portion only in one wall. The walls had, however, been built in the dry and there was complete evidence of a growth between the foundation and the wall, and no evidence of any water immediately underneath the wall. The proposed Darwin wall, on the other hand, will be launched on to its prepared bed, and its own weight will cause its grip to develop. It must be conceded that some loss of weight will take place, and this has been allowed for in the design.

I am confident that a modern bucket dredger will easily deal with all the spoil at the rates I have allowed for and in the times stated, viz., 1s. per cubic yard for mud, and 5s. for schist. On the other hand, if obsolete plant is used it may cost anything in a port like Darwin, and react on the whole scheme, as if delays take place, it would mean putting men off, and would lead to complications.

In the event of the scheme being proceeded with it would, as a natural sequence, result in an influx of population into Darwin, and possibly would result, after the completion of the scheme, in a general improvement of affairs in the Territory. I understand that there is a marked shortage of fresh water in Darwin, and only a very limited amount of electricity for lighting purposes. It is strongly urged that steps be taken at once to remedy the position in regard to these every-day needs, taking into consideration the requirements of the proposed scheme.

The following is a summary of estimated cost of wall 96 feet long as completed. In my report of 17th October, 1924, I stated that the cost per foot run of the quay wall would be £158. This has been slightly modified, the estimated cost now being as under:—

Preparing launchways, and getting ready a bed in the dock for each caisson	£600
Caisson 96 ft. long ready for launching, 841 cu. yd., at £7 10s. per cu. yd	6,307
Launching and placing caisson in position	100
Filling in caisson with concrete, 1,558 cu. yd., 10 to 1 concrete, at £3 per cu. yd.	4,674
Mass concrete wall on top of caisson, 1,002 cu. yd., of 8 to 1 concrete, at £4 per cu. yd.	4,008
Weepholes in wall, say,	50
Hand packed rubble drain at back of wall	200
Mooring bollards, grids, &c	100
	£16,039

Cost per foot run—say—£167.

RECAPITULATION OF COST OF SCHEMES A, B, AND C.

Scheme A.

480 lin. ft. of caissons, at £167 per ft. run, including mooring posts, &c.	£80,160
Marrying quay wall into jetty at head of dock, 30 ft. x 25 ft. = 750 s. ft., at £4 per s. ft.	3,000
Marrying quay wall into existing jetty, triangle area, 25 x ½ = 250 s. ft., at £4 per s. ft	1,000
224,360 cu. yd. spoil, at 5s. per cu. yd., for filling in, from Stokes Hill	56,090
28,070 cu. yd. stone pitching, representing 17,319 cu. yd. solid stone, for slopes, at 18s. per cu. yd.	15,587
Dredging—soft, 535,000 cu. yd., at 1s.	26,750
Dredging—rock (schist), 49,600 cu. yd., at 5s.	12,400
Embankment on tongue between branch docks, to hold mud up, 15,040 cu. yd., at 5s.	3,910
Retaining wall at back of existing jetty, 520 lin. ft., at £9 per ft. run	4,680
	£203,577
Add 10 per cent. contingencies	20,357
Cost of quay A	£223,934

Scheme B.

450 ft. x 44 ft. = 19,800 s. ft. ferro-concrete wharf, at £3 per s. ft.	£59,400
67,000 cu. yd. filling, at 5s. per cu. yd.	16,750
3,000 cu. yd. stone pitching, representing 1,851 cu. yd. solid stone, 18s. per cu. yd.	1,065
	£77,215
Add 10 per cent. contingencies	7,781
Cost of quay B	£85,596

Scheme C.

1,000 lin. ft. of caissons, at £167 per ft. run	£167,000
Marrying end of quay wall into quay at end of dock	3,000
260 lin. ft. of caissons at end of dock, at £167 per ft. run	43,420
266,950 cu. yd. filling, at 5s per cu yd	74,237
	£287,657
Add 10 per cent contingencies	28,765
Cost of quay C	£316,422

Branch Dock ABC.

Estimated cost of making branch dock ABC, including quays outlined, together with all reclamation and filling in	£625,952

I have endeavoured to put the position plainly, fairly, and concisely before the Committee. The problem is an interesting one, and although I did not seek the task of reporting on extensions to Port Darwin, yet it affords me pleasure to respond to the request of the Minister for Home and Territories, and I can only say that the

work has been most interesting, and has received my most earnest consideration.

11th June, 1924.

My dear Acting Minister for Trade and Customs.

In view of Cabinet's approval, on the 10th instant, of my recommendation that Mr. J. F. Ramsbotham, Director of Lighthouse Services, should be asked to report on the question of harbour improvements at Darwin during his forthcoming visit to the Territory in connexion with lighthouse work, I shall be glad if you will kindly arrange for the necessary instructions to be given to this officer on the subject.

Mr. Ramsbotham's attention should be particularly drawn to the reports by Sir William Clarkson and the report of the Parliamentary Standing Committee on Public Works in regard to the Darwin wharf. Copies of these reports have already been forwarded to Mr. Ramsbotham.

Yours faithfully,
(Sgd.) G. F. PEARCE.

The Hon. Sir Littleton E. Groom, K.C.M.G., K.C., M.P.,
Acting Minister for Trade and Customs, Melbourne.

The Director of Lighthouses.

A copy of the attached communication from the Minister for Home and Territories is forwarded for your information and guidance. The Director's attention is particularly invited to the two reports mentioned in the Minister's communication.

(Sgd.) R. McK. OAKLEY,
Comptroller-General.

16th June, 1924.

Commonwealth of Australia.
Lighthouse Service,
Melbourne, 29th July, 1924.

Mr. Mehaffey, Assistant Engineer.

Proposed Extensions to the Port of Darwin.

The Cabinet has requested me to report on the proposed extensions to the Port of Darwin. Unfortunately, it is at present impracticable for me to visit Darwin, and my Minister has agreed to the proposal that you should proceed to Darwin in order to obtain certain data and particulars that I require in order to enable me to furnish a report.

2. Your passage has been booked on the s.s. *Marella*, leaving Sydney on 2nd August, arriving at Darwin on 12th August, and it is thought that a residence of three weeks in Darwin should enable you to obtain what I require.

3. Mr. Bell, Commissioner for Commonwealth Railways, has instructed Mr. Millican, officer in charge, to carry out and pay for work that you desire to be done, and you should get in touch with him on your arrival.

4. Information is desired on the following points:—

(*a*) *Shaft.*—A shaft should be sunk above high-water level, 35 feet below low-water level mean spring tides, on the Darwin side centre of the proposed new branch dock, adjacent to the existing wharf. The best class of men for doing this work will be miners or prospectors, and you should try and obtain their services, being guided by Mr Millican as to what their wages should be. In all probability you will have to timber the shaft, and I should feel inclined to do it with poling boards instead of runners. The shaft should be of such a size as to enable a man to work comfortably in it. The size I have used myself has been 4 ft. 6 in. square. If by any chance you strike water at a high level, due to seepage or springs, I do not think I should persist in sinking the shaft, as unless you are provided with suitable pumping plant considerable expenditure would be incurred, and unless you have experienced men for your timbering a certain amount of risk would be run.

(*b*) *Boring Plant.*—I am arranging for a boring plant to be sent, so as to make certain that some reliable data is obtained with regard to strata. This information is required in order to enable me to affix a fairly reliable price for dredging out the body of the proposed docks, and I should also like some information as to what the bearing capacity of the ground will be at the foundation level for a wharf, also with regard to its suitability not only for driving piles, but for withstanding a statical load from 4½ to 5 tons to the square foot.

(*c*) *Probings.*—You should take some probings on the surface of the mud so as to form an idea not only as to its general depth, but also to give a close approximation as to the volume of heavy dredging.

(*d*) *Levels.*—Sufficient spot levels should be taken in order to obtain full quantities of dredging and filling-in where required.

(*e*) *Tide.*—The alignment of the new proposed wharf will be governed by the direction of the currents, and I shall be glad if you will obtain the direction and velocity of both the flood and ebb tides. It will be necessary for you to take them at various stages, as you will find that the velocity will vary considerably between high water and low water. Generally speaking, it slackens an hour before reaching both high and low water, and at the same period afterwards. I am arranging for a tide gauge to be sent with you registering from 0 to 30 feet. It would be as well for you to request Mr. Millican to put a reliable person on to obtain some data with regard to both spring and neap tides.

(*f*) *Wind.*—I should like to know the prevailing direction and the force of the wind. In addition, any data relative to bad storms, hurricanes, &c., would be interesting.

(*g*) *Silt.*—I am satisfied from what Capt. Mortimer, of the R.M.S. *Marella*, states, that considerable silting has taken place since the last dredging was done on the inside berth of the jetty. If you could obtain any data about this it will be of interest, and I should like to know if the silting shows a marked increase during the summer months when the rains are on, also whether such silting is deposited from the rivers, or is carried in suspension along the coast.

(*h*) *Sites for Building Ferro-concrete Caissons.*—I have in mind the building of ferro-concrete caissons about 200 feet long and in the neighbourhood of 30 feet wide. They would be built on launchways at the head of the proposed dock, and it will be necessary for you to ascertain if any sites are available for building two side by side at the head of the proposed branch dock. You should carefully examine the ground, making certain that it will be able to withstand a load of, say, 2 tons to the square foot, and whether or not it will be necessary to drive timber piles for fortifying the ground in order to enable it to withstand the requisite load. Assuming that the caissons are 36 feet high and founded at 20 feet below M.L.O.S.T., I should like to know what time would be available each tide for working at the level of 6 feet above M.L.O.S.T.

(*i*) *Stone.*—I shall be glad if you will obtain samples of the stone which is available for concrete and also for pitching the slopes; about 74,000 cubic yards will be required. You should remember the necessity for the quarry being adjacent to the existing railways, so that it can be brought down on trucks to the dock. It is desirable to obtain the unit weight of such stone.

(*j*) *Sand for Concrete.*—You should obtain samples of the sand available for concreting purposes, also the unit weight.

(*k*) *Soft Spoil for Filling.*—Approximately 119,000 cubic yards of filling will be required, and you should see if any waste land is available where such can be obtained, it being proposed to use a small navvy for this purpose.

(*l*) *Water.*—You should ascertain whether fresh water will be available for making concrete.

(Sgd.) J. F. RAMSBOTHAM,
Director.

Commonwealth of Australia.
Lighthouse Service,
Melbourne, 23th September, 1924.

The Director.

Darwin—Proposed Port Extensions.

I left Melbourne on 31st July, 1924, and returned on 18th September, 1924, after remaining at Darwin for 24 days. The results of my work are submitted herewith.

2. The town of Darwin stands on a plateau about 100 feet above L.W.S.T. On the eastern side, the ground slopes gradually to high-water level, at French Bay, but elsewhere there is an abrupt drop to sea level. The small bay, at one side of which the present jetty stands, is at the south-east extremity of the plateau, and the ground around the bay rises precipitously to 90 feet above low water, except where a small gully exists. Through this the railway and road have been made. Were a great growth of Darwin to take place, and a large vehicular traffic between the present waterfront and the town develop, congestion at this point would present a problem. The width of opening of this bay between Port Point and Stokes Hill is 2,100 feet, and its greatest depth is 1,100 feet. A plan of Darwin is submitted (sheet 1). For future wharfage extensions when the present bay has been taxed to its limit the waterfront at Carl's Beach, the western shore of Francis Bay, after dredging, would give another 2,500 feet of berths, no further distant from the centre of the town than is the present jetty, and with an easy grade for roads from wharfs to the town.

3. An examination of the ground surrounding the bay showed that the cliffs are composed of a schist, on the top of which lies a volcanic rock, magnesite, of an average thickness of 20 feet. Between the magnesite and the schist is a thin layer of conglomerate. (Samples of these rocks are submitted herewith.)

4. It became apparent that it would be a difficult and tedious work to sink a shaft. On the foreshore in the bay there was no site that did not cover at high water neap tides, except one place where an outcrop of schist existed. The road around the bay is excavated in the schist, and thus any shaft sunk beside the road would have necessitated the use of explosives from the commencement. (The vehicular road stops 1,000 feet from the shore end of the jetty, and pedestrians, to reach the jetty, must walk along the railway embankment.)

5. On realizing this I commenced to put down a bore—No. 2—intending to sink it to a depth of 70 feet below dock level. This I was not able to do on account of the light nature of the boring gear, which, though quite satisfactory when an auger could be used, was not serviceable for jumping through rock. Thus I had to confine my boring operations to sinking through the mud and soft clays until the auger entered the arenaceous schist of which the country surrounding Darwin Harbour is mainly composed.

6. To ascertain whether it was reasonable to presume that the schist, thus bored into by me, is continuous to any great depth, I made inquiries at the Departments of Lands and Mines, and of Works and Railways, to find, if possible, particulars of bores put down in Darwin in search of water. The following are some of the bores put down:—

(*a*) *Myilly Point*—
Depth 0 feet to 21 feet—Magnesite.
21 feet to 58 feet—Stiff clay.
58 feet to 62 feet—Quartz rock.
62 feet to 208 feet—Schist.

Note.—At 208 feet this bore was about 105 feet below L.W.S.T.

(*b*) *Police Paddock*—
Depth 0 feet to 18 feet—Magnesite
18 feet to 201 feet—Schist.

Note.—The bottom of this bore was about 120 feet below L.W.S.T.

(*c*) *At Government Store*—
Depth 0 feet to 14 feet—Magnesite.
14 feet to 226 feet—Schist.

Note.—This bore reached about 170 feet below L.W.S.T.

(*d*) *Public Works Yard*—
Depth 0 feet to 5 feet—Soil.
5 feet to 8 feet—Quartz and ironstone
8 feet to 104 feet—Schist.

Note.—The bottom of this bore is 120 feet below L.W.S.T.

7. As the same schist is seen at the other sides of the harbour, at West Point, Talc Head, and Middle Point, it seems reasonable to assume that the schist found by my borings at the bottom of the bay is continuous to considerable depths, and may be relied on to carry any loads imposed by normal structures.

8. Plans showing the positions of borings, sections of the bores, and typical cross sections, are submitted herewith (Sheets 2, 3, 4, and 5.)

9. On the bore diagrams the portion described as clay consists of the black mud consolidated for the first part, and below this, schist that has been softened somewhat by water. In boring, the auger could be pushed down through the depths recorded as mud. Through the area recorded as clay the auger had to be turned to advance it, but it would advance through the whole thickness without difficulty, while on entering the schist the auger pulled up and had to be withdrawn and the schist cleaned off after an advance of a few inches. Down to the schist level the dredging may be regarded as light.

10. When the present railway embankment was built it was found, I am informed, that considerably greater quantities of material were needed than originally estimated. This is understandable, as the soft nature of the mud and its great depth would allow deposited material to sink, and this sinking would continue for a long period. It was found recently, when reclaiming the shore spans of the approach, that the abutment had sunk a further 8 inches since the jetty was opened for traffic. It would thus seem advisable, if stone embankments are used, to dredge if possible to solid bottom before depositing the stone, and thus avoid continued settlement over a long period.

11. In some cases quartz was met (some of the chips showed gold in small quantities). Quartz veins are to be seen in the cliffs surrounding the bay, the thickest being about 4 feet, but for the most part they are small.

12. Samples of the material obtained at the bottom of each bore are submitted.

13. *Bearing Power of Schist.*—I was not able to measure the bearing power of the schist at any great depth below the mud, but determinations made in depths of mud up to 3 ft. 4 in. showed that the schist underlying the mud required a load of at least 28 tons per square foot to cause sinking.

14. I had no apparatus to do this work with great accuracy, so I had, at the railway works, a mild steel bar ¼-inch diameter set up at its lower end to a diameter of ⅜ inch. At a distance of 42 inches from the lower end a solid collar was welded to the ¼-inch rod, which rod continued for 2 feet above the collar. A cylindrical weight of steel with a 9-16-in. axial hole fitted over the top length of ¼-inch rod. This weight of 75 oz. was allowed to drop 6 inches on to the collar, and the penetration per blow under a series of blows was then measured. A set of ¼ inch per blow represented a mean resistance to penetration of 28 tons (approximate) per square foot.

15. I used this gear also for testing the ground along the possible slipway sites.

16. *Tides.*—The gauge was fitted and readings taken each quarter hour between 8 a.m. and 5 p.m. on the working days I was at Darwin. The times of change in direction of the stream at the ends of the jetty were also noted.

17. The diagram of observations of the tides is submitted herewith. (Sheet 6.)

18. In addition to the observations at the jetty, measures were made of the velocity of the tidal streams at various spots in the harbour.

19. The gear for measuring the stream was made up of oil drums. Two lashed together to give increased surface were perforated and fastened to a sinker. A third drum supported the other two and the sinker, the floating drum containing sufficient water to permit it to float with 4 inches of its body showing above water. Thus little surface was exposed to the influence of wind. The lower drums were suspended to the upper one by a line which made the distance of the centre of the lower ones 20 feet below the surface of the water. Thus the velocity of the floats over the ground would represent approximately a mean of the velocities at the surface and 20 feet below the surface. The upper and lower floats were attached by a bridle to a light line that ran freely out from the launch. The time the floats took to run 200 feet was measured by stop-watch, and the direction of the motion was noted by sextant angle.

20. As each observation took about a quarter of an hour, I was not able to measure the maximum velocity that occurred at each station, but at the spots where I found the tidal stream to be fastest I carried out a series of observations to determine the maximum velocity at these points. These spots were at the second span of the approach from the jetty head, and near the south-east corner of the jetty.

21. The velocities I found are probably not the greatest that do occur, as the maximum range of tide while I was at Darwin was 20 feet, whereas I am informed that at the equinoxes the tides rise 2½ feet higher and fall 2½ feet lower than they did while I was observing them.

23. Generally speaking, my results showed that in the vicinity of the jetty the direction of the ebb stream makes an angle of 22 degrees with the line of the face of the jetty, and that the flood stream makes an angle of 12 degrees with the same line. A short distance to the westward of the jetty, however, the directions of both the flood and the ebb streams is approximately parallel to the line of the jetty end.

23. The greatest velocity of the tidal stream to the eastward of Fort Hill occurs at the places mentioned above in the vicinity of the present jetty, and while I was at Darwin was 3 knots.

24. To ascertain whether my floats gave a correct measure of the velocity the top drum only was tried, and run beside a similar drum floating freely. The loss due to the light line attached to the gear was negligible.

25. The observed tide directions are shown plotted herewith (Sheet 7.)

26. It was noted that the ude slackens and that the ebb stream ceases to run one and a-half hours before low water, the flood stream running fast at the time of low water. A similar occurrence was noted at high water, the ebb stream commencing to run one and a-half hours before high water.

27. On most occasions between the cessation of running of the flood stream and the commencement of the ebb, a current of low velocity sets on to the jetty at approximately right angles to the line of its face. The same happens at low water, the first of the flood being across the jetty, after which it runs parallel to the face of the jetty until low water is reached.

28. *Silting.*—I was informed that since the present railway embankment was completed the breadth of the stony beach within the bay has been considerably reduced by the advance of the mud. This is probable, as the result of building the railway embankment was to push out the southern boundary of the still water within the bay. The present boundary is a line joining the low-water line off the embankment and the low-water line off Fort Point. Within this line there is no perceptible tidal stream, while immediately beyond it the tide runs with a velocity of approximately 2 knots.

29. At the western end of the jetty, where no current exists when the ebb stream is running, the depth has reduced from 24 feet to 18 feet.

30. I was informed that during the wet season the ebb stream is much discoloured, indicating considerable quantities of sediment in suspension.

31. The plan of Captain Lawson, who was in charge of dredging operations in 1917 and 1918, shows that during the wet season the area in the vicinity of the western corner of the jetty silted considerably, and that that part of the work had in consequence to be dredged twice. It is now 18 feet in places.

32. A limited amount of silting has taken place in the inner berth at the jetty, but only to the extent that the 24-feet contour is now parallel to the direction of the tidal stream at the jetty. Over the greater part of the inner berth, scour, rather than silting up, has taken place. A copy of Captain Lawson's dredging plan is submitted herewith (sheet 8). The present depths are noted in red.

33.* It will be noted that the surface of the mud in the bay within the line of low water (that is where no tidal current runs) lies at a slope of about 1 in 90, while between the low-water line and the 24-feet contour the slope is about 1 in 4. It is this relatively steep slope as at the edge of the tidal stream, and is maintained by the stream; it appears probable that any area in the harbour not scoured by the tide will tend to rapidly silt up and to approach a state similar to that now existing in the bay.

34. *Slipway Site.*—There is no suitable site for a slipway within the bay, chiefly because there is no area above high-water mark for working. However, at Carl's Beach, behind Stokes Hill, at the western side of Francis Bay, is a suitable site. Here the distance between high and low water marks is

600 feet and the bottom is schist, outcropping in most places, and nowhere covered with more than 2 feet of mud.

35. At distances of 5 chains and 10 chains from high-water mark holes were jumped into the schist to depths of 6 feet.

36 Between high water and the railway line the country is generally level, and suitable for storing materials or placing workshops. The distance from high-water line to the railway track is 300 feet.

37 *Stone.* The only stone at all hard in the vicinity of Darwin is the magnesite that overlies the schist. This is not suitable for concrete, but might be used for pitching slopes.

38. The schist from Stokes or Fort Hill will make good dry filling. It, however, will need explosives to bring it down, after which it could be handled into trucks by a steam shovel.

39. Stone suitable for concrete occurs at 17 miles from Darwin alongside the railway line. This place, however, is not suitable for a quarry, as the surface of the outcrop is below the level of the railway line. Samples of the stone are submitted.

40. At Darwin River, at 42 miles from Darwin, is an outcrop of diorite, where a quarry economical in working could be opened alongside the railway line. The stone is hard, and would be costly to quarry and crush. At this spot there is a good supply of fresh water. Samples of stone are submitted herewith.

41. Further along the line, at 72 miles, there is an ideal quarry site on the side of Mt. Carr, where easily-crushed stone could be quarried and treated in an economical manner. The plant would be about 6 chains from the main line. A water supply exists at Snake Creek, about 10 chains distant, but a more copious source would be the Adelaide River, about 2 miles distant. Samples of Mt. Carr stone are also submitted.

42. *Sand.*—There is no river sand in any quantity closer to Darwin than the Adelaide River, 75 miles. I gathered some samples of this sand, of which about 20,000 yards could be obtained within a mile of the railway line.

43. At the Edith River, 120 miles, a further suitable sand exists. All the rivers beyond 100 miles could, I was informed, yield sand, but the Adelaide was the only one I was able to visit.

44 On the beach at Talc Head, about 8 miles across the harbour, is a large quantity of sand that could be obtained by allowing barges to take ground as the tide fell. This sand is suitable in most respects, but is heavy in mica.

45 Samples of sand from Talc Head and Adelaide River are submitted herewith.

46. Freights to Darwin for stone or sand are :—

From 17 miles—5s. 1d. per ton.
From 42 miles—7s. 9d. per ton.
From 74 miles—11s. 4d. per ton.

47. *Water.*—There is no supply of fresh water at Darwin, and the residents depend on wells and tanks for the water required for domestic purposes.

48. The needs of shipping and of the Railway Department at Darwin are met by 5,000,000 gallons stored by a dam 1¼ miles from the jetty. The area behind this dam fills each wet season, and this quantity at present suffices for railways and shipping.

49 There is a source known as Freer's Springs, about 18 miles from Darwin, that has been under consideration as a possible water supply for the town. The daily flow has been measured at various times between 1917 and 1923, and the lowest flow per twenty-four hours was 508,500 gallons, measured on 20th December, 1923, towards the end of a long dry season. On 1st January, 1924, after some rain, the daily flow increased to 2,733,480 gallons.

50. It was estimated in 1916 that it would cost £40,000 to deliver this water to Vestey's works at the outskirts of the town. As the level at the source is about the same as at Darwin and two higher ridges have to be crossed, a pumping plant would be necessary.

51. *Electric Power.*—Residents at Darwin are supplied with electricity for lighting by Mr. Holmes, the proprietor of a refrigerating plant. His power plant consists of—

One 85-h.p. Hornsby gas engine.
One 40-h.p. National gas engine.
One 20-h.p. Fielding and Platt gas engine.
One 62-kilowatt 220-volt generator.
One 23-kilowatt 250-volt generator.

The engines are driven by suction gas, made from charcoal which the proprietor has prepared on his own property. The 85-h.p. engine and 66-kilowatt dynamo are recent additions to the plant to permit extensions of electric lighting, and the proprietor estimates that he will have during the day a surplus of from 20 to 30 h.p.

52 A 40-h.p. generating plant supplied in the beginning for lighting the jetty, and working capstans and the turntable on the jetty, is stored at Darwin.

53. *Winds.*—The prevailing wind is from the south-east. This blows as a moderate breeze for about eight months of the year. During the wet season the north-west wind is most frequent.

54. Hurricanes seldom occur. One violent storm occurred on 6th March, 1919. It started from the south-east, and during the night swung round to the north-west. The coal hulk *Warrego* was driven high up on the rocks at Carl's Beach, where she remains. The outer end of the railway embankment was damaged, and some of the buildings in the town suffered. This was the only severe storm of which I was able to obtain any record.

55. Meteorological observations are taken at the Post Office at Darwin, and the readings forwarded to the Weather Bureau, Melbourne.

56. *General.*—While at Darwin I was greatly assisted by the officers of the Railway Commissioner, and those of the Administrator Mr Millilcan, officer in charge of railways in the Northern Territory, did everything possible. He obtained for me all the materials, plant, and labour that I needed, arranged for my visits to Adelaide River and the possible quarry site at 20 miles, also supplied a lot of valuable general information, while a room in his office was given me for working in. The launch *Olga*, belonging to the Administrator, was placed at my disposal.

(Sgd.) M. W. Mehaffey, B.E., Assoc. M.Inst. C.E.,
Assistant Lighthouse Engineer.

Commonwealth of Australia.
Lighthouse Service,
Melbourne, 29th July, 1924.

Dear Sir,

Further to my recent conversation with you and your Captain Mortimer, I shall be glad if you will inform me what the loaded draft of the *Marella* is, and also whether you have in contemplation building any boats in excess of the *Marella's* loaded draft, in the near future, for the Darwin run.

Yours faithfully,
(Sgd.) J. F. Ramsbotham,
Director.

The Manager, Burns, Philp and Co. Ltd.,
84 William-street, Melbourne.

Burns, Philp and Co. Ltd.,
Melbourne, 4th August, 1924.

The Director of Lighthouse Service, Melbourne.

Dear Sir,

Further to our letter of the 1st inst., we now have to advise that the loaded draft of the *Marella* on leaving Sydney is usually about 24 feet; however, on arrival at Darwin it is reduced to about 22 feet.

We have no intention at present of building any steamer larger than the *Marella* for the Darwin service.

Yours faithfully,
per pro Burns, Philp and Company Limited,
S. E. Potts,
Manager at Melbourne.

(Extract of letter from A. F. McCormack, Engineer's Department.)
Mersey Docks and Harbour Board,
Liverpool, 6th August, 1924.

Our minimum radius for rails coming round the ends of sheds, &c., is 120 feet, though we have one or two at 90 feet, but I do not think locomotives have ever been round them. The locomotives in general use on the estate off the main lines are four-wheeled, the wheel base being 9 ft. 8½ in. Six-wheeled locomotives have been in use, but they have had to have the flanges taken off the middle wheels. The speed is "dead-slow."

(Sgd.) A. F. McCormack.

Commonwealth of Australia.
Department of Defence, Hydrographic Branch.
Melbourne, 13th October, 1924.

G.A. 658/201/315.

The Director of Lighthouses, Melbourne, Victoria.

In reply to your communication L.24/286 of the 9th October asking for my opinion as to the rate of the tidal stream at Darwin, I beg to state that I consider that there is a strength of 4 knots per hour at abnormal spring tides.

I have no diffidence in stating this, as this was my experience there during a stay of three months.

I had no instrument to indicate this accurately, but it is not difficult to judge the speed at these rates.

(Sgd.) C. W. Stevens, Commander, R.A.N.,
Officer in Charge, Hydrographic Branch.

2. *To Mr. Mackay.*—The existing jetty will not detrimentally affect the scheme under consideration. On the contrary, it will be found to be beneficial, as the structure can be used for tipping from in order to fill up the area enclosed by quay "A" and the existing jetty. I should say that by using the jetty the work would be made less expensive than without it. We do not, however, have to rely upon the strength of the existing jetty for the stability of the proposed structure. The two will be kept absolutely independent. The outside berth will be available during the time the work is in operation, but the inside will have to

be relinquished at a very early date after a commencement has been made. The latter, I understand, is not a popular berth, and is one that is seldom used. Full inquiries have been made concerning the tides, but at the same time I think an automatic tide gauge should be installed at Darwin, and the data collected and collated and handed to the Admiralty in London and the Department of the Navy in Melbourne, as by this means the information derived concerning tides would be available all over the world. It is very difficult to say whether the fact that there will be dead water in the area covered by the abutment from which the viaduct springs will have the effect of increasing the deposit of silt in that area. I believe the effect of filling in from the abutment and the viaduct will tend to push the current further into the stream, and I would hazard that its effect will be to make the formation of any bank further removed from the jetty than is at present evidenced. I am inclined to think that it will have a beneficial result on the inside of the proposed dock, as sediment and detritus is carried down on the ebb tide, whereas the current of the flood tide is inclined to keep further away from the jetty than that of the ebb tide. The flood tide will not take the same course as the ebb tide. If the trade warrants it, two-storey sheds should be constructed on the wharf, but, whatever is done, the sheds should be so built that their capacity could be increased if necessary. The lower floor of the proposed sheds would be 18 ft. 6 in., from floor level to floor level, and the upper floor 12 ft. 6 in. from floor level to roof. The height of the floors from a ship's deck would, of course, depend upon the construction of the vessel and the tide. With the use of cranes no difficulty should be experienced in lifting cargo from the bottom of the ships to the upper floor of the proposed storage sheds. Electrical power required for the various appliances, including conveyors, as well as electric light in connexion with the proposed works, is as under :—

1 12-in. centrifugal pump, 34.5 b.h.p. ..		34.5
2 concrete mixers, each delivering 22 cubic feet per batch, each 15 b.h.p. ..	..	30.0
Shops, about 10 b.h.p. ..	..	10.0
Conveyors, say, 40 b.h.p.	..	40.0
Electric light, say, 10 b.h.p. ..	..	10.0
		124.5

Information concerning the electrical power available at Darwin at present has been supplied by Mr. Mehaffey. The conveyors to be used in constructional work could be afterward utilized, if necessary, for conveying frozen meat from the store on the wharf to the ships. The radius of the curve proposed for the railway approach to the wharf is 120 feet. I am aware that information concerning the radii of curves varies, and knowing that engines and railway wagons negotiate the ends of the sheds, I communicated with the Chief Surveyor of the port of Liverpool, who in reply, on the 4th November, 1924, wrote as under—

Just a line in reply to yours of the 29th September last, received this morning. Locomotives do not round the 90-ft. curves, but the 120-ft. radius. To do this, as I think I mentioned in my letter to you, the flanges are taken off the centre wheels of the six-wheeled locomotives. The maximum speed on the Dock Estate is 6 miles per hour, and of course they will take the curves at a less speed than this.

I am aware that Mr. Hobler stipulated a curve of 7 chains, or at least 5 chains, for similar work. The estimate I have submitted includes only the cost of railway construction, rails, sleepers, &c., necessary for carrying out temporary railway work. My plan does not contemplate the construction of the railway lines shown, which are merely given as an indication of what railway provision could be made. That is a matter that must be decided by the Commonwealth railway officials. Mr. Mehaffey has prepared a scheme in relation to the position of the vehicular road to give access to the jetty, particulars of which can be obtained from him. I have had no previous experience in caisson construction such as is contemplated, but I have every confidence that work carried out on this principle will be successful. From investigations made, I am satisfied that material suitable for the manufacture of satisfactory concrete can be obtained in the vicinity of Darwin. I am aware that trouble has arisen in connexion with the concrete work put in at the Darwin meat works. If trouble occurred in connexion with the caisson construction, it would not be a serious matter, because it has all to be filled in, and therefore becomes solid. If there were any cracks on the face the inside would be solid. It is not proposed to have any timber fenders to protect the face of the quay walls. I have endeavoured to reduce the cost of quay "B" on account of its length of 450 feet. Small coasting vessels would use this berth, and therefore would not require the full depth of 27 feet below low water mark. If, on the other hand, it should be decided to use caissons at the same level as at quays "A" and "C," they could be put in at an additional cost of £19,500. I have suggested the open type jetty in ferro-concrete for quay "B." I am satisfied that concrete piles of the requisite length can be driven in the class of material likely to be encountered at Darwin, because I have driven green-heart piles in solid stone. The method adopted was to use a special type of shoe, with a 9-in. spike 3 inches in diameter, the spike of which was introduced by a diver into a small hole which had previously been bored, and was then tapped home. It proved most successful, and I should say that if the ground were hard the same practice could be adopted. I anticipate that the work of filling and dredging can be undertaken throughout the whole year, but in the construction of caissons I would use my own judgment, as that work could not be advantageously undertaken during the wet season. In building a lighthouse at Cape Don work was suspended during the rainy season, and on questioning some of the workmen on their return from the site, I was informed that work during the wet season was practically impossible, as the mosquitoes that came out of the ground at that time of the year made life almost intolerable. Similar conditions may not exist at Darwin, but I do not think it would be desirable to undertake the work mentioned when the conditions were unfavorable. The men engaged on the Cape Don lighthouse were brought back during the wet season, but of course that could not be done in connexion with a scheme such as this. The construction of a road to the wharf should be regarded as a necessary part of the scheme to enable passengers to get their luggage to the boats with a minimum of inconvenience. Caisson construction will be undertaken largely by unskilled labour, the number of skilled artisans required being relatively small. I have allowed 26 months for the completion of the section of the work shown on plan No. 1. I do not think any damage would be done to the work if operations had to be suspended for a time during the wet season. I would not recommend launching any of the caissons until they were ready to be placed in position. I do not think the weather conditions or the tides will interfere with the successful carrying out of the proposed structure. The estimated cost of completing schemes "A," "B," and "C," including the work shown on plan No. 1, together with the cost of reclamation and filling, is £625,952. I would approve the construction of scheme "A" apart from schemes "B" and "C" if that were considered necessary. After dredging had been done, vessels could use quay "A" without inconvenience. Silt has always been present, and with the construction of scheme "A" it would not be necessary to keep a dredge constantly

employed. The construction of the bank, the cost of which is included in scheme "A," would be a protection against silting inside. That work should be undertaken before dredging was commenced.

3. *To Senator Reid.*—It is not proposed to extend the existing wharf. It is proposed to take off a little at the back, and fill it in with solid spoil. A length of 10 feet will be filled in, and the timber piles eventually dispensed with. Under the present scheme one berth will be lost and another provided. I have been informed that at times there has been trouble at the present wharf, due to currents, and some master mariners have informed me that they have refused to take their vessels in there. Under the present scheme that difficulty would be overcome. There would be plenty of room in which vessels could swing when approaching or leaving the wharf. According to the borings made under Mr. Mohaffey's direction, the bottom in the locality can be regarded as entirely satisfactory. I have been assured and feel confident that there is a good schist bottom where the work is to be undertaken; in fact, it has been stated that owing to the solid nature of the bottom there may be difficulty in getting some of the piles in. From what I can gather we will be able to get a good hard bottom all along the front. The caissons will be set on a hard bottom, and uncertain patches would be bridged by the caissons. The estimated cost of scheme "A" is £223,924, which includes all the necessary dredging required for scheme "C," and covers the cost of the plain wall finished up to 31 feet above low water, but does not include the cost of the necessary sheds, &c. In obtaining the required filling, we would practically remove Stokes' Hill. If Darwin progresses, the land from which the filling is obtained should be of value, and in certain circumstances might, if sold, return sufficient to meet the whole cost of the scheme. Provision has been made for a crane and two sets of rails on the wharf, and the proposed shed will be 30 feet back from the wharf front. Space has been left for two additional sets of rails, and an area on which cool storage accommodation could be erected if required. I have not had an opportunity of visiting Darwin. It is proposed to drive piles 2 feet to 2 ft. 6 in. below the solid bottom, although less would be sufficient. The necessity of the proposed work is suggested by the fact that at present 3s. 2d. per ton is charged on everything going over the wharf, and in these circumstances it is impossible for the trade at Darwin to expand, or the Territory to develop. When the construction of the north-south railway is undertaken, very large quantities of material required in connexion with the construction would have to be taken over the Darwin wharf, which at 3s. 2d. per ton would represent a substantial sum. Vesteys might feel inclined to lease cold storage accommodation on the wharf if it were provided. Provision has also been made for an additional dock, 1,335 feet long and 450 feet wide, with a quay on each side. As such accommodation is not likely to be required for some considerable time, the estimated cost, which should not be ascertained without additional boring, is not available.

4. *To Mr. Jackson.*—Considering the area of the Northern Territory, a satisfactory shipping port should be provided. I have not ascertained how long the existing wharf has been in a state of disrepair, but I believe that minor repairs are constantly being undertaken. It is reasonable to assume that when the existing railway is extended further south there will be a fair amount of traffic from the station, particularly in the nature of boring equipment, fencing material, stores, &c. Similar provision to that on the Fremantle wharf has been made for vehicular traffic. It is not proposed to drive right through the schist in placing the piles in position. Sufficient dredging will be done to enable shallow-draught vessels to remain afloat even at low water. Having in view the set of the tide on one hand, and dead water on the other, the berthing of vessels should be facilitated.

5. *To Mr. Mathews.*—The principle involved is almost identical with that adopted at Zeebrugge, where a large scheme embracing this particular type of construction was commenced in 1895 and finished in 1906, at a cost of £2,200,000. I think I am correct in stating that the Belgian Government shared the cost with the port of Bruges. In the Zeebrugge scheme caissons were first built of ¾-in. steel boxes, reinforced on the inside with steel and concrete. The sides of the caissons vary, but they were generally about 82 feet long, 24 ft. 7 in. wide, and about 30 feet high. The freeboard when floating was from 1 ft. 9 in. to 2 ft. 6 in. A similar scheme to that used at Zeebrugge was subsequently adopted at Bilbao. In Japan caissons for breakwaters have been used at Otaru, Muroran, Rumoi, Kiirun, and Takao. Caissons for quay wharfs have been used at Kobe, Nagasaki, Moji, and Yokahama. At Yokahama their length was 60 ft. 8 in., width 26 ft. 3 in., and height 47 ft. 6 in. They were of the cellular type, but were built in a graving dock. At Kobe the length was 110 feet, width from 23 to 34 feet, height 35 ft. 6 in., and the weight from 1,000 to 2,400 tons. The walls were 8 inches at the top and 18 inches at the bottom, with a centre wall of 9 inches. All of these Japanese caissons have been completed within the last twenty years. At the time the Zeebrugge work was undertaken engineers had not the same knowledge of ferro-concrete as they have to-day. The sea bed at Zeebrugge was not very favorable, as there the engineers, who had to contend with a 5-knot current, had to deposit stone in order to prevent the work being interfered with by the tides. Such difficulties do not exist at Darwin, where the water will be dead. The mole at Zeebrugge was constructed on the caisson system. I am aware that the Commonwealth Railways Commissioner has stated that the present wharf at Darwin is sufficient to meet the requirements for some time to come, but I think that he does not wish his Department to be saddled with the cost of the work. To allow the Department 3s. 2d. per ton would mean that the money would have gone forever, whereas the proposed structure, if erected, would always be a good asset. The present wharf would be available during the whole time construction on the new wharf was in progress.

6. *To Mr. Blakeley.*—I have not seen an official report concerning the damage done to the reinforced jetty at Port Sampson in Western Australia during a recent cyclone. Doubtless the construction of the proposed work will alter the direction in which the silt is carried, but, as I have stated, I think the tendency will be to force the current further out from the wharf. I do not think the incoming tide will wash the sand deposits into the basin, although a certain quantity will naturally pass in that direction when the water is fully charged with silt. I do not expect any excessive deposit of mud in the basin, but there will, of course, have to be periodical cleanings, as is necessary in almost every port in the world. Fremantle and Hobart are exceptions in the matter of maintenance dredging. The addition to the old jetty will consist of ferro-concrete, and stones weighing approximately 5 tons will be placed at the bottom of the existing wharf. On top of these smaller rocks will be cast until the natural slope is obtained, and then the whole will be carpeted with stones weighing approximately 100 lb. Instead of carrying the slope to the top, a small wall has been provided, which is an advantage, because timber piles have been giving a good deal of trouble. In under-water engineering a slope of 45 degrees is considered safe. We shall depend upon the weight of the rocks forcing out the silt at the bottom. If the Commonwealth Railways Commissioner thought it advisable to use a 3-ft. 6-in. gauge for the present, with the intention of adopting the 4-ft. 8½-in. gauge later, allowance would have to be made for the difference between the two gauges for the two sets of rails, and the removal of the shed to that extent. I would suggest that that be done. Five sections would have to be filled, launched, and sunk for quay "A." I do not think there would be any danger in launching the caissons, as the centre of gravity is very low and the weight also low. Notwithstanding what Mr. Bradley has said in regard to curves, as contained in his evidence on page 88 of the Committee's report, I still adhere to the figures I have given. After reading his evidence, I wrote to the surveyor of the port of Liverpool, who on the 5th August, 1924, wrote me as follows:—

> Our minimum radius for rails going around the end of a shed, &c., is 120 feet, though we have one or two at 90 feet, but I do not think locomotives have ever been round them. Locomotives in general use on the estate off the main line are four wheels, the wheel base being 9 ft. 8½ in. Six-wheeled locomotives have been in use, but they have had to have the flanges taken off the middle wheels. The speed is dead slow.

There was a point in that communication concerning which I was not clear. The Chief Surveyor said, "I do not think the locomotives have been round them." I thought that remark applied to the 90-ft. curves, but it might have applied to the 120-ft. as well. I wrote further and received the information contained in the letter, dated 4th November, which I submitted earlier in my evidence. I am therefore confident that the locomotives and trucks can negotiate a curve of 120-ft. radius. At Liverpool docks the trains proceed slowly, and a man walks in front of the engine with a red flag. I have read Admiral Clarkson's evidence concerning the estimated cost of dredging the silt and schist, but I have intentionally kept everything on the safe side, as one never knows what is likely to happen. If tenders were invited, I think it would be found that the prices would be a good deal lower than I have mentioned. I have studied the particulars given in the Committee's report concerning the imports and exports of Darwin during the last ten years, and there is no doubt that the trade of that centre at present is in a state of stagnation. Trade cannot increase unless improved shipping facilities are provided. The construction of the wharf, costing £250,000, would facilitate development of that vast tract of country. From an economic stand-point, and having in view the exports and imports during the last ten years, I believe the Government would be justified in spending the amount estimated as the cost of this work. Vesteys have complained bitterly concerning the absence of adequate shipping facilities, and if the construction of an up-to-date wharf resulted in the meat works being re-opened the scheme would be justified.

7. *To Senator Barnes.*—It was not my duty to inquire into the efficiency of the existing wharf. My instructions concerning the proposal were contained in the following minute, dated 11th June, 1924, from the Minister for Home and Territories (Senator Pearce) to the Acting Minister for Trade and Customs, which read:—

> In view of Cabinet's approval on the 10th inst. of my recommendations that Mr. J. F. Ramsbotham, Director of Lighthouse Services, should be asked to report on the question of harbour improvements at Darwin during his forthcoming visit to the Territory in connexion with lighthouse work, I shall be glad if you will kindly arrange for the necessary instructions to be given to this officer on the subject. Mr. Ramsbotham's attention should be particularly drawn to the reports by Sir William Clarkson and the report of the Parliamentary Standing Committee on Public Works in regard to the Darwin wharf. Copies of these reports have already been forwarded to Mr. Ramsbotham.

I am aware that Mr. Bell has stated that the present wharf would meet requirements for the next sixteen or twenty years. I have not gone into the figures as to the tonnage the existing wharf would be capable of handling in one year. Additional wharfage accommodation is needed, as the absence of proper facilities retards commercial enterprise. At present, if more than two steamers were in port, berthing accommodation would not be available. Up to the depth provided, warships could be accommodated at the wharf.

8. *To Mr. Cook.*—I have a knowledge of the northern ports from Thursday Island to Geraldton in Western Australia. I do not know the Macarthur River, and therefore could not say whether the proposed amount could be spent to better advantage in that locality. The cost of removing spoil and similar material at Liverpool in pre-war days was 2½d. per yard, but that does not allow for interest or the cost of constructing temporary railways. I consider 5s. a yard a conservative estimate. Due allowance must be made for the difference in the labour conditions at Melbourne and Darwin. The estimate mentioned includes the cost of purchasing engines, a steam navvy, and the necessary railway materials. The actual cost of getting the stuff out would be about 3s. 6d. per yard. Evidence of siltation is to be found in the fact that dredging had to be undertaken at Darwin from time to time, and soundings taken by Mr. Mohaffey show that there has been a decrease in the depth of water. Within 26 months I estimate that the dredging of the basin would be completed, the wharf constructed, and the filling-in finished. I have had as many as 1,500 men under my control. Most of the work that I have had charge of has been done by day labour. The advantage of doing work under the contract system is that the cost is known, and that of day labour is that one is always master of the situation. I submitted supplementary estimates after having further time to study the whole proposition. I now feel that I have given the whole project full and thorough consideration, and if the scheme is approved the next step will be to design it. If the proposed work is undertaken, repairs and maintenance to the existing structure would be practically dispensed with, and I am confident that if a new wharf is erected the cost for maintenance and repairs would be negligible. It would be interesting to know what has been spent up to the present on maintenance and repairs to the Darwin wharf.

8A. *To Mr. Mackay.*—The period of 26 months mentioned in which to complete the work is to be taken from the date on which authority was given that the work should be proceeded with or contract signed. Apart from industrial troubles the work should be completed in that time. Notwithstanding what Mr. Bell has said, and considering the position in which Vesteys say they are placed, I am still of the opinion that the proposed scheme is the most inexpensive one to undertake. I consider the present proposal the most suitable, the method suggested the proper one, and the expenditure warranted.

9. *To Mr. Mathews.*—In all our estimates, the hard level and not the mud level has been taken.

10. *To Senator Reid.*—I have read of the semi-permanent work suggested, which did not dispense with the tide trouble. I am strongly opposed to temporary expedients for overcoming difficulties such as exist at Darwin.

11. *To Mr. Blakeley.*—My estimate of 533,000 cubic yards takes into consideration the mud in all the area to be dealt with. It is assumed that all the mud under constructional work will be washed in.

(Taken at Gladstone.)

TUESDAY, 24TH MARCH, 1925.

Present:

Senator LYNCH, in the Chair;

Senator Barnes	Mr. Cook
Senator Reid	Mr. Jackson
Mr Blakeley	Mr. Mackay.

Gideon George Dennis, Chairman of the Gladstone Harbours Board, sworn and examined.

12. *To Senator Lynch.*—I have been chairman of the board since last May. Concrete has been used here for wharf construction for about eighteen years. There are three sections to the wharf—an old wooden portion, the first concrete portion, and the new concrete portion. The construction of the new concrete portion was begun in September, 1922, and completed in November, 1923. I have inspected the wharf very closely. I think the older concrete wharf at Gladstone was the first wharf constructed of concrete in Queensland. I do not know whether it was the first in the Commonwealth. I am not too conversant with other concrete wharf constructions in the Commonwealth. The original concrete wharf, up to a few years ago, had not been very costly to maintain. The increased cost of maintenance latterly had been caused by the corrosion of the steel reinforcement rods in the concrete. When the steel corrodes it bursts the concrete off. The trouble has only made its appearance during the last few years. The first time the concrete wharf had to be repaired was in 1912. The cost at that time was £370. Mr. Crowe, an older member of the board, knows about that happening. We found corrosion through four piers. I think it was caused through the reinforcement rods being too near the surface of the concrete. The salt water and air must get to the rods and cause the corrosion. The trouble did not reveal itself until three years after the wharf had been constructed, but since its first appearance the maintenance costs have continued to increase. We believe that this year will be the most expensive we have yet had. A good deal of the work this year has been on parts of the wharf that had previously been repaired. The patches that had been put on earlier have been breaking away again. The new concrete patches we have put on have not adhered to the original concrete. That would be due to us having no satisfactory method of putting on the concrete patches. I think that that weakness in our repair work has been remedied, for lately we have been gunnetting the patches. Previous to the gunnetting method being adopted, the Harbours and Rivers Department recommended using hot tar on the structure, but we did not find that to be effective. The corrosion still continued. We applied hot tar to the girders, and put it over everything, immediately after the repair work was completed. The cost of our repair work has continually increased on account of us always trying to do it in a better manner. It is apparent to us that the whole of the damage to the concrete wharf has taken place between wind and water. There are no defects below low tide. It is where the concrete work becomes wet and then dries, time after time, that the most serious defects appear to be. I think the concrete has been well tested below water. Some time ago, when we were doing some repair work, we asked for permission to take off some of the oysters and marine growth underneath to see whether any damage had been done. We took some of the growths off, but could see no sign of anything wrong. The oyster shells seem to form a natural armour over the piles and girders. The weakness has only shown itself above high-water mark, and between wind and water. The new structure appears to be much more satisfactory than the older one. I think it will stand the test of time much better than the older one. Better material was used, and the steel reinforcements have been more deeply bedded in the concrete. Of course, the new wharf has not yet had time to be thoroughly tested. The new work was gunnetted after it was completed. The gunnetting is really a method of compressing the cement, sand, and water. It forces the concrete mixture on to the old place under air pressure. It is practically shooting it on. The former process was to daub it on with a trowel. There is a good deal of waste with the gunnetting, but I think it makes a much better job. I do not think that much more strain would be put on the wharf if we had to handle even double the quantity of stuff that we handle at present. We have had a considerable amount of trouble with fender piles. In the old jetty we had a big block in between the concrete piles and the fender piles. The concrete wharf being more rigid than a wooden wharf, needs protection. A wooden wharf will give where a concrete wharf will not.

13. *To Senator Reid.*—I have noticed that the beams suffer rather more than the piles, but I cannot explain why that should be so. The wash of the water against the beams may have something to do with it. The flooring of the wharf does not seem to suffer much damage. We have never had to repair underneath the flooring of the wharf. Only the beams, the girders, and cross beams have been repaired. The new wharf was gunneted over at the suggestion of the Engineer for Harbours and Rivers (Mr. Cullen). It was done from the water level right up after the work was finished. It was thought that if there were any pores in the concrete the gunnetting would block them up and so exclude air and water. The new wharf was built by day labour under the supervision of the Harbours and Rivers Department. The old concrete wharf was done by contract work seventeen years ago. The banging of a ship against the wharf did some damage some years ago, but it was slight.

14. *To Mr. Mackay.*—The wooden portion of the wharf was built 41 years ago. It is 120 feet long by 60 feet wide. The first cement portion is 200 feet by 60 feet. The first concrete portion of the wharf cost £8,222. The new concrete portion is 447 feet by 60 feet, and it cost £44,284. The wooden portion has iron cylinders filled with concrete for piles. It is only wooden on the top. The wooden portion has stood exceptionally well. In twenty years I suppose it did not cost more than £10 to maintain. Our accommodation is 780 feet for tying up boats drawing up to 26 feet at low tide. That would be the absolutely minimum depth. The rise and fall of the tide is 12 to 14 feet. Not many boats are calling here at present. Up till recently we had a boat twice a week. The buildings on the new concrete portion are 140 feet long by 30 feet wide. We have a double set of railway lines running the full length of the whole structure, and there are two sets of points. I regard the new system of sinking the lines to the level of the wharf as being a big improvement on the old system. There have been no repairs to the iron piles on the wooden portion of the original structure. Nothing has been done to them. They have never been broken. They are screw cylinders on the rock bottom. The rock is soft. We have a similar foundation for the full length of the pier.

15. *To Mr. Blakeley.*—We can ascertain the cost of the first portion of the wharf, and also the cost of upkeep to date. We can find out for you the years in which expense has been incurred. In some years there has been no expense, and in other years it has been fairly heavy, but the damage has been taking place all the time. I will furnish the Committee with the figures that have been asked for. Most of the work that is being done is correcting old faults that have been repaired once, although some new faults are to be found. About 40 per cent. of the work being done by our repair gang is new. I consider the damage has been caused through corrosion. Air and water have found their way through the concrete. I think air and water would not get through if good material were used, and if the steel were not too close to the surface of the cement. In my opinion the faults have developed in consequence of (1) poorness of material, and (2) steel too close to the surface of the cement. The Government engineers have inspected the wharf since the faults have developed. I believe their opinion as to the cause of the trouble is the same as mine. The material that was used in construction was rather poor. I think the cement was defective. The sand and broken metal were good enough. The piles on the oldest section of the wharf are protected by fender piles in the same way as the piles on the second and third sections. There are no swinging fenders. There is a considerable space between the fender piles and the main constructional piles. The iron piles have cost us nothing since we took over the wharf. The only cost that has been incurred in connexion with the newest portion of the wharf is that fender piles have been broken or damaged by ships. There has been no damage to the structure itself. The oldest portion of the wharf has been built 41 years. The practice is for ships to pay for the damage they do to the wharfs.

16. *To Mr. Jackson.*—It would be very hard for me to say what I would do in connexion with your suggestion for building a wharf at Darwin with a solid front. I think a wharf built with caissons and filled in from the back as has been suggested for Darwin should be a very good job. That could not be done here. It would not matter how many tons of earth we tipped in here it would slide away. If a crack should develop in the front of a mass construction, such as has been suggested, I do not think it would be so serious as a crack developing in a construction such as we have here. If the Darwin structure could be built with a solid front at anything near the same amount as a pile structure could be built, I would recommend it.

17. *To Mr. Cook.*—The ultimate cost of the wharf must be taken into consideration. Our revenue in the past has been derived more from passenger traffic than from goods, but we are expecting developments in consequence of the Burnett scheme. We also expect to handle a good deal of coal and wool, and we should get a fair amount of cotton over the wharf as well. Horses are another factor. I consider that this port should be the natural outlet for the whole of central Queensland. I have never been to Darwin, and I have not much of an idea of the potentialities of the Territory. I should be inclined to say that this port should be more important than Darwin. The total cost of this wharf up to the present, with the appliances, has been between £65,000 and £70,000. I think £70,000 would be the outside figure. I still consider that the present structure is only a new one, and until I have seen it in use for a few years I would not be prepared to express an opinion on whether it would be better to use concrete than timber. Timber, of course, is very much cheaper. I suppose you could build three timber wharfs for the cost of one concrete wharf. I think we could do that here at any rate. Until concrete has been thoroughly tried I feel inclined to say that the timber wharf is the better proposition. A concrete wharf recently collapsed in New Zealand, I understand. I have not had any details of the accident, nor do I know its cause. I believe that New Zealand wharf was built about the same time as our concrete structure. It was built by the same people who built our wharf. We have an approach to our present wharf which is built on timber piles, and the piles are still good. They have been Muntz metalled. Some of the metal has come off, but some of it is still good. Our revenue last year was slightly over £2,000, which shows a return of about 4½ per cent. on the capital cost of the structure. I understand that in Darwin you will have the whole of your exports concentrated on the one wharf. In central Queensland four ports are competing for the trade. The Rockhampton wharf revenue is about £22,000, whereas ours is only about £3,000. I believe the revenue from the four ports that are competing for the central Queensland trade will amount to about £26,000 this year. The nearest port to this one is about 28 to 30 miles north. That is Port Alma. Broadmount is about 10 miles further, and is about 40 miles from Rockhampton. The distance between the two extremes of these ports is about 60 miles. I favour concentration in dealing with shipping, for the reason that it ought to be very much cheaper to maintain one port than to maintain four. If the maintenance of the wharfs is cheaper there must be a considerable saving effected. If handling costs are reduced the producers would be able to sell cheaper. I do not think that we ought to condemn concrete. The idea of a concrete wharf is a good one, and it should not be put out of court because of faulty construction in the past. I consider that the material was faulty in this work, for the reason that I have been told that a number of piles were condemned and were broken up. Mr. Cullen, the Engineer for Harbours for Queensland, is our concrete expert. The reinforcement steel in some of the concrete work here is very near the surface. I think it is not any more than ¼ inch deep in some cases. I would not say it was faulty specifications that caused the steel to be so close to the surface. It is quite possible that the instructions of the engineer were not properly carried out. Once the steel frame is set in the mould no engineer in the world could tell how deeply the steel was embedded in the concrete. They could not say whether it was ½ inch or 2 inches. The frames need very careful hanging in the moulds in the first place. The reinforcement is first put in the frame, and the concrete is then poured in. The utmost care has to be exercised in this work. The Gladstone Meat Works has a private wharf. We do not lose any revenue on account of it, unless it be berthing charges, for we collect harbour dues from them just as we do from our own wharf. The only revenue we would lose would be the berthing charges. I will supply figures showing the tonnage that has passed over this wharf in the last few years. I do not know how much the meat works' wharf cost. I understand that their maintenance costs are very heavy. Our shortage of revenue is on account of competition from other ports. I visited Rockhampton and tried to get cargo for central Queensland. The bar to our getting it was not the difference in the harbour dues, nor wharf-handling costs at Rockhampton, Port Alma, and the other ports, but the tremendous difference in railway charges. The Rockhampton charge for oil, for instance, is 13s. 4d. per ton, but the Gladstone charge is 4Bs. 10d. per ton, although there is only about 28 miles difference in the distances.

18. *To Senator Lynch.*—Our port charges are much cheaper than those at other ports on the Queensland coast. I think we are the cheapest port in the whole of Australia. Our charge for frozen meat is 1s. 6d. per ton, and for tallow and sundries 3s. per ton. Handling charges are for loading into the ship, and the shipping people pay them. Our low maintenance cost is really the reason for our low charges. We have such a fine natural port that the upkeep is very small. We have practically no dredging expenses, for instance. Two men are constantly at work on the meat works' wooden structure. I suppose their upkeep costs are about £1,500 a year. In the old portion of our concrete wharf the railway lines are set in asphalt, and the water can get right through the asphalt on to the concrete. I do not think that is desirable.

19. *To Mr. Mackay.*—The maintenance costs of our wooden wharf have been practically nil. Our expenses have been incurred on the first portion of the cement wharf. I think the board was induced to give concrete another trial in consequence of the recommendation of the Harbours and Rivers Department. We had the option of building a wooden or a concrete wharf. We had seen the defects in the first concrete wharf, and decided that we would go in for a wooden wharf for the new portion. The pre-war price given to us for a wooden wharf was £19,000, and for a concrete wharf £42,000. Before we undertook the work, Mr. Cullen, the Engineer for Harbours and Rivers, came up and discussed the matter with us. He assured us that there had been considerable improvements in the

construction of concrete wharfs, and he practically gave us a guarantee that if we went in for a concrete wharf we would not have the faults and defects of the first concrete wharf repeated. It was on his advice that we changed our mind and decided to build the latest portion of the wharf in concrete. If one had only the experience of our old concrete wharf he would naturally be prejudiced against using concrete again. Of course, a concrete wharf must have a longer life than a wooden wharf, but looking at our experience one must admit that the wooden structure has been absolutely satisfactory. It has been standing for about 40 years, with a very small expenditure on maintenance. Our harbour is land-locked, and we do not suffer from gales or silting up or anything of that description. With the contemplated addition to our wharf, which has already been agreed to by the Government, we hope soon to proceed with the construction of another 200 feet, which will make our structure 1,000 feet long. I think that ought to be sufficient to cope with the whole of the trade of central Queensland. When we were thinking about adding the last portion of the present concrete wharf, the only alternatives we had under notice were concrete or wood. The use of iron piles was out of the question.

20. *To Mr. Cook.*—There are no defects in the new portion of the concrete wharf. It is quite possible that it may be a perfect job. The general opinion is that the older a concrete job gets the better it gets. If that is so it should be a few years before we have any trouble with the new portion of the wharf, although it is too soon yet to speak with certainty about its merits as a permanent structure.

The witness withdrew.

Joseph Galister Howie, General Manager of the Gladstone Meatworks, sworn and examined.

21. *To Senator Lynch.*—I have not been to Darwin, and, therefore, it would be presumption on my part to attempt to make suggestions in regard to what ought to be done in that part of the country so far as handling meat is concerned. If they cannot handle meat satisfactorily under the conditions that have been described to me the circumstances must be very different there from those of Central Queensland. They must be far worse there than here. To carry meat 2½ miles from the meatworks to the ship it should not be necessary to have insulated trucks, but certainly advisable. There should be no difficulty at all in sending meat 2½ miles from meatworks in any part of the world. You have seen the method of handling our meat at the Gladstone works. We aim to get our meat from the works to the ship in approximately twenty minutes. If the vans which carry the meat were left standing on the wharf for an hour or more it would naturally thaw the meat a little bit. The Government inspectors are very strict in their examination of meat, and so also are the engineers of the ships. They will pass nothing that is showing any sign of softness. The temperature of our cool stores at the works is anything from zero to 8 degrees above. That is the range. The temperature of the meat itself would probably be a couple of degrees higher than that of the chamber. The temperature of our sea water at Gladstone has been as high as 89 degrees. It was that temperature in February. We had a temperature from 86 degrees to 89 degrees for about a fortnight. I do not think it would be worse than that at Darwin, for they were very exceptional conditions. We kept our works in full operation during that period. That was the highest temperature I have known in thirteen years, and it did not affect our loading.

22. *To Mr. Mackay.*—The way it affects us is in the cooling of the ammonia we use the salt water on our condensers.

23. *To Senator Lynch.*—There should be no difficulty in transporting meat 2½ miles even in Darwin if they use insulated trucks such as we do here. We were shipping our meat during the high temperatures to which I have referred, and we experienced no difficulty. The high temperatures would only affect our refrigeration in the works; it would not affect the loading. While we were loading that ship we did not leave the meat out on the wharf during lunch hour. We do all our loading between 8.30 a.m. and 9 p.m. We do not do any loading after 9 p.m. Twenty minutes is approximately the average time that our meat is exposed. The atmospheric temperature in Gladstone ranges from 70 degrees up to 90. I am afraid I cannot say what the percentage of moisture is. We have had practically no trouble with our meat, except for an odd quarter or two. We have sent a few quarters down to the ship that have not been absolutely hard, but they have been taken. We have never had a big parcel of refrigerated meat rejected by a shipping company. I cannot say whether the type of truck we use here is the same as they use at Rockhampton and Townsville. The trucks we use are part of our own plant. Our trucks are similar to those in use in the Government service. We get 35 quarters into a truck. Each truck weighs about 8½ tons. We do not use any Government trucks. We load meat into these trucks regularly without trouble. In Darwin it would probably be better to have thoroughly insulated trucks where the distance is 2½ miles, as against our ¾ of a mile. We have a continuous service here. We send down a rake of 4 trucks at a time. If they send down 14 trucks at a time in Darwin the standing time would be longer, for it would take longer time to unload 14 trucks than to unload four. We make nineteen runs in nine hours. To put it another way, we send down 76 truck loads. Twenty minutes on the average would cover the whole run from the time the meat is loaded until the trucks are ready to be returned. We use a petrol engine to do our running. The time of the run from the works to the wharf is less than three minutes. I suppose it would take about ten minutes from the Darwin works if they were organized on the same basis as ourselves.

24. *To Senator Reid.*—The weather conditions which we have in February, and to which I have already referred, would not worry me at all, even if I had to go through them all the season. It is not absolutely necessary for us to have insulated trucks, but I prefer them because it is a safeguard in the event of any delays occurring. We would not send out meat down to the wharf if it were not likely to be unloaded for some time. If it were left standing on the wharf for long it would thaw out. If meat is in our ordinary insulated truck it would keep all right, but it might not keep absolutely hard—freezing—as we like to get it aboard the ship. If it were left standing for a time it might get into a condition that would lead the ship's official to reject it. The whole essence of handling meat is to get it hard as quickly as possible, and keep it in refrigeration without exposing it. If holds are subject to opening up at foreign ports it is likely that the meat will be affected. I have been through the Redbank meat works in Brisbane. It takes them about four hours to get their meat to the wharf. I have not heard of them having any trouble. I have not been to Townsville. It is possible for the Aberdeen people in New South Wales to send meat to Newcastle, 100 miles, or Sydney, 180 miles, and land it in good, hard condition with insulated trucks.

25. *To Mr. Mackay.*—The advantage of our system of loading is that the meat is sent down to the ships in small, quick batches. The engine we use is a 65 horse-power Napier motor-car engine. The first engine of this class we obtained was on a chassis which was bought for £250. It cost us about £500 to mount, and about £800 landed here. The 60 horse-power engine which we use cost us £280, or mounted, about £1,300. We had that one about six years before we obtained the larger 65 horse-power engine. The weight of these engines is 4 tons 15 cwts., and 4 tons 13 cwts. respectively. They will haul 40 tons on the level. It is much more profitable to send rakes of four trucks. We could not handle a long string of trucks on our wharf. In any case I prefer to send the smaller number. If there is slackness in unloading the delay might affect the meat if the string of trucks is long. The number of trucks which can be safely sent to a wharf depends upon the conditions of the wharf, and also on how many holds are being worked.

26. *To Mr. Cook.*—Meat can be carried satisfactorily for 180 miles in New South Wales. The distance at Darwin should not cause great difficulty in any way if the meat is properly handled.

27. *To Mr. Blakeley.*—Our wharf was built when our works were established about 30 years ago. It is built of wood. Its present condition is good. We had a diver here some time ago to examine it. He went through the whole structure and reported that it was in excellent condition. We are continuously working on it. Our piles are all metal sheathed. We have not used concrete in any way. I should say it cost about £1,500 a year to maintain the wharf. I cannot tell you offhand the capital cost of the structure. The cost of maintenance remains about the same. We have a wharfinger there continuously. His wages have to be met, and if there is any extra damage occasioned to the wharf it has to be repaired. We are always replacing piles, and generally keeping them up to date. Some of the piles have been in almost since the wharf was first built, and are still good. I am certain that all the piles have not been renewed. It is generally the outside piles that get damaged. The piles are ironbark and mahogany.

28. *To Senator Lynch.*—I do not think that the muntz metal used now is as good as we got in the pre-war period. I would not care to offer any opinion as what form of wharf construction is desirable. We have not estimated how long our wharf is likely to last. The wharf is quite good now, and I anticipate that it will last as long as I am likely to be at the works. I feel quite safe in saying that the wharf has a long life before it yet. The diver marked any of the piles that he thought were doubtful. I could get information as to how many of the original piles are still left, and as to when the other piles were renewed. I will get a copy of our plan of the wharf made for you. The only recommendation I would make in regard to the construction of a wharf where meat is to be handled is that it should be built so that a ship can load as many hatches as possible simultaneously. There is a wharf in Argentine, so one of the ship captains told me, where during the war period he was able to discharge his cargo, coal, and load approximately 4,500 tons, and he was only there five days. It seems to me to be a big disadvantage that we should have boats spending two or three days here, and at Brisbane, Townsville, and Port Alma in discharging and loading, when it is possible for vessels in other parts of the world to load and get away so quickly. It would be advisable, I think, to make every effort to get boats away as quickly as possible from Darwin.

The witness withdrew.

John Alexander Sampson, Chief Engineer, Gladstone Meat Works, sworn and examined.

29. *To Senator Lynch.*—I have occupied my present position for thirteen years. I have been to Darwin once every three months for five years. I have a fair idea of the position in regard to the meatworks. Vesteys' works was built after I left. I know the position of the wharf, the last time I saw it was in 1914. It is an iron wharf. There was very little business being done at Darwin then. It was very satisfactory when we were there, because Chinese were unloading the ships. They did some fine work. Meat could be loaded at Darwin just as we do it here, but they would need a double line of rails. I understand that they have a turntable. If meat is soft through two hours' exposure it was not properly frozen when it was put in the truck. The temperature of the freezing chamber is not the thing that matters. It is the temperature of the meat that counts. Meat should be in the cool stores for a least a week with the temperature at zero, or 5 above. It takes seven days to get meat down to the right temperature. I know of no reason why meat should not be successfully loaded at Darwin. There should be no delay if they had a double line. If they handled rakes of fewer trucks they would get the meat more quickly into the ship. They could have a train loading at the works while another was discharging at the jetty. The Darwin temperatures are no worse than ours, or if they are, it is only a matter of a very few degrees.

30. *To Senator Reid.*—It only takes 30 seconds to handle rolling-stock over a turntable.

31. *To Senator Lynch.*—We do not test the temperature of our meat with a thermometer as a rule. We test it with a sharp dagger. If we cannot push the dagger in with a little pressure the meat is hard enough, but if it goes in it is not hard enough. The lowest actual temperature of our rooms to day would be about 3 degrees, but the actual temperature of the meat would be 11. The meat would have been there for nine or ten days. When we test the actual temperature of the meat we bore about 9 inches in, and put a thermometer right in. There should be no difficulty in getting meat from the Darwin works into the ship's hold even if the work takes some hours, provided that it is carried in well insulated trucks, and that its temperature was low enough before it was put into the trucks. We keep our trucks away from the sun if they are likely to be left standing any time. They are mostly kept under cover the night before loading, but even if they are left out in the sun it would not make any difference to speak of. The meat does not thaw out. The temperature of the truck when we begin to load is the atmospheric temperature outside. There might be 5 or 6 degrees difference. There is no pre-cooling at all here. Most of the refrigerating works have ice compartments for pre-cooling. If the meat is sufficiently frozen it would not matter whether there was any pre-cooling or not at Darwin. The meat must be sufficiently frozen before it is shipped. I know the type of truck used on the Queensland railways. It is satisfactory. The stuff we got from Redbank when I was with the Eastern and Australian Company was always the worst we shipped. We took meat there that would not be taken to-day. The trucks used should be airtight. This is more important than insulation. If you have a draught going through the truck you will thaw the meat. We use pumice in our own trucks here for insulation. I think the Queensland railway authorities use cork. An area of about 4 inches all round is needed. If the floor is properly insulated it should not matter whether it is of metal or wood. It seems to me that the necessary conditions for shipping at Darwin are a double line of rails on the wharf and quicker handling, with a fewer number of trucks.

32. *To Senator Reid.*—I was referring to some years ago when I mentioned the Redbank meat. I blamed the distance it was carried for its soft condition. It would be better to use a small rather than a large truck at Darwin, for you would have less air circulating in such a truck.

33. *To Senator Lynch.*—It would be a good thing if proper experiments could be carried out, under the supervision of the university authorities, for instance, on the different temperatures required in thawing meat. Experiments could also be carried out with profit in freezing meat to different temperatures, rapid freezing, and rapid and slow thawing. I do not mean laboratory tests, I mean practical commercial tests. It would need to be something on a big scale. We are not in a position to conduct experiments on our own account, but if we could get help we would be glad to make tests. I would not like to ask the Gladstone meat works to do it at their own expense, but if the meat for the purpose could be provided by some other

authorities I would not mind asking them to do the work. The room also would have to be found. We could arrange that there would be no costs of labour and keeping records.

The witness withdrew.

James Skinner McKenzie, Foreman of Works, Gladstone Wharf, sworn and examined.

34. *To Senator Lynch.*—I was in charge here when the wharf was constructed. I was then employed as foreman by the Ferro-Concrete Company. Mr. C. M. Boult was the engineer. He was their engineer in New Zealand. We had quite a lot of material used in the beams and decking of the wharf which was of inferior quality, principally the cement. It was used at the start of the job and in the making of the first piles. Some of the piles had afterwards to be broken up. They shattered in the process of driving. Some of the cement that was used was, I believe, stored in the shed for as long as fifteen months, and when it was used for making beams and decking it had deteriorated seriously. When the casks were opened quite a lot of it was in lumps, and it had to be broken up with a sledge hammer. I did not think that that was good practice. I was the contractor's man at that time, and I was there to study the interests of the contractor. An officer of the Harbours and Rivers Department inspected the material, and did not take any exception to it. I cannot guarantee that the lumps were sufficiently broken to ensure that they would pass through a sieve. The mixture was turned over with a shovel, and the majority of the mixing was done with salt sea water. None of the new part of the wharf was made with salt water. That is about as much as I can tell you about the construction of the first part of the wharf. Any other evidence I can give you to account for the breaks in the work is only theoretical. I have always had the opinion regarding concrete wharfs that it does them no good to allow ships to hit against them. Mr. Fison, of the Harbours and Rivers Department, supports me in that view. The hitting of ships against the columns of the wharf has a tendency to buckle the beams, and to start cracks in them. These are only my opinions; I have no engineering knowledge on the matter. Another thing in connexion with the first concrete wharf is that it does not get good treatment in quite a number of ways. The railway lines are built on asphalt, and the water drains through the asphalt on to the wharf. I think that makes a bad job. On the new wharf the rails are put down to the level of the concrete and on a concrete base. Under the old scheme, if there is any bad concrete about the water will find it out, and will get through to the steel reinforcements, and so will cause trouble. The greatest trouble we have on this wharf occurs between wind and water. The earlier repairs we made have evidently not been effective, for new cracks have developed at the same places. The old methods of repairing was different from that which we now use. Under the old arrangement we used to clean the steel rods and then replaster them with cement. Under the new system more cleaning is done, and the cement is gunnetted on. We use a three to one mixture, with about 25 lb pressure. There is, roughly, about 35 lb. pressure when the mixture leaves the machine. We have only been using this method for about a month, so we have not had time really to say whether it is effective or not. I am inclined to go back to wood for wharfs, in view of what Mr. Cullen says in regard to the naval brass he has been getting lately. He says it is an improvement on the muntz metal. If you have a guarantee that the metal will last for 30 years, I think a jetty with ironbark piles covered with naval brass is a very good proposition. Rather than incur the risk which seems so far to be associated with concrete I would be inclined to advocate timber. I have lost a good deal of my faith in concrete. I am not altogether satisfied with the concrete piles themselves, and there is trouble to be faced in the beams and decking. I began concrete work in 1905. I have no decided preference for round, square, or hectagonal piles. If the piles were cased after driving you might be able to repair the damage from cracks, but there must be a good deal of extra expense in doing a thing of that kind. I am not too well inclined towards Darra cement. In any case, I think the use of concrete is still in the experimental stage. It cannot be said yet that it has been tried out and proved. That is my opinion as a layman. I would not argue the matter with engineers.

35. *To Mr. Cook.*—The older part of the wharf here was made with concrete mixed with salt water. The inspector must have approved of that, I suppose. I brought the matter up more than once during the job, and asked the engineer whether there were likely to be any ill-effects from an excess of magnesia. He did not seem to think there would be any trouble. I could not say definitely whether the use of salt water is really the cause of the trouble. The drying-out process might have overcome that. I do not think they use salt water in any present-day constructions of concrete. I cannot say that any one was to blame for it being used in the first part of this job, for it must be remembered that the work was done seventeen years ago. I know it was used in the construction of some portions of the Auckland Wharf. I believe it was used just for the reason that it was handy. Experience has proved that fresh water gives better results, and, although it may have been justifiable to use salt water seventeen years ago, I think it would not be so to-day. Unless proper precautions are taken in the drying-out process there is a danger of cement piles cracking. When we made our piles our system was to keep the piles covered with bags, and to wet the bags two or three times a day, or else to bury the piles in sand and keep the sand moist. Neglect to take some such precautions would have a detrimental effect on the piles.

36. *To Mr. Blakeley.*—You have to be very careful in driving concrete piles, and care is also necessary in carrying them. They must be protected from liability to fracture. I have never used a microscope to examine the faults, but to successfully correct a fault you must get an absolutely good adhesion between the cement and iron, or else other cracks will develop. As far as I have been able to ascertain, there does not seem to be any crack directly against the iron. From what we can see, when we are doing our repairs the steel in the reinforcements does not seem to be very deeply pitted. Of course, if the corrosion were allowed to continue, the trouble would become serious. Apparently moisture gets into the concrete and against the steel, and the moisture and the air cause the rust, and that makes the concrete burst. The rust does not appear to affect the steel or iron very much by reducing the thickness of the reinforcing rods. I do not think you would find much difference between the thickness of the steel today and when it was first put in. I removed the top portion of the screw piles at Port Alma, and Mr. Bashford carried out experiments there, and did not detect any difference in the thickness of the iron after 25 years. He compared the thickness of the iron as it is now with that which was specified for the job. I think he was not able to say definitely that the cast-iron casings were affected even to the extent of 1.32 part of an inch. So far as I know, there is no really definite theory as to what causes the rust. Mr. Boult, the engineer at Cairns, says that when the tide goes out there is a suction which creates a partial vacuum drawing air in, and the combined action of water and air causes the trouble.

37. *To Senator Lynch.*—I have heard of a concrete wharf in New Zealand collapsing, but I do not know anything about the matter other than what I have seen in the newspapers. I do not know anybody who could tell you anything about it first hand, but I think that wharf was built by day labour under the Auckland Harbours Board. The general manager of the Ferro-Concrete Company, of Melbourne, Mr. W A Robertson, would perhaps be able to give you some fairly reliable information. He was general manager for the Ferro-Concrete Company then, and Mr. Hamer, of the Harbour Board, was responsible for the job. Mr. Owen Thomas was then engineer with the Ferro-Concrete Company, and I understand is now with the British Concrete Company, Little Collins-street.

(*Taken at Bowen.*)

WEDNESDAY, 25TH MARCH, 1925.

Present:

Senator LYNCH, in the Chair;

Senator Barnes	Mr. Cook
Senator Reid	Mr. Jackson
Mr. Blakeley	Mr. Mackay.

Walter Dunross Goudie, Civil Engineer, Bowen, sworn and examined.

38. *To Senator Lynch.*—So far as I can say the principal reason why concrete is being adopted in wharf construction is to counteract the effect of the cobra, or toredo in timber. The cobra, of course, attacks timber very quickly and disastrously. On the other hand, when thinking of the two methods of constructing wharfs, one has to remember that when a timber pile needs renewing it can be much more readily replaced that a concrete pile. In fact, I have never heard of a concrete pile being replaced. I have never heard of one needing replacement. That is the chief reason why concrete is undoubtedly superior to timber in water. The damage to concrete in water seems to be between low water and high water. There appears to be no damage at all where the concrete is always under water. So far as the concrete pile is concerned, it seems to me that providing you use good material a rich enough mixture, and that the danger of error from the human element is eliminated—that is to say, provided you could get a perfect job—you could make an everlasting concrete pile. I think it is possible to make a pile which for all intents and purposes will last for ever. Good material and careful work are essential. I do not think you ever get these conditions fulfilled, however. It is very seldom that you can eliminate careless work for one thing, especially when you are on a big job. I have not had a long experience on concrete construction of this nature. This, as a matter of fact, is my first experience; but I have been connected with concrete work of other descriptions in this country and in Canada. So far as I know, concrete has taken the place of timber in all important wharf constructions everywhere. I cannot say whether there have been any innovations here in the construction of wharfs. Of course, designs have been altered. This is the first job of this design that has been used by the Harbours and Rivers Department of Queensland. They used longitudinal beams under the railway lines in the rail wharf that runs alongside the timber wharf, but we have none at all in the new wharf. That is an innovation. There is no doubt whatever that the heavy impact of ships against a concrete wharf does harm. It is for that reason that we have used raker piles on this job. They are driven in diagonally, and are there to take the bump of the ship. That is not a new thing by any means. I do not know Port Darwin from personal knowledge. If the wharf has to be built 55 feet above the ground it means that it will be a high construction. When piles have to be driven 20 feet the work is extremely hard in certain classes of ground. It would not do to have only 15 feet in the ground when there is 55 feet above the ground unless the piles were properly braced and driven through good ground. The longest pile I have handled here is 55 feet, and that, with an ordinary plant, is about as large a pile as one can handle with safety. It seems to me that for Port Darwin you would need something as long as 80 feet, and with a correspondingly big section. Such a pile would probably weigh 20 tons. Ours weigh 11 tons. To build a jetty with piles of that length at Darwin you would need a bigger plant in every respect than we have here, and the added danger of the piles breaking as they are being handled must be a consideration. Long piles like that are apt to snap like carrots when they are being lifted from the flat. A ½-in. sag will crack them. Our piles have four 1⅛ in. rods through them. Personally, I should say, without knowing any more than you have told me, that it is doubtful whether a wharf of this particular type of construction would be suitable for Darwin. I know nothing of caisson construction. Our piles vary in size. The outside piles are 10 feet in the ground, the next row are about 16 feet, and the two middle rows about 20 feet in the ground. Some of the bottom has been dredged and some has not. The ground is not dredged where the middle piles are driven. The piles go through a strata of decomposed granite. The ground is dredged on each side of the jetty, and the piles that are put into that ground are not driven as far as the piles that are driven into the non dredged ground. The bottom was bored to show rock. Nothing but the best material should be used in concrete work of this description, and the workmanship should also be of the very best, otherwise you are wasting money. The whole secret of success in placing concrete lies in the working of it while it is in the liquid state. I have four men, and sometimes six, tamping the concrete as it goes into the moulds. That is done to get all the air and surplus water out. If the tamping is carelessly done you might just as well save your money as attempt to do effective work. Whether the job is done by contract or day labour the utmost care is necessary to ensure an effective construction. A most important thing is the placing of the concrete.

39. *To Mr. Mackay.*—In making our piles we used 3 parts of cement, 5 of stone, and 4 of sand; for the superstructure we use 3 parts of cement, 5 of sand, and 8 of stone. The proportions depend entirely upon the size and character of the work and materials. Our stone is graded from ¼ inch to 1½ inch. The reinforcement should have a covering of not less than 2 inches of concrete where the work is in contact with water. That is the absolute minimum covering in my opinion. A great deal of the trouble with concrete construction has been caused by insufficient covering of the reinforcing bars. I have seen the Gladstone wharf. I do not say that the fault there was that the reinforcement was not given sufficient covering. I do not know what covering there was supposed to be. With the best designing in the world a couple of labourers can ruin a job by walking on the steel once it is in position. Very close supervision is absolutely necessary. It is a mistake to mix cement with salt water whenever there is any steel about. I have had a good deal of experience in building construction. We have sometimes put three times as much steel as we need theoretically for strength into a job with the object of counteracting the damage that might be done by men knocking the steel about once it is in the mould, &c. If steel gets out of its proper position the job loses strength. The piles in the railway approach to this jetty are about nine years old, and they are entirely of concrete. The older jetty is of wood. Some of the wooden piles have only the muntz metal covering holding them up. They have been there for 30 or 40 years. I would not agree with a proposal to put a concrete top on wooden piles, although I think a wooden top on concrete piles has a good deal to be said for it, assuming that the decking can carry the load. A cement top is desirable and necessary if the loading is to be exceptionally heavy, but for ordinary purposes a timber top is in my opinion much better than concrete. You can get

at a timber top and repair it from time to time as need arises. The trouble with concrete is that you can never tell what is going on. For instance, when there is damage through the expansion of the steel in consequence of rust, the first intimation you have of it is the crack of the concrete. I am giving you my opinion for what it is worth; there is nothing official about it; but I advocate a wooden top on concrete piles for wharfs which have to carry ordinary loads.

40. *To Senator Barnes.*—Nearly all concrete mixing is done mechanically nowadays. It also requires a lot of supervision. There is danger from careless mechanical mixing, just as there is from careless hand mixing. Too much sand, stone, or water may easily be put into the mixer. I have taken precautions to see that care shall be exercised on this job. I have a gauge on the side of the tank, for instance, so that we may know how much water is put into the mixture.

41. *To Senator Reid.*—Corrosion of the iron in concrete is caused by the presence of water. It is impossible to make concrete absolutely watertight. Darra cement, dry, has 50 per cent. voids, although you would think that nothing could be finer. No cement is absolutely non-porous. If the steel reinforcements are sufficiently protected from air it is possible to prevent the rust from occurring. Where corrosion does occur the steel may be too near the surface or the quality of covering material may be poor. The rust that takes place between low and high water is a different oxide from the rust which forms where there is always water. There is no trouble from rust below water. It is where the work is wet and dry alternately that the trouble occurs. I believe Mr. Cullen has carried out some experiments with the object of protecting iron from rust, but he will be able to tell you about that. The stone we use is all screened. A 1½-in. mesh and a 1-in. mesh are used. Anything below a ¾ inch is taken out. The average grade is a little more than ¾ inch. If the concrete work is properly done the *chances of corrosion would be eliminated. Successful* work is practically a matter of good supervision, good material, and good design.

43. *To Mr. Blakeley.*—*It is nearly two years since* I was in Gladstone. I have seen nothing that has occurred there since then. There were faults in the *wharf then, but nothing of great importance so far* as I know. I would not care to give an opinion on the cause of the trouble, but it looks as if it might be on account of an *insufficient covering on the steel.* I know the principle of caisson construction, but I have had no experience of it. I think that for Darwin *some such system of caisson construction near the shore,* as you have described to me, with a filling in of earth and stone from the back, would be practicable, but it *is very hard to express an opinion, for* I know so little about the situation. It is absurd to express an opinion at all really, but I imagine that such a system would be *more suitable than that which we are using here.* We only tamp our concrete, but I believe in the vibratory method, which is an excellent way of tamping. *material. With a proper vibratory method you can* make pretty certain of overcoming voids. The object is to exclude anything that can possibly contain air *and water. Assuming that the point of impact is not* too high above the ground, fenders are all right on a wharf; but where, as you are suggesting, there is a *height of 50 feet above the ground the thrust of a* vessel would be likely to do a good deal of harm. The thrust of the vessel at high tide on the top of such a pile would tend to break the pile off near the ground level unless piles were strongly braced.

43. *To Mr. Cook.*—Assuming that the earth is readily obtainable, I would prefer some solid construction to piles. My principle objection to wooden construction is the damage caused by the teredo. I do not think that the principles of concrete construction have been properly mastered yet. Certainly concrete wharfs are not yet an assured success. At any rate, that is my opinion. Worms have got into the concrete in the Panama Canal. They have got into the bottom of the largest lock. Success in constructional work of this kind lies in skill as well as material. We have excellent materials around here. We have good sand and good stone. It is not always easy to secure such good materials. The stone we have here is the best that I have ever used for concrete purposes. I have had no direct experience of using salt water in steel construction. I should not dream of using it myself, for I am quite sure that it would be detrimental. It may be partly the cause of rust in the steel at Gladstone. We use fresh water running through a hose right down into the walings here. We take every means to exclude salt water. We even wash traces of the salt water out of the moulds. It may be that it is an unnecessary precaution, but I am telling you of it just to show you the length to which we go. I am not widely experienced in wharf work. I was resident engineer on that job at Ball's Head, Sydney. That is a wooden jetty, with no concrete about it. That is the largest job of this nature I had anything to do with previously.

44. *To Senator Lynch.*—I have known cases where engineers have been out of it in their advice in the use of concrete construction. I know of the Auckland wharfs. I have heard that a concrete wharf at Auckland has collapsed, but I know nothing definitely about it. I should think the trouble was due to faulty construction. Handling concrete is an extremely tricky business, and it is impossible to exercise too much care. A few years ago the cost of concrete construction was about half what it is now, but you probably know that. Constructional costs are going up all the time. This job is, I believe, the most costly that has ever been done by the department in Queensland. I cannot tell you what the cost is, as I have not been informed as to the cost of the material. Roughly, I should say that timber costs about half or two-thirds as much as concrete, assuming that the timber is reasonably available; but the cost would depend on a lot of factors. There is nothing official about the evidence that I have given on these matters, and that is particularly so when I say that while I think that this is a magnificent jetty, I also think that the cost is out of proportion to the utility of it.

(Taken at Townsville.)

SATURDAY, 28TH MARCH, 1925.

Present:

Senator LYNCH, in the Chair;

Senator Barnes	Mr. Cook
Senator Reid	Mr. Jackson
Mr. Blakeley	Mr. Mackay.

Vincent James Lalor, Secretary Townsville Harbour Board, sworn and examined.

45. *To Senator Lynch.*—The Townsville concrete wharf was completed in 1913. No additions have been made since then. It is a reinforced concrete pile structure, with a reinforced superstructure. Its length is 600 feet, and its width 125 feet. Concrete piles were used. The length of the piles is 55 feet at berth, and 45 feet under the wharf, and the piles are 18 inches square. The area was dredged to suit the structure. The structure cost £35,000. The highest recorded rise of the tide here is 12 ft. 9 in., above datum, and the greatest recorded fall 1 ft. 1 in. below datum. The extreme range of the tide is 13 ft. 10 in. The average rise is 6 ft. 6 in. at neap, and 10 feet at spring tides. Various weaknesses have developed in the wharf. They have been mainly due to the corrosion of the steel reinforcement rods. When the corrosion occurs it bursts

the concrete away from the rods. When these weak places first developed in the piles of the under section the concrete was cut away from the rods, the rods were cleaned and then re-plastered with cement concrete; slightly increasing the section of the piles. When it was found that this practice failed to arrest the corrosion it was abandoned. When subsequent defects developed the rods were cleaned and tarred but not re-plastered, and the whole understructure was then tarred. Corrosion still takes place, and whenever it manifests itself it is dealt with in the same manner. The tar is a remedy in some places, but not in others. It does not seem to stop the corrosion. I cannot say whether the trouble would have been obviated had the rods been tarred in the first place. Our superintendent has reported that his experience does not commend the present class of structure to him, beyond saying that I cannot express an opinion on the matter. He tells us that it would certainly be necessary in any future construction to bed the rods more deeply in the concrete. Up to the present our structure has not been damaged from collision of vessels, so we have no experience to describe to you in that connexion. The defects occur both in the beams and in the piles, and particularly at the junction of the beams and piles. Sometimes defects occur immediately below the junction. We have not located any trouble below the low-water level. The damage has occurred between wind and water principally. It is mostly on the upper portion of the piles. Neither the plastering nor the tarring methods of remedying these defects has been wholly satisfactory. So far as we have had any experience the damage has only occurred between the steel reinforcement rods and the outside section of the piles. John Alexander Stein, our superintendent, could answer any questions as to the technical part of the work. Our Harbour Board has the choice of material in the construction of the wharf. They submit their ideas to the Engineer for Harbours and Rivers, who has a final veto. If the board desired to build a wooden structure he would approve if *he thought it would meet the purposes intended.* When the Townsville Harbour Board chose concrete in preference to timber the idea was that there would be less *maintenance, and that it would be fireproof.* During the war period we had a shed on the concrete pier wholly destroyed by fire. If the wharf had been a timber *structure it would have been burnt right to the* water's level. We saved the cost of the wharf by reason of the fact that it was built of concrete. I would *not care to give an opinion as to whether concrete is* better than timber. We have both a wooden and a concrete structure here. The wooden structure is very *much older than the concrete structure. We have had* it in use now for over twenty years, and, naturally, the maintenance at present would be higher than that of a *structure built in 1913. One difficulty we have had* with the timber construction has been the deterioration in the quality of the muntz metal sheathing for the piles. We *experienced difficulty before the war,* and we have not been able to get satisfactory muntz metal since the war. We substituted naval brass with satisfactory results until quite recently. We found the naval brass to be better than the muntz metal, but our last consignment was not up to the standard of previous consignments. It appears that a *chemical action takes* place which destroys the material. The chemical action seems to set in after the metal comes into contact with the salt water. Some naval brass has been used with satisfactory results since 1908, but some that has been in use for a much shorter period has become defective. The muntz metal makers have not been able to explain satisfactorily the deterioration in the metal. Extensive inquiries have been made. I have read and heard the deterioration ascribed to the effects of the electrolytic extraction of the copper from the ore. Certain impurities are removed by the electrolytic process that seem to take away necessary elements from the life of the metal. Naval brass is practically muntz metal with 1 per cent. of tin added. On the whole naval brass proved satisfactory until quite recently. The change must have taken place in the metal itself, for the conditions here are unchanged.

46. *To Mr. Blakeley.*—The concrete wharf was constructed by day labour. Fresh water was used exclusively in the work. You will need to ask the superintendent for the cause of the troubles we have had. I do not feel that I ought to express any opinion on that matter. The piles have not been examined by a diver recently. There is no evidence near the low-water level of corrosion of the piles, and there is nothing to lead us to believe that corrosion has taken place under the water level. I do not consider it extraordinary that the trouble has occurred between wind and water. I understand that concrete can be made waterproof. Wherever unprotected wood is used in wharf construction the teredo becomes active. It enters sheathed piles where the brass becomes defective. We maintain a periodical inspection of our sheathing. When teredo activities are discovered the holes are cleaned out and fresh pieces of sheathing are put on the piles.

47. *To Senator Reid.*—Our first method of cleaning the defective steel reinforcement in the concrete wharf was to clean off the rods and replaster. The rust was scraped off. I think it was burnt off in some places. I was not present when the work was done. I have no idea to what extent the rods suffered. Our superintendent reports that the corrosion that has taken place has not affected the life of the structure seriously. Within twelve months of repair work in some places the concrete broke away again. The rust showed right through the new work in some instances, and the new work was broken away by the expansion of the steel due to the corrosion. The new patch burst away in the same way as the original section. The rods were then about 4 inches from the surface of the patch, but the corrosion still went on. In the piles as originally constructed the rods are 1¾ inches from the surface. We have put tar and red lead on the rods to try to prevent corrosion. We used boiled oil originally, and put the concrete over rods that were dressed with that, but it was not effective. We have never attempted to put cement on the top of the tarred patches. I will ascertain the capital cost of both the cement and the timber wharf, and the upkeep of both, and let you have the particulars. On some of the wooden sheathed piles the muntz metal has stood for over twenty years, and is still good, but in some instances coverings of muntz metal have failed within six months. So far as I know, the metal was applied under the same conditions, and it was supposed to be the same quality metal. The metal failed on the same structures and the same piles, and was put on by the same workmen. I do not think that the failure of the metal had anything to do with the local workmen or conditions. The complaints about the quality of the metal are general, and not limited to Townsville. We adopted naval brass in 1903, although some was used prior to 1900. We have instances where there is still life in the muntz metal, although it is nearly 30 years old. The naval brass has given us more satisfaction than the muntz metal. It was standing up to its work well when the muntz metal was failing. There is really no difference in the price of the two metals.

48. *To Senator Barnes.*—The Muntz Company supplied the metal from the United Kingdom. The metal that lasted for only six months was from the same people. We could peel some of the metal off with our fingers. If air and water can be excluded from concrete, rust can be prevented. In patching a defective portion we cut away the whole of the section that shows corrosion, and we work at the rods until we get the steel clean. I have had no experience of lead having been used as a protection for the steel. It is too technical a question for me to say whether it would be effective. We have used lead sheathing on buoys, but it soon becomes defective. It is bored into by some of the sea life.

49. *To Mr. Cook.*—I will ascertain how long the wharf was erected before we first noticed the defects in the concrete. Offhand, I should say it was about two or three years. We are continually getting information that the defects are still occurring. We had evidence of it in some sections of the wharf quite recently. Because the concrete patches continue to break away we have abandoned attempting to re-cover the rods with concrete. When defects occur now we simply cover the rods with tar immediately the rust is cleaned off, and if further rust occurs, as it does in some cases, the rods are cleaned and tarred again. I cannot say that the timber wharf is a very much better proposition. Our concrete structure has been in existence for too short a period to be able to fairly contrast it with timber In dressing the steel rods we use hot tar. Muntz metal has become defective in some cases, notwithstanding that it has come from the same firm and in the same consignment. We have brought the matter under the notice of the firm, but have had no satisfaction from them. The firm told us that it could guarantee the Kangaroo brand of metal, but the guarantee was not satisfactory. They stated that, provided the best tarred hair felt was used and only nails of their own manufacture, they could guarantee the metal for twelve months, and that if it lasted for twelve months no doubt it would last a great number of years. That was not a satisfactory guarantee. It appears that there is a defect in the component parts of the metal. The alloy is not correct.

50. *To Mr. Mackay.*—I have been secretary to the board since 1903. I am familiar with the early works of the harbour. Some of the work here was constructed by the Government before the board came into existence. The breakwater was so constructed, and is very effective in assisting shipping. They are purely breakwaters, and are not training walls. They are purely to protect ships against the action of the sea. We have built a massed concrete structure with satisfactory results. Our superintendent favours a mass concrete construction in preference to reinforced pile structures. In our mass construction we built a wall and filled it in with earth and other materials. We have in this harbour a wooden pile structure, a cement pile structure, and a mass concrete structure. The massed concrete is the best from the point of view of maintenance, but it is a quay wall as opposed to a pier. The conditions are not similar. The reinforced concrete structure was most expensive, but conditions are changing all the time. Our structures were not built under conditions that could be compared one with the other. One was built a long while before, and one was built immediately preceding the war. Either type of structure would be very much more expensive now. In the estimates furnished to us of the cost of a wooden structure as against a concrete structure there was not a great deal of difference. We have not had an inspection of the concrete piles below water level. We make regular inspections of the wooden piles. We keep a staff of men specially to maintain these structures. It is their duty to make regular inspections and make any necessary repairs. Repairs have been necessary to the wooden decking of the wooden wharf, on account of dry rot. The total expenditure of the Harbour Board on works and administration is about £1,500,000 since it was created in 1896. The breakwaters had been constructed, a small amount of dredging done, and a small wharf built previously. I suppose, taking in everything, the cost of the harbour here has been about £2,000,000. That would be a safe estimate. So far as facilities for handling ships are concerned, we claim that this port is as well equipped as any in Queensland. We can accommodate all the ships that are visiting this part of the world. The *Euripides*, of 15,000 tons, was here, and we had no difficulty with her. Our charges on cargo are 4s. a ton inward and 3s. a ton outward. These have been our charges for over twenty years, without variation. The berthing charge for steamers is ¾d. per ton per day based on the gross tonnage. We count the day as 24 hours from the time of arrival. Our berths at the wharf are dredged to 30 feet. At present the minimum depth available for navigation is 26 feet. The vessel of the biggest draught that has recently been in here was the *Tanda*. That had a draught of 26 ft. 10 in. The *Bombala* claim was for salvage. There was no trouble inside the port.

50A. *To Mr. Cook.*—Our revenue last year was £53,000. I have not worked out the percentage on our outlay. Our lowest revenue for the last five years was £42,000 in 1919, and the highest we have ever had was just under £62,000.

51. *To Senator Lynch.*—We have been getting our wooden piles from New South Wales. We are not able to get the length in local timber. I understand that our superintendent attributes the faults in the concrete work to the workmanship. At the same time, he has expressed the opinion that the reinforcing rods require to be more deeply bedded in the concrete. There should be a greater section of concrete round the steel. It needs to be watertight and airtight.

The witness withdrew.

Arthur H. Rolf, Works Manager, Swift (Australian) Meat Export Company Limited, Townsville, sworn and examined.

52. *To Senator Lynch.*—The temperature of our freezing rooms is held at zero. The meat is loaded into trucks from that temperature from our store-room and then taken to the jetty. Our procedure is to load a rake of eight trucks. We usually load from one to two, and at times even three at once. That meat leaves our works at 12 noon, and is on the jetty about 2 p.m. A start is then made to put it into the ships. We have made some tests on the loss of temperature from the time the meat leaves our store until it is in the ship's hold. I cannot quote the particulars of those tests offhand, but I can get the information by referring to our records. Two classes of trucks are used. One class has a raised roof, giving an aired space between the ceiling and the roof of the truck. That is not insulated. We found that that truck had a tendency to soften the meat considerably quicker than the other type. The other type is closed in, and has no air space at the top. I am referring now to State railway trucks. We have no trucks of our own; we use the State trucks exclusively. There has been no rejection of our meat to speak of owing to loss of temperature. In some cases, when meat has been out of the chamber unduly long it has been rejected by the ship. The cause of the rejection was solely the inordinate length of time the meat was in the open. The average time occupied in getting our meat from the store to the ship's hold is twelve hours, but meat has been out as long as 30 to 50 hours and has still been accepted by the ship. That was in July or August—during the winter here. Perhaps the average time our meat is out would be from twelve to eighteen hours. Our works are 21 miles from the jetty. It is not the practice of our company to pre-cool the trucks before use. We never pre-cool trucks. We have made complaints to the Government about these raised-roof trucks, but we have not complained about the other type, which suit us very well. So far as I know, our experience is the same as that of the other meat companies here. The truck with the bungalow type of roof is not a suitable one. Perhaps I should say that it is not exactly unsuitable, but that a bigger risk is taken by putting meat into that type of truck. We had one rejection of 47 hindquarters during the whole of last season. That was during a period when the men were working only eight hours a day on the jetty. That would not have occurred had they been working continuously as they usually do. That meat was out of the cool chambers an undue length of time, and it softened a little on the roast end. We hold the ships responsible for the good delivery of our meat. It is their business to see that it is properly received here. I do not know the exact temperature at which they are supposed to take meat, but it is generally understood that they will take meat up to 20 degrees at the bone or less. They will not take it over that. We have had no trouble about the floors of trucks. Our trucks all have wooden floors; none is lined with zinc. My opinion is that the zinc flooring would not be as satisfactory as the wooden flooring, for zinc would be a heat conductor. I do not think that meat which had been in trucks of the type we use here for eight hours would be rejected by the ship. We would not expect any trouble if the meat had only been eight hours out, provided that it started with the temperature of zero. A lot depends upon the temperature of the meat when it is loaded into the truck. I make a sharp distinction between the temperature of the meat taken from the stores and the temperature of the stores themselves. The temperature of the meat is the vital point. The difference in the temperature of the meat at the bone and the temperature of the stores—that is, if the meat has been in the stores for a reasonable length of time, say two or three weeks—is from 3 to 7 degrees. If the stores are at zero hindquarters which had been in the store for two or three weeks would register a temperature from 3 to 7 degrees above zero. We have had meat put into the ship with a bone temperature of 20 degrees. I think that is quite the maximum temperature recognized by the ship, although I do not know of any rule on the subject. We have never found it necessary to load meat in the night-time. We do the majority of our loading during the day-time at all seasons of the year. The only time when we load at night is when it is actually necessary to get the work done.

53. *To Mr. Cook.*—I have never been to Darwin

54. *To Senator Reid.*—Our trucks will hold an average of 10 tons of frozen meat. I have no idea what they are insulated with.

The witness withdrew.

Robert Patterson Kirk, Shipping Manager, Burns, Philp Company, Townsville, sworn and examined.

55. *To Senator Lynch.*—The regular custom here for steamers loading large quantities of beef is to work the hatches of the ship continuously night and day. It is necessary sometimes to load meat at night-time to get the ship dispatched, but never necessary for the safety of the meat. If the steamer is not in a hurry we do not work at night. We only arrange for sufficient meat to come down to carry on for the day. I do not think it should be necessary at Darwin to load meat in the night-time. A great deal depends upon the class of ship that is loading the beef, whether the refrigeration is by direct expansion or cold blast If it is an old-fashioned ship they might require to load the meat at night-time. Although I have never been to Darwin, I do not think, from what I have heard of it, that there is much difference between Darwin and Townsville. They are both good climates. The ship's engineer stands by and tests the beef as it comes along. If there is any dispute as to the hardness of the meat they bore into it and take the bone temperature. The first test is a skewer test. If doubts arise from that test then a thermometer test is applied. I have seen beef go in with a bone temperature of 20 degrees. They may take the beef with a higher temperature than that, but I have never seen it accepted. The general understanding is that the beef must be 20 degrees or less, not more. I have known meat to be in the trucks 50 hours. That was in February. The meat was not injured, and was accepted by the ship. That was during the war period. The meat on that occasion was slightly soft, but it could not be said that it was unsafe to ship. At any rate, it was accepted by the ship. It was a bit soft on the flank. I agree with the evidence that has been given by the previous witness as to the type of trucks. I condemn what is called the double-decked trucks as being unfit for meat. The other type is very much more preferable.

(Taken at Cairns.)

TUESDAY, 31st MARCH, 1925

Present:

Senator LYNCH, in the Chair;

Senator Barnes	Mr. Cook
Senator Reid	Mr. Jackson
Mr. Blakeley	Mr. Mackay.

Charles Norton Boult, Civil Engineer in charge of the Cairns Harbour Works, sworn and examined.

56. *To Senator Lynch.*—My experience in wharf construction has extended over 21 years, but it has not been limited to concrete construction. Reinforced concrete was not used in this State 21 years ago. Twenty-one years ago I was in Auckland, and was engaged as a contractor's engineer. I was working on the first concrete wharf in New Zealand. It was not the same wharf which was concerned in an accident lately. The wharf which has been damaged had a pile front, with loose material banked up against it, and a sloping bottom. That is one of the great problems which wharf builders have to face. It is more strictly a modified quay wharf. I cannot say what is the state of preservation of the wharf at Auckland on which I was working. Factors which led to the adoption of the concrete wharf in Queensland were the damage caused by teredo in timber wharfs, and the deterioration in the quality of muntz metal. I think those factors may be said to have weighed equally with the Queensland Government when it decided to swing over from timber to concrete. The first principle of wharf construction is that the design must meet the situation. Concrete wharfs must be built so that the thrust of vessels is not taken up in any way by bending the piles. You must not bend the piles in any way. If you have a ship berthing right against the wharf you tend to push it over Even if you have the piles braced for 10 feet down you may have 30 feet unbraced, and there is a tendency to bend the piles at the ground. In no circumstances must concrete wharfs be built so that the thrust of vessels is taken up by the bending of the piles. This is vital to concrete work in my opinion, when the work is in contact with salt water. You will always get a certain amount of bending of the columns due to earth pressure and other things, but that heavy thrust of vessels must be eliminated, otherwise concrete will crack. Then you will get the work absorbing ozone from the sea. The deterioration in the concrete is due to it absorbing ozone. If there is a fracture in the wharf the ozone will get in and cause oxidization, which will make the concrete burst Ozone is due to evaporation, and it is that which causes the rust. It is not the salt water. There has never been any trouble where the concrete wharfs are always wet. It is only where the wharf is wet and dry alternately that the rust occurs. The plain fact is that air must be excluded. The next principle of successful wharf construction is that the concrete must be made absolutely impervious. Not only must the quality of the mixture be right, but there must be a sufficient covering of it over the reinforcement rods. That is absolutely necessary. I have used a mixture for concrete which comes into contact with sea water as rich as 3 to 1—1½ sand, 1½ metal, and 1 cement by volume. I arrived at that proportion by watching the deterioration that has gone on. The poorest mixture I have used is 5 to 1. I would not make it richer than 3 to 1. To do so would be to invite ill effects. A richer mixture than that would tend to crack. A rich concrete always tends to crack. The proportions of material that should be used in concrete depend upon the position the work is to occupy. I have altered proportions during a day's work. A number of circumstances enter into the situation, and I feel that practical experience is necessary

to settle the nature of the mixture. The great object is to ensure that there are no flaws in the work. If they occur you have to cut the work out and fill it in again. There can be no half way. In reinforced concrete work it is essential that every bar must be in its right place, and every bar must have a sufficient covering of concrete. Every bar must be the proper distance from the timber casing. The work is too important to leave to a ganger. The ganger has not yet been made who is sufficiently capable to attend to this important work himself. The work has to be supervised by a trained engineer. It must be under trained observation all the time the mixture is in hand. The weaknesses in concrete structures in this State I set down largely to the fact that the mixtures originally made were not made rich enough; and secondly, that the bars were not sufficiently covered in those parts of the wharf in which the most danger occurs, that is, between high tide at neap and high tide at springs. The minimum cover I used in the first wharf I built was 1½ inches. That proved to be not enough. I used 2 inches, and that was not enough. I then used 2½ inches. I do not know whether that is enough or not. That work is still under observation. In future wharfs I am going to use a minimum covering of 3 inches in piles 20 by 20 inches. I would make the piles 24 in. by 24 in. if I could handle them. In this last structure I hope the weaknesses of the earlier structures have been overcome. In our last structure I believe we have come so near to freedom from trouble that the smaller faults that may occur will not matter very much. It does not matter how careful you are in building a concrete structure, you will not get perfect work. You can guard against abnormal strains by boats bumping them. You may get a small amount of trouble on that score, but it would only be a small percentage on the cost of the wharf. As a commercial proposition, a concrete wharf is the only thing to build. The matter must be looked at from an economic aspect. I have not lost faith in a concrete construction. Its most marked weakness is in allowing the bars of iron in the concrete to come into contact with air and water between wind and water. There should be 3 inches of concrete covering the bars. It is where the water comes up and goes down again and dries out of the concrete that the trouble occurs. Above water damage is easy to get at. The bars, even when they corrode in such a position, owing to insufficient covering, do not cost very much to clean, and ought to last afterwards for five or six years without more attention. Seeing that the damage is all above water, and the repairs are fairly easy, the domage is really not so serious. I do not know Darwin from personal experience. I am aware that there are high tides there. From the plans and particulars you have given me, it appears that concrete piles for a wharf there would need to be 70 feet before you reach your foundation. I have seen the plans. It appeared to me there was no support for piles; no natural support I mean. You simply have the piles standing on almost bare rock. I cannot possibly say without a great deal of consideration what I would build at Darwin. Our position here is not the same as the position at Darwin. I will say this though, that timber is impossible. It cannot be considered. The muntz metal that we get in these days simply falls off the piles. I consider that the Gladstone structure is almost the finest in Australia. They have cast-iron cylinders on the wooden jetty there. I believe this wharf cost 24s. a square foot when that structure was built. It would probably cost £4 to-day. It is proposed to build an additional wharf here 88 x 400 feet. The piles will be 55 feet long. It will cost, including plant, about £80,000. The piles will cost about 26s. a foot; that is a good price. It will be a very heavy wharf. The actual concrete work on the wharf will cost about £60,000. The cost of cast-iron piles and wrought-iron girders would be very much heavier. I should think such a wharf would cost about £4 a square foot.

56A. *To Mr. Mackay.*—I do not know anything about the wharf at Bowen. I know the conditions at Gladstone. The concrete wharf there that is deteriorating so much was built by a contractor. He was a German, and used almost entirely very dirty gravel. The material was inferior, particularly the sand and gravel, and there was no proper supervision at all, I understand. I believe sea water was used. I use fresh water. I think the trouble with that wharf is entirely a matter of bad material. I also think that the wharf is narrow, possibly too narrow. It is only 40 feet wide, and there is a heavy current running there. It gets some very heavy blows. I do not think the design was adapted to the place. Mass concrete is the only proper and permanent form of wharf building. The trouble is the great expense. Another factor that must be considered when contemplating the building of a mass concrete wharf is that the time of building would be so long that trade would pass by, and it would probably be lost by the time the wharf was ready for it. I went very carefully into the matter with the idea of having a mass wharf here. The time of building and the expense would have been enormous. It is, however, the only genuine form of wharf to build. There is a depth of 26 feet at low tide here. The rise of our tide is 10 feet. I believe in raker piles, for the raker piles take the thrust. If you have raker piles the thrust of the vessel goes right to the earth. The Darwin proposition is a very difficult one, and I would need months to consider it before I could express an opinion. Caissons are the only method of building concrete in place. It is really another method of mass construction. My experience would rule out a wooden structure altogether. I think a concrete wharf is the best substitute within reasonable money. The mixture I use in my work is arrived at by my experience. I am very chary at building anything in sea water, and it is only with the utmost supervision that you can get success. You have to have men who are above suspicion. I have not yet had a foreman sufficiently intelligent to watch concrete all the time. You must have an engineer with wide experience watching the work. Men who have been engaged in concrete work for ten years would probably have a different opinion on matters to-day compared with their views ten years ago. In about twenty years the Harbours and Rivers Department has constructed four or five wharfs. They have been watching the work carefully, and using their own judgment. I have had no one to talk to about the concrete work in which I have been engaged. I have had to exercise my own judgment. There has been an attempt on the part of the Institute of Engineers to get together all the information worth having on this subject, for it is a universal matter. I do not know what conclusions have been arrived at. It is only engineers who have a lot of time on their hands who can find opportunity to send in their experience. The trade here is somewhat similar to that of Townsville. They have nearly twice as much as we have. We have very serious congestion here. We contemplate making further concrete extensions down the river.

57. *To Senator Barnes.*—The life of concrete work is not yet known. Concrete work in sea water is always doubtful. Although a concrete wharf had been standing for 50 years I should regard it as being still in the experimental stage. In ten years' time engineers will be much wiser than they are now. If you have timber piles you cannot use a concrete decking. If you have concrete underneath you must have concrete on top, because you have to guard against movement of the timber top. Concrete is desirable in my opinion because of the absence of maintenance cost compared with timber. If a concrete wharf wears down you can cover it with bituminous concrete, which is the hardest and most wearing surface in the world. The nature of the traffic on the wharf depends entirely upon the kind of trade that is done. I consider that the use of rubber-wheeled trucks on wharfs would be a great advantage, and would tend to reduce the wear and tear on the decking. It is cheap enough to have rubber vulcanized on the wheels, and renders waterside work less arduous. The trucks would be appreciated by the workers. I know that, because I had a couple of rubber-wheeled trucks here, and the men used to "plant" them overnight to be sure of getting the same truck the next morning. Rubber trucks would also obviate a great deal of the noise that renders wharf work so unpleasant. With rubber-tyred trucks wharf work would become comparatively quiet and noiseless. I was responsible for the new wharf which we are proposing to build here. It will be 400 feet long by 84 feet wide. I get the sand necessary for my concrete work from the rivers in the neighbourhood, or sometimes from the beaches. I obtain both the broken metal and the gravel locally. I suppose the longest distance we have to cart any of our material is 25 miles. I know there are other wharfs which are better served in respect to material, but I would not regard 25 miles as being a serious matter.

58. *To Senator Reid.*—I was here regularly between 1908 and 1912, then I was away, and I have been here for the last three years. I designed and built the first wharf here. Generally speaking, considering the excessive loads it has had, and the excessive size of the vessels, I think it has come out very well. Deterioration has taken place in the piles in the small area inspected. Provided a small sum were spent on maintenance, to cut out the parts affected, the wharf is absolutely intact, and has not deteriorated. The weakness at the head of the piles is due to surface water which is highly charged with ozone coming in contact with them, and then when the high tide passes, drying out. The water gets into a few minute pores and then dries out. Unless you keep the ozone out you will have rust. Theoretically the joint at the heads of the piles is a weakness, but practically I do not think it is. The trouble in the beams has been caused by bad workmanship, I believe. I have not found trouble in well-constructed beams. The bars in those days were placed in some cases 1 inch apart. But you cannot be absolutely sure that you get the concrete thoroughly around them when they are so placed. Nowadays we use bigger bars, take more space, and work the concrete right round them. I believe that the concrete piles will last if the bars are properly covered, but only time will definitely prove it. In colder waters the wharfs stand well, but in hotter waters there is a more violent chemical action, and ozone is drawn through the concrete to the steel. There is absorption even in a granite wall. It is where the water goes in and out that trouble arises. I have not found any deterioration of the work in beams in the salt water except where there has been bad work. The trouble occurs between wind and water. I would never use salt water again in mixing concrete. Although it does not seem to make any difference I would never risk it. I prefer fresh water. Our piles are, on the average, 42 feet from the ground up, and about 36 feet from the bottom of the beams. Our piles have not been affected by bumping of ships. The thrust is taken up by the ground at the back. I do not think diagonal bracing would be of any use, for they would only be shifting the trouble further down. Bracing a concrete wharf only transfers the trouble to some place where you cannot see it. I cannot express an opinion as to whether raker piles would suit Darwin. A solid wall job is the best you can get. There is nothing equal to it. It is a question of price.

59. *To Mr. Cook.*—I prefer solid walls before anything else. It is only the cost of such a wharf that would stop me from constructing it. Filling in from the back costs an enormous amount. I would not use a hill even if it were here. I would regard it as being too expensive. Here I would have earth for nothing from the dredger. I desired to build a solid wall here, but could not on account of the cost. The existing wharf is 1,500 feet by 90 feet. It cost £130,000. Some of it was built before the war. I do not think that you can use timber unless you are working in fresh water. Timber, of course, is much cheaper than concrete. I have never built timber wharfs here, but I have elsewhere. If I wanted to build an ironbark structure, I would have to get the timber from New South Wales. I think I could land very good timber piles here for 7s. a running foot. Then, of course, I should have to copper them. A first class concrete pile would cost 25s. a foot. My relative prices here are 7s. for timber and 25s. for good concrete piles. I recently had an engineer here from England, who stated that 16s. or 17s. a foot was the cost of concrete piles in England. That would be for a smaller section than mine. Cement is half the price there, and labour is half the price. I cannot tell you what muntz metal would cost for timber piles. A very approximate estimate would probably be 7s. a foot. Our accommodation for loading here is far superior to what it was three years ago. We now have railway lines on the wharf, which saves £2,000 or £3,000 per annum in waterside labour. We have no record of loading or handling costs or freight charges. Bringing the railway on to the wharf has done away with a lot of waterside labour. That must result in reduced costs. For making concrete piles all material must be first class, and the reinforcing bars must be covered by at least 3 inches of concrete. I would not make any piles less than 20 inches in diameter, and if material were reasonable, I would make them even larger. I prefer gravel for concrete, but if gravel is not available I would use broken metal. I prefer slate or hard gravel. It must be perfectly clean and well graded. There are excellent scientific methods now for estimating the quality of gravel, although I never use them. I am giving you my own experience and judgment. The scientific methods are only used in big laboratories. There is no gravel in this district nearer than 40 miles good enough for making piles, but broken metal can always be used as a substitute. I have not seen the Bowen metal. Any hard stone will make metal good enough for concrete, but the best available should be obtained. You must get well-graded stone. I do not think teredo will attack a concrete pile. I have not seen any sign of animal life attacking concrete piles in these waters. I have heard that there is a crab in the West Indies that eats right through concrete. I consider that a perfect concrete job could be obtained with expert experience and supervision. An engineer may be an excellent railway engineer or sewerage engineer, but if you were to start him driving concrete piles he might do a great deal of damage. He might make good piles, but he certainly would not overcome minor troubles that only practical experience could solve. I have never driven any piles over 65 feet. Providing that the diameter of the pile is increased, I think piles could be driven up to 75 feet with gear properly designed to handle them. I never lift concrete piles with rope slings. I use a beam and lay the pile on it. The pile is fastened to the beam to eliminate the sag as far as possible. I would recommend absolute insistence on cork fenders on all boats berthing at these wharfs. The boats should be compelled to have them. There is a wonderful amount of resilience in cork.

60. *To Mr. Blakeley.*—I have only just started using naval brass. It was recommended by the Harbours and Rivers Department. Deterioration in muntz metal is assigned to the electrolytic method as against the smelting method of treating copper. If all the noble metals are taken out of the copper it becomes brittle, whereas the slightest trace of noble metal will make it more ductile. Four years after muntz metal has been on the pile you can tear it off. I got some naval brass worked up by the plumbers, and they told me it was more brittle than muntz metal. The moulds that are used in concrete work must be absolutely clean. In mixing concrete perfect work is necessary, and it must be done by a measure in every case. Your rammers must be men specially picked, and if they do their duty they are the hardest worked men on the job. The concrete

must be *in such condition that it will* flow readily. It must be worked *from top to bottom*. *Every* bar must be well away from its neighbour, and the rammers must have rammers that will scrape every portion of every bar to ensure that there are no air bubbles. The whole mass must be stirred up and down until it is just like cream. I hand-pack my piles. The vibratory method of packing is new to me. The principle of it seems sound. I should think a great deal about making piles under pressure if it were possible. It makes very fine concrete. I do not know that the vibratory method would improve the concrete very much. Our repair patching is done here by hand application. When the signs of rust or cracking are noticed men gad the concrete out and clean the bars. They use a chipping hammer and steel brush to clean the bars. The place is then washed out *carefully*, and carefully plastered with a two to *one mixture*. You cannot use pressure in work *of that kind*. The men work off a floating punt. I have used sheet piling very considerably. For a retaining wall behind a wharf they are all right, providing proper stresses are not exceeded. I cannot suggest anything to obviate the ozone difficulty. The only thing that has occurred to me is to increase the thickness of the concrete. I repeat that the quality of the work must be there Cast-iron sleeves down the piles for a distance might be employed very profitably

61. *To Mr. Jackson.*—There is hand shunting on this wharf. If there is a lot of moving to be done the men push the trucks about. The men here often shunt full trucks. I have not examined the site of the proposed Darwin wharf, nor do I know the exact materials it is proposed to use in its construction. Provided that a mass wall is suitably designed and properly built, I do not think that there is any wharf of any type that can be compared with it. It is a perfect wharf. It is the only type of wharf, where money is no object. The plumber who handled the naval brass for me told me it was much more difficult to work than muntz metal. He used 22-oz. metal.

62. *To Senator Lynch.*—The caisson method is only another method of constructing a solid wall. It is really a solid wall. I have seen it adopted in other parts of the world where I have been. I read all the records that I am able to obtain respecting the types of wharf and methods of construction. The only possible flaw in the caisson method of construction is that the concrete sometimes goes to pieces in sea water. There was a strict specification at one time against the presence of magnesium. In Europe they usually face solid wharf constructions with stone, which makes a lasting job.

63. *To Mr. Blakeley.*—I know that a big crack has developed in the Burns, Philp wall in Townsville. The wall was built about eleven years ago. I cannot say what is the cause of the trouble. Probably it was poor design.

(*Taken at Brisbane.*)

MONDAY, 6TH APRIL, 1925.

Present:

Senator LYNCH, in the Chair;

Senator Barnes	Mr. Cook
Senator Reid	Mr. Jackson
Mr. Blakeley	Mr. Mackay.

Edward Alexander Cullen, Engineer for Harbours and Rivers, Queensland Government, sworn and examined.

64. *To Senator Lynch.*—I have had a good deal of experience in the construction of wharfs, and since occupying my present position I have been responsible for the construction of all the Government work. A good many Harbour Board wharfs have been built since 1901. I have adopted concrete for wharf construction very largely, but not exclusively. The reason for changing over from timber to concrete was our failure to protect timber against the ravages of insect activities due to the failure of the metal sheathing we had been receiving. It was successful up to about twenty years ago. We considered that whatever was the additional cost incurred in building a concrete wharf as compared with a wooden wharf, it would be compensated by the longer life of the concrete structure. Basing my estimate on the cost of a concrete job we completed last year, and a timber structure now in the course of construction in the same place, I should say that concrete costs 33 per cent. more than timber. Both were first-class structures suitable for ocean-going ships. Those are Brisbane prices The increased cost of the concrete wharf is more than compensated for by the greater permanence of the structure as compared with wood, in my opinion Concrete takes much longer to construct than timber, and altogether involves more work. I cannot say definitely how much longer concrete takes in construction than timber. The life of a timber structure, if everything is good and favorable, might be set down as 25 years. We have not yet had sufficient experience of concrete structures to say how long their life is. I cannot say how much longer concrete will last than timber. For the proper construction of a concrete wharf I should say that the principal condition, and a condition of vital importance, is that the constructing engineer should be thoroughly conversant with and have experience in concrete construction, both practically and theoretically. Practical experience is more important than anything else. A good wharf can be designed by any practical engineer. There is no difficulty about designing. Successful concrete construction requires that the man in charge shall have a thorough experience of the best methods of mixing concrete, and shall thoroughly supervise the work to see that the concrete is made impervious to air and moisture. I think I have there stated the essence of successful reinforced construction. The design may be perfect, but if the construction is faulty, in two or three years the structure will begin to decay through corrosion of the steel. To mix cement concrete in such a way as to make an impervious preparation, which is the secret of success, requires particular knowledge on the part of the engineer. I should say that the success of the work depends entirely on the constructional engineer. Workmanship is, of course, of great importance. It is comparatively easy to provide that materials shall be all right. Steel is bought subject to test, and other materials can be properly tested. With proper material, design, and workmanship, I think only minor weaknesses may be looked for, and they can be easily dealt with. They would become an ordinary maintenance charge. The scaling off of material would not weaken the structure provided that the corrosion of the steel is not permitted to go too far. A wharf constructed in the way I have stated, and subject to a careful watch, would be practically a permanent structure. That is my opinion. Those portions of the structure in the vicinity of high water, and a little below high water, are apparently the most likely to suffer. My experience is that the portions of the concrete wharf below mean sea level do not suffer at all, given ordinary good work. I attribute that to the fact that marine growths exclude the air, hence corrosion of the steel does not take place. The greatest damage is done about the line of high-water level. We have a rise and fall of from 5 feet to 20 feet on the Queensland const. We have no concrete wharf subject to a rise of 20 feet. Our maximum rise where there is concrete would be 12 feet. We have a 20-ft. rise at Mackay. They have a 22-ft. rise at springs at Flat Top Island. That is our maximum on the coast where there is any traffic. At Broad Sound we have a rise of from 33 to 36 feet. There is no traffic there. The variations in the tide do not increase the injury to the piles along the coast line. The damage is just the same in those parts where the rise is great as in those where it is

small. The tidal rise is not a factor that will bear upon the durability of the structure. I am not personally acquainted with the caisson type of structure, but, speaking very generally, I think it has a great deal to recommend it. But it costs so very much more than pile construction that it is a luxury that I have never been able to contemplate in Queensland. We have passed it by because it costs more than we can afford. At Antwerp and on the Scheldt River it has been adopted successfully. Zeebrugge is another place that comes to my mind. The only American and English experience I have is from reading. I have no idea of the relative cost of the caisson method as compared with the ordinary pile method. My general impression is that it is much more costly than a pile structure.

65. *To Mr. Jackson.*—The circumstances of a place like Darwin, with a 26-ft. rise and fall, would not make the use of a caisson method absolutely necessary or indispensable. Darwin, it appears, would require a pile 75 feet long. That is not an immense pile although it is a big one. I have heard that they have used piles 90 feet and 100 feet long at Auckland, New Zealand. It is within my knowledge that the timber wharf here in Brisbane, at which the Orient and other large ships berth, is built on timber piles 105 feet long. That length is necessitated by bad ground. The piles were spliced. It is not inherently impossible to use piles 70 or 80 feet long, but their use would necessarily mean a more costly job. The gear must be heavier, the pile-driver larger, the winch stronger, and the monkey heavier. All these factors bear on the problem. There is nothing impossible in a pile of that length, however. The rise of 26 feet at Darwin would be a matter of some difficulty. In British ports where there is a rise of 30 feet or more the practice has been to put the ships in dock to handle the cargo. There are what are commonly called wet docks. That is how the British engineers have met the difficulty of such a big rise. That is the method at Liverpool, and at all the Bristol Channel ports, Avonmouth, Cardiff, and so on. My opinion, for what it is worth, is that the caisson type of structure has many advantages owing to its permanence, and that practically there should be no maintenance with it. The preference that engineers have shown for pile construction is a preference for the cheaper and quicker job. I think, rather than for the class of job.

66. *To Mr. Mackay.*—I have never been to Darwin, and to give any definite opinion on the plans would require an intimate knowledge of the local circumstances as well as a good deal of study. I am familiar with the concrete constructions on the Queensland coast. The Bowen structure is a little more than half completed. We have not got our costs out for it yet. It is being built by day labour. My original estimate was £70,000, but it has cost approximately £100,000. The time for its completion has been nearly doubled. It may cost another £15,000. That is only an expression of my opinion. The physical difficulties of the situation are considerable, but we anticipated them. Our main difficulty has been with labour. The mass concrete wharf at Townsville was founded on caissons, but was very costly. The concrete used in the first part of the Gladstone wharf was not mixed with salt water. To use salt water would be considered a very serious fault in these days. The Admiralty have recently prohibited the use of salt water in all classes of concrete work. I am now using 2 inches of cover for the reinforcing rods in my concrete work. My minimum pile has a 15-in. section. We have used 15-in., 18-in., and 20-in. sections. The larger the construction is, the bigger we make the pile. They are all solid piles.

67. *To Mr. Jackson.*—A 75-ft. pile would not be very expensive to make. The cost per cubic foot of pile would be the same for a 75-ft. pile as for any other length. There is increased risk in handling; the greater the length of the pile. That is where the value would be of having a practical and skilled man in charge. Given the proper experience and skill the risk is easily overcome. If you are using a pile up to 75 feet long with four points of suspension, there is no risk of bending or cracking. If the caisson construction costs 30 per cent. more than the pile construction, I would say, spend the 30 per cent. more.

68. *To Mr. Blakeley.*—I have recently visited the wharfs at Bowen, Gladstone, and Cairns. I have noticed the faults on the transverse beams between wind and water. Practically all the wharfs of this class have been built to my design, and under my direction, more or less direct. Bowen and Gladstone are directly under myself. Where corrosion has occurred, the only remedy for weakness that we have devised is to cut away the defective part of the concrete, clean the steel bar, and plaster it over with new concrete. About two years after we had done that at both Bowen and Gladstone the same faults developed again. Casting about for a better method of remedying the defects, I decided to obtain a cement gun—I only got it last year—and we have not had the work that it has done under observation sufficiently long to enable us to form an opinion of its value. So far as it has gone I have been favorably impressed. I think we have found a remedy. In practice, new concrete, if it is properly applied to the old surface and the old surface has been thoroughly cleaned and scraped and is then washed with cement before the new mortar is applied, should adhere all right I think there is enough evidence to warrant one in saying that concrete wharfs will last. How long they will last I cannot say, but they will certainly last twice as long as timber wharfs, in my opinion. The only reason that I can give for the breaking away of the cement is that the steel was not sufficiently protected from the salt air and water. I think the faults were due to bad work and poor material If the air and water get to the steel it will corrode A covering of 2 inches of concrete as against 1 inch simply means that we have a better change of excluding the air. There is no merit in the depth of cover *per se*. It is merely that 2 inches gives a better chance of excluding air and water Our experience, so far as it has gone, is that given good workmanship 2 inches of covering is adequate. There is no guarantee that 6 inches of covering would be impervious If there is not proper workmanship no depth of covering would be sufficient. We are more insistent now than we were formerly that the packing of the moulds shall be carefully done. We are very insistent now in packing, grading, and testing. We test the mixture now. I do not think there is any warrant for saying that ozone is bad for concrete. Where the concrete is at fault from sea action I think bad workmanship, bad material, or bad supervision is really the cause. We have only used the hand packing method in Queensland. I know they are using the vibratory method in Western Australia. I rather like it. The only application I would make of the vibratory method would be in constructing piles. Our piles for the jobs that we now have in hand were constructed long ago. They are all driven now. If the size of any new job warranted it I would be inclined to adopt that method of pile making. The tapping of the concrete is just an idea of some of the men or the foreman at Bowen. It is not an instruction of mine.

69. *To Senator Reid.*—I prefer concrete wharfs to timber wharfs on the ground of durability, and also because they are free from insect activities. A timber structure must fail sooner or later, possibly in twenty year, or even in a much shorter time, from the operations of insect fungus, dry rot, or white ant. The concrete wharf is free from all these things. Apart from that, given first class workmanship the life of the concrete structure is indefinite compared with that of the timber wharf. Maintenance work on timber structures may be said to begin five years after the completion of the job, and to continue as long as the structure is in use. Whatever the cost of concrete may be, the life of the wharf is sufficient to pay for it in my opinion. It is of more value to the community than a timber wharf would be. We were forced to adopt concrete, because we could not protect timber piles from teredo and other insects due to the failure of muntz metal sheathing,

which, until twenty years ago had been quite effective. The metal has failed for some obscure reason all over the world. There are one or two instances in different parts of the world of small mollusc attacking concrete, but to such a limited extent as to be practically negligible. The Institute of Civil Engineers in London some years ago appointed a committee to investigate the deterioration of structures in sea water. I am corresponding member of the committee. I have been making tests for four or five years here. The committee has issued three or four interim reports up to date. They have received reports from various parts of the Empire, and I think in only two instances has reference been made to mollusc attacking mass concrete. There are some mollusc that bore into rock. We removed a quantity of basalt impregnated with ironstone from the Brisbane River some years ago, and we found evidences of mollusc in it. At Naples some of the marble buildings which have been submerged for 200 years have been attacked by mollusc, but not to any great extent. I am not aware there is any need whatever for apprehension respecting marine insects attacking concrete. The insects appear to have a little auger-like head, and it is supposed that the fish secretes acid which helps the boring. The only instances I know of insects attacking rock are that which I have mentioned in the Brisbane River, which is slightly tropical, and that in the Bay of Naples, which is extra tropical. If the rust that appears in the steel bars in the concrete work were neglected the steel would disappear in time, but it would take a long time. After seven or eight years of corrosion the steel bars in the old part of the Bowen Jetty were reduced from $\frac{5}{8}$ inch to $\frac{3}{8}$ inch. The thickness of concrete covering around those bars was $1\frac{1}{2}$ inches. You cannot resist the operation of rust. It has a tremendous lifting power. It will lift, as we have seen it frequently do, a steel plate under a 3-in. timber decking fastened down with bolts. I suppose a metallurgical chemist could tell you why rust lifts. It is surprising how rust will scale off. A sheet of steel the thickness of a piece of blotting-paper will produce rust $\frac{1}{4}$ of an inch thick. The iron becomes converted into oxide of iron, and takes on from 10, 20, and even to 50 times its previous volume. The bursting effect of rust is enormous. I am making some experiments for the committee, of which I spoke, to see whether the action of rust can be counteracted. I suppose many engineers have tried to discover that. I built a small concrete wharf here seven or eight years ago, which I tarred when it was built, and gave another coat twelve months later. So far it has been successful. I cannot say whether the success is due to the tar. It is quite possible that the concrete was impervious on account of good work. I designed the Bowen wharf. It is the last one we built, and we put all we knew into it If financial considerations were not the controlling factor in Darwin, I should say build the solid wharf. I am not familiar with Darwin. I do not understand the silt question, for instance. We have never used caissons in Queensland. I have never had enough money for it.

70. *To Mr. Cook.*—The Muntz Metal Company management has not been able satisfactorily to explain the reason for the deterioration in muntz metal. One of their managing directors told me some time ago that there was a large reward available for any one who could solve the problem. Their chemists and metallurgists have been puzzled over it for twenty years. The sheathing of wharf piles is a minor matter. There is a more serious effect when the metal is used for condenser tubes in men o' war. We cannot say definitely whether the electrolytic process is the cause of it. I have been using, in the last few years, some sheathing made from fire-refined copper. The mixture contains 1 per cent. of tin. It has given us good results, but not as good as we formerly got. There would be no harm in offering a prize for the production of an effective sheathing, for I do not think it would ever be claimed. I am also using another method of protecting piles. It is a form of Hume spun pipes. That is at Mourilyan Harbour, 900 miles north of Brisbane. They are being used on a large private wharf in Brisbane, which is being built for the Blue Funnel Company. I think they promise well, but I cannot say definitely. Their cost is about the same as muntz metal sheathing. Even if the sheathing is effective I do not know that I would favour wood. In wooden construction, where there is any considerable traffic, you have to begin renewing your deck after two years. You also have to renew some of the beams. You never stop working on a timber structure after five years. With a concrete structure your maintenance cost is very slight indeed, given good workmanship. Concrete makes a very economical structure. I do not think that a greater thickness than 2 inches of concrete around the reinforcement rods would be any advantage. Given good workmanship and good materials, 2 inches of covering should be sufficient. There were some physical difficulties to overcome in the Bowen work, but I took those into consideration in my estimates. Had the conditions of twenty years ago obtained now, we should have constructed that work at, or about the estimate. It will probably cost from £115,000 to £120,000 by the time it is finished. I am solely responsible for it. Whether the trade around the district will be sufficient to warrant such a structure was a question of policy on which I was not asked to express an opinion. The Government possesses a coal mine 55 miles by rail from Bowen, and it is hoped that an export trade will develop which will warrant the construction of this wharf. With greater facilities for loading there will be, of course, much less labour required on the wharf. Better loading facilities should reduce costs. If the ground is firm at Darwin the piles should not need to be driven more than 15 feet. I use piles of 15-in. sections up to 50 feet long, and 16-in. sections up to 56 feet long. I have not had occasion to use any piles longer than 56 or 58 feet. If I had to use piles of 75 feet long I would probably use at least a 20-in section. I am using 20-in. piles at Bowen not on account of the length, but on account of the coaling crane. The inside piles at Bowen are 18 inches, and the outside piles that carry the crane are 20 inches. I think I could get timber piles in place for a wooden wharf at about 10s. per lineal foot. A concrete pile in a similar wharf would cost perhaps about 14s. 6d. per foot.

71. *To Senator Lynch.*—The grading for concrete should be done in accordance with scientific methods, and not by guesswork as it is frequently done. The conditions I have mentioned in my evidence are absolutely necessary for good concrete work. I am slightly more confident now of the value of concrete construction than I was when I began it. The proportions for a good concrete mixture vary according to the nature of the material you have to use. The method developed by Professor Abrams, of Stanford University, California, is a good one. I never take any chances with my material. I test everything. I use Australian cement. It is very good indeed. The 400 feet x 88 feet wharf it is proposed to build at Cairns is estimated to cost about £60,000, and incidentals to the wharf will cost about £20,000. The incidentals include £5,000 for dredging, £3,000 for rail and earth approaches, and £11,000 for reclamation, and so on. I advised the Queensland Treasurer that the estimate was reasonable, and that the work should be done within the amount. That is about our average cost for this class class of work. Even if I had a more perfect sheathing for timber piles I would not go back to timber unless there were special reasons for speed in the construction. Unless time were the most important considerarion I would not go back to timber. Taking all the conditions as they are I am in favour of concrete construction. I have only heard through newspaper reports of the concrete wharf in New Zealand collapsing. I have formed no opinion of why it collapsed. I am going over there next week, and I shall make some inquiries What we call Brisbane schist is too hard for dredging. Brisbane is built on schist rock. We have dredged soft rock in many places with a bucket dredger. It is costly and slow, but much cheaper than any other method. I cannot say whether that method could be used at Darwin.

(Taken at Sydney.)

THURSDAY, 23RD APRIL, 1925.

Present:

Mr. GREGORY, Chairman;

Senator Barnes	Mr. Blakeley
Senator Reid	Mr. Cook.

George James Edwards, Manager, Australian Investment Agency, Sydney, sworn and examined.

72. *To the Chairman.*—We act as representatives for Vestoys Limited at Darwin. Since I last gave evidence new proposals have been put forward for wharfage at Darwin. I have examined the plans closely. I am authorized to speak for the company in this matter. In the first place, I do not think I need say anything about the efforts made heretofore to get a wharf at Darwin. I think it has been settled that the port should have a new wharf. Darwin has been wisely chosen, in my opinion, as the metropolis of the Northern Territory, and it must be developed to enable the Territory to go ahead. I have looked at Mr. Ramsbotham's plan and have read his report. I have nothing whatever to say in regard to the engineering difficulties involved. I was agreeably surprised to see the experience that Mr. Ramsbotham had had in this class of work, and I accept him as an authority. If he says that a thing can be done, I am satisfied that it can be done. Therefore, I only look at the plan to see if what he plans to give us will be satisfactory to us. Therefore, I take the triangle quay "A" with the old jetty on one side, the new quay on another side, and the viaduct on the third side That arrangement will give Darwin the minimum essentials necessary to carry on any business. It will provide a shed on the wharf. The absence of such a shed is one of our greatest difficulties. It will give us direct access by locomotives and trucks without the intervention of a turn-table, and that is probably the most important thing required. It will give access to the quay from the town by motor cars, vehicles, and carts generally. At present no vehicle can get on the Darwin wharf. If you land with any luggage you have to carry it 200 yards along the railway metals before any cart can be reached, or you have to put it in a railway truck, which, of course, is absurd. The new quay will give us berthage for two steamers, the minimum requirement for Darwin if the port is to do any export trade. I am not prepared to say that the minimum will be insufficient, but it will not be too much for the time being With provision for two steamers, we can carry on our freezing works without interruption by the general trade of the town. We have often given evidence about the enormous cost to which we are put because these facilities are not now available. I do not propose to weary the committee with repeating that evidence, but I shall try to imagine what will happen when this quay is finished and a Burns, Philp steamer arrives. The vessel will discharge cargo for four different destinations. Some will be for transhipment into local or constal steamers for other ports, some will go to the merchants in the town of Darwin, some will go to the meat works $2\frac{1}{2}$ miles away, and some will go into the interior. The new quay will solve all existing difficulties. A steamer will undoubtedly get very much quicker dispatch. The first essential is to get the cost of freight down, and to do so you must enable the steamer to get away as quickly as possible It is cost that is killing the development of the Territory now, and will always prevent its progress Any place on earth can be settled if a man can make a profit in it That is the one and only test For years past it has been impossible to make any money in Darwin, because everything we produce is on the lowest basis of value, while the cost of handling it is exceedingly high. Everything we use is on the basis of the highest cost, because of the heavy charges we have to pay. I shall give a little example of the difference this new quay will make. Take cargo destined for Victoria river, Borroloola, or any other out port, for transport by lugger or coastal steamer. At present cargo for these places is taken out of the Burns, Philp steamer, placed in a railway truck, because there is no shed on the wharf, taken via a turn-table with its heavy expense to the existing sheds 200 or 300 yards away, discharged from the truck into the shed, stored in the shed, held there for a certain time, and then, when the coastal steamer arrives, loaded on a truck, brought down to the wharf over the turn-table, discharged from the truck, and put on the steamer. All that service costs £1 11s. 6d. a ton. To give an idea of what it means, let me say that wheat can almost be sent to England for that cost. We get no real service for that £1 11s. 6d. There is nothing done to add to the value of the goods. They are simply for transfer from one steamer to another, and the cost of such an operation in Sydney is about 1s. 6d. a ton. Practically the whole of this charge of £1 11s. 6d. a ton will disappear when the new quay is available, because the goods will simply be placed in the shed on the wharf. Just as in Sydney, there will be no further handling of them. Next week, or next month, the local steamer will come along and pick them up and take them away. Nearly the whole of that £1 11s. 6d. a ton will be saved. The cost of freight on the steamers to-day is largely due to the delays occasioned at Darwin. I have just had the task of chartering a coal steamer for Darwin. I employed one of our foremost chartering brokers in Sydney to negotiate for me. I found, somewhat to my horror, that practically no Australian company was willing to put a ship into the port of Darwin at any price whatever, partly because of the knowledge the companies possess that Darwin is a slow port, and partly because the press correspondence at Darwin is making out that the labour conditions at the port are worse than they really are. I have told the ship-owners that, in my opinion, at the present time Darwin is probably as quiet as Sydney, or any other Australian port, has been in the last three months, so far as the handling of cargo is concerned. However, we could not get the owner of an Australian steamer to go to Darwin at any price. Finally we got Mr. Scott Fell, who was chartering a Japanese steamer, to take the risk. His cry all the time has been, "Look at the time it is going to take. Why should I go into Darwin? I can go to Java and put out 800 tons a day and get the whole cargo out in a few days at practically nothing in the way of cost. I can keep my steamer on the move." I could not guarantee Mr. Scott Fell an output of 800 tons a day at Darwin, but I was able to guarantee an output of 200 tons a day, and I am glad to say that the labour at Darwin did it. The men worked well, and we saved a day on the job. The cost was not as bad as it used to be. Fortunately there was no other steamer at the port at the time, and we had a clear run But we had to pay two and a half times as much to get the coal to Darwin as we would have had to pay to get it to Java. We do not employ niggers to discharge a vessel, and we cannot expect to get a vessel handled at Darwin at anything like the cost at which it would be handled by nigger labour in Java. The principal factor was the time taken in getting out the cargo. Therefore, we had to keep the men working well in accordance with the limits placed upon them by the lack of facilities at Darwin. Every steamer that comes into an Australian port has to pay light dues, and there is no extra charge in that regard

for a vessel which loads coal at Newcastle, and subsequently calls within three months at Darwin. We have troubles in that regard, but I do not propose to weary the Committee by detailing them. I have already dealt with the cargo placed in sheds for future transhipment. I shall now deal with cargo for delivery to merchants in the town. This cargo is now placed in a railway truck, taken over the turn-table, hauled to a shed, and there sorted and loaded into carts. The handling cost is 15s. 9d. a ton from the ship's side to the sheds. This charge is occasioned by the fact that the goods cannot be dumped on to the wharf, and picked up by carts on the wharf. Everything has to go into a railway truck. When the proposed quay is erected, the goods will be discharged into a shed as in Sydney, and the merchants will be able to send their trucks down to the wharf to pick up the goods, and take them to their own stores. This will enormously reduce the cost of handling. All along the line the new quay will considerably reduce the cost of handling everything that goes in and out of Darwin. I consider that the existing jetty, with a curved railway approach and 535 feet of accommodation, as proposed by Mr. Ramsbotham, will meet the normal requirements of Darwin for a number of years. Mr Ramsbotham proposes to leave it to the people of Darwin to settle among themselves what else they will require beyond a goods-shed and certain railway lines We are anxious that nothing shall be done that will cost more than is necessary to render the quay efficient. I do not think a goods-shed 80 feet by 450 feet will be necessary Probably a shed half that size will be ample for all requirements However, questions like that should be settled on the spot by the people and the Railway Commissioner's representatives. Mr. Ramsbotham makes provision for a cold store on the wharf The meat works will not require it, because they will not place frozen meat into trucks 2½ miles away, and discharge it into the cold store on the quay, and then load it again from that store into the steamer That process would simply add another handling charge when it is necessary for us to avoid as many handling charges as possible We must reduce costs Therefore, there is not the slightest need, so far as the meat works is concerned, for any cold store on the wharf. Such a cold store would need a very considerable refrigerating plant costing a great deal of money to keep in operation Although a cold store on the wharf would be unnecessary for the meat works, there might be other things to consider, such for instance, as the need for a cold store to hold butter and other perishable products for the use of the people at Darwin I am not prepared to say that such a store would not be needed for that purpose, but it would not be required for the meat works Quay "A" as planned would give the minimum required at Darwin, providing facilities for handling two steamers at once That is an essential. Quay "B" as planned by Mr Ramsbotham would provide facilities for handling a third steamer But as expense should be avoided wherever it is possible to do so, my personal opinion, which I give without binding my people in Darwin, is that I think that for the time being quay "B" could be done without It could be made in future, and utilized for landing cattle from outlying ports of the Territory. The future development of the cattle industry in the Territory depends on whether it can be made to pay. It is perfectly clear that all along the north coast of Australia, in the Caledon Bay and Arnheim Land districts, which are not used at the present time, cattle can be grown. It is ideal country for the small man, because of its unlimited water supply. There are difficulties—pests, mosquitoes, and so on, and there is also a very heavy rainy season to contend with, but this country of which I speak will be an ideal place for the small settler. We were told only the other day, on the authority of Mr. J. Warrington Rogers, a settler on the Roper River, that he knows Arnheim Land, and that it could easily carry 250,000 fat cattle from October to December. However, this country will not be settled by small pastoralists unless they can make a living on it. But if it were so settled it would be difficult to drove the cattle to the meat works at Darwin, and we should be obliged to do, as is done in other parts of the world, provide something in the nature of a flat-bottomed steam lighter to get the cattle to Darwin. It would mean the salvation of the works at Darwin to get an extra supply of cattle in this way. In that event quay "B" would be an ideal way of landing them, because we should never put these cattle on railway trucks. We would drove them to the meat works, put them into the paddocks there, and treat them in due course. However, that is only looking into the future. People ask whether the north can be settled. I have quoted the opinion of one man who knows the north, and who is trying to settle it. I think the only mistake Mr. Ramsbotham has made is his suggestion that the berth at quay "A" should give a depth of only 28 ft. 6 in. below low water, and that a depth of 26 feet should be sufficient for some years to come. Mr. Ramsbotham has applied to Burns, Philp, and Company and asked them if they propose to build any larger steamers than those in use by them at the present time. They said "No," and he was satisfied to give a depth that would enable that company's steamers to load at the Darwin quay. He should, in my opinion, have been guided by the size of meat-carrying steamers which are bigger and heavier than the *Muella* or *Montoro*. This morning I was in conference with a marine superintendent, who has had a great deal of experience in dealing with ships He tells me that the ideal depth is 30 feet, or, if that cannot be obtained, not less than 29 ft. 6 in. That is on the assumption that a boat leaving Darwin will be full. I think the future course of trade will be Sydney, Brisbane, Townsville, Darwin, Wyndham, and England. Consequently, ships will be very full on leaving Darwin, and will require a depth of at least 29 ft. 6 in. Of course, vessels are not always at a dead level when they call at or leave an Australian port. A vessel calling at Darwin may also be calling at Wyndham to complete her loading. Such a vessel may be down 6 inches at the stern. We ought to be guided by what the every-day ordinary meat-carrying vessel used in Australian waters requires as its maximum. Mr. Ramsbotham's ideas in regard to accommodation on the wharf are merely tentative. The main thing is that he shows how we can get that great essential, namely, a means of getting on to the old wharf without the intervention of a turn-table. When the quay is completed those who are interested in the trade should confer with a view to providing the best facilities on the wharf. The plan will confer four great advantages. it will not be necessary to scrap the old wharf, the difficulty of the tide will be met by making the steamers' course absolutely in the same direction as the tide, the quay is made part of a bigger scheme, should it ever be required, and there will be no need to scrap the race by which live cattle are loaded on to steamers. Vehicular traffic will be able to go on the wharf. I do not think there is any other wharf that has not a road to it. The course the road should take is entirely a matter for the people on the spot. It should be a very simple proposition. I have always been strongly of opinion that immediately a decision is come to to do something at Singapore in the direction of building a base, something will also have to be done at Darwin. Looking at a map, it seems to me that Singapore and Darwin are two ends of the same street. The present position in regard to the refrigerated trucks on the Northern Territory railways is like the Scottish verdict of "Non-proven." We have agreed, for the time being, to drop the matter. We still do not think that the trucks are efficient, the railway authorities think they are. Very good; we shall load our meat into the trucks provided by the Commissioner of Railways in the daytime, any day of the year for conveyance to the wharf in

whatever weather that comes along, hot or cold. The Commissioner has said that the trucks will carry the meat in a proper condition to the ship's side. If they do so, we shall have no complaint, but if they do not we shall refer the matter back to the Commissioner. The Commissioner always has the right to inspect the condition of the meat going into the trucks, and I have no doubt that he had an officer there when we were shipping that meat, but I could not swear to it. It is quite impossible for meat to leave the works soft. Temperatures are taken every four hours. If the meat in one corner of the works went soft the whole lot would go soft. The temperature does not vary. This matter has been discussed at a previous inquiry and it has been agreed to stop the altercation. We are prepared to leave the matter to the Railway Department, and throw the blame back on that department if it fails to convey our meat in a proper condition to the ship's side. The charge for refrigerated space from all ports in Australia is the same except in the case of Wyndham, where there is a surcharge of ½d. We have done our little bit towards getting that surcharge removed, and when the time comes we shall do our best to prevent Darwin from being surcharged. Whether we shall succeed or not I cannot say. I had a call from a shipowner the other day, and he assumed that Darwin would pay the surcharge of ½d. I told him that there would be no frozen cargo this year. He said that he would be willing to go into Darwin, and would surcharge us 10 per cent. or 15 per cent. When the time comes it will be our business to get the surcharge as low as possible. Every penny taken off the cost of handling the stuff gives a better return to the producer. The ship-owners agree that in future some of their boats will take the northern route from Townsville, calling in at Darwin, if it has any cargo offering, and at Wyndham, and then going thence to the United Kingdom. It is not likely to happen that the ship-owners will get an ample cargo at Queensland ports, so that we would be compelled to charter special boats to take full loads at Darwin. The shipping on our coast can lift a greater amount than is offering. An occasional boat may leave Townsville full, but all vessels do not leave full. I am exceedingly hopeful that the meat export trade will develop. In order to assist the further development of the north the railway should be run as a function of development, more or less regardless of financial results. I am not making the slightest complaint about the Commonwealth Commissioner of Railways. He has to make his railway pay, but from an Australian stand-point I think that is a wrong policy to pursue, and I look forward to the day when it will no longer be pursued and when the settler in the Northern Territory will not inevitably be charged £20 for service merely because the cost of rendering that service is £20. He is already charged just as much, if not more, than he can stand. If he can only stand £5, that should be the price charged. If the rates charged in the southern portion of Australia applied in the north, and if the Commissioner of Railways were recompensed for the loss, we could not expect anything better than that. It would certainly be a very great help, because everything we do up there is eaten up with charges. On the general question of the development of the Territory, the present Commonwealth Government intends to do quite a lot for us. Of course, we are always wanting more, but we are now getting something. We are getting roads to the back country. The progress is slow, I admit, but still we are getting them. Everything that is being done is on the right lines to avoid the horrible waste of money that goes on. If you have to give a carrier a huge price to carry your goods because it takes him a week to get over the King River it does not do the carrier any good, because he has to occupy all that time on his trip. We can now get over the river in a few seconds, and without that week's delay, and we are that much better off. Everything possible should be done to cheapen the cost of handling things in the Territory, and then it will go ahead. If freights, harbour dues, and wharfages were to be reduced in order to enable the people in the Territory to get on their legs and assist developments, the period over which such reduction should apply should not be anything less than ten years. The meat works at Darwin will be opened this year for the purpose of boiling down cattle. It is the strong desire of the company to re-open the works next year, and every year thereafter, for freezing. But they will no longer, as they did before, open the works in the face of an obvious loss. Boiling down means that the animal is sacrificed for its hide, its tallow, its extract, and a few sundries, like horns and hoofs and fertilizer. No portion of the beast, not even the tongue, will be used for food. Consequently, only the old and otherwise lean cattle will be boiled down. No good cattle will be treated in this way; they will be kept for freezing next year. The export of live cattle is going on all the time at the rate of 1,000 a month in two fortnightly shipments. The tonnage outwards as the result of boiling down will be from 1,750 to 2,000 tons of material. The tonnage inwards will be about 1,600 tons of coal and 300 tons of general goods. However, we are not going to have boiling down every year. In fact, we shall not boil down again. This is only a trial spin, preparatory to freezing next year. With the works in full swing, the export figures are entirely altered. We may have up to 6,000 tons of beef, 700 tons of tallow, 700 tons of hide, 500 tons of fertilizer, and 200 or 300 tons of oddments. We may also import 6,000 tons of coal and 400 or 500 tons of general cargo. That is what freezing means to Darwin. We are waiting for the completion of the oil tanks at Darwin to convert our machinery into oil burners. When that happens one of the great difficulties, the cost of fuel, will be greatly reduced. The number of cattle in the Territory is undoubtedly increasing, and will continue to increase even if no new land is taken up or no new settlers are induced to go there. It will also increase even if more intensive methods are not adopted. I think we can almost divide the development into five-year periods. We are looking forward to being able to secure in 1928, for the first time, that volume of cattle which will really give our works a chance. I think that with every subsequent five-year period there will be a given increase. It is the view of our general manager in Darwin that eventually our works will run a longer season than even the Townsville works ever can. That will be due to the improvements we are making in the out-back country to enable us to run more cattle. We are spending tens of thousands of pounds on our runs. Another cause will be the extension of small settlement on the coast. Every day we are getting proof that a certain number of fat cattle can be produced on the coastal country. The improvement of the herds in the north is very difficult, because of the expense involved. No pastoralist in the Territory is, so far as I know, making anything. Every one is living on his capital, and consequently no one has the money with which to improve his herds. We are in a more fortunate position than the small men. Although we have no money, we are in a position to get it, and are getting it. In March we forwarded 34 bulls to Darwin, and next month we are sending more. Of course, it is but a drop in the ocean, but, nevertheless, it is something, and it is the most we can do. I am quite sure that if the other men could turn the corner and make a pound or two, that is to say, if they have something in their pockets enabling them to buy good bulls, they will do so. That is one of the detractions of the north. The people are so impoverished that they have to stand by and do nothing whatever to improve their herds.

73. *To Mr. Blakeley.*—I have noticed what Mr. Cramsie has said about the carrying capacity of the north, but I do not think the numbers could be increased to 7,000,000, for many years to come. It takes many years to bring about a substantial increase in any herd. I am not prepared to say that it is physically impossible to run that number in the

north, but I am ready to say that a great deal more could be run than are run there to-day. No beef export company in Queensland made a profit last year. There is only one which is a public company publishing a balance-sheet, and speaking from memory, I believe that company operating on a capital of £660,000, and handling a turnover which was not mentioned, but which would run into £300,000 or £400,000, made a profit of £1,100 That was the Queensland Meat Export Company. Judging from these figures, and from my general knowledge of the other works, I do not think that any meat works in Queensland last year made a profit. The Darwin works are not freezing to-day, because they cannot return to the pastoralists a price which would enable those pastoralists to grow cattle, and pay all the charges to which they are subjected, without suffering a loss. The Darwin meat works are owned by capitalists who are as keen as any one on the earth to have no plant lying idle, and to have everything working at full pressure at a profit, however modest, but at the same time not at the expense of slaughtering the man in the country who is growing the cattle If you do that he has to go out of production ultimately Therefore, the first essential is not that the meat works make a profit, but that the pastoralist should get as much for his bullocks as it costs him to grow them The price of meat has increased within the last twelve months, and is now getting to such a stage as would, with reasonable costs, enable the Darwin meat works to re-open and keep open. Our anticipation that we will be in a position to re-open the works next year is based on world-wide opinions collected for us, and given to us from all sources, tending to show that in the slump of recent years men in all parts of the world killed in excess of the number they were replacing. The result was that where for three years there was a surplus, now there will be a shortage Further than that, the most wonderful thing that has happened to the world's meat trade is the development of eating meat, and particularly frozen meat, on the continent of Europe I suppose that more than half the beef that left Australia for England last year did not go to England, but went to Italy, France, and Belgium. It is particularly suitable for the requirements of Latin races They were willing to pay for it just as high a price as England was willing to pay, and, of course, that put up the price. Undoubtedly, no matter how far you may go the price of meat depends upon the old question of supply and demand. Assuming that the increase in the price of meat is firm, and has a tendency to become firmer, we should put through from 25,000 to 30,000 head at the Darwin meat works.

74. *To Mr. Cook.*—In discussing Mr. Ramsbotham's proposal, I am looking at the matter, not from one stand point, but from all stand-points relative to the development of the Territory. The meat works are only the medium by which the cattle of the far inland may be marketed The development of the Territory means, among other things, the development of cattle. If the meat works have to pay unnecessary or excessive charges, amounting to 10s. a head, the inevitable result is that they in their turn must give the grower of the beast 10s. less for it. Therefore, any costs you save the meat works do not go into the pockets of the owners of the meat works, but go right back to the primary producer, who is the man we have to look after. I do not know the Gladstone meat works, but I know they are probably the most favorably constructed and situated meat works in Australia. They have every advantage, enabling them to kill, freeze, and place on board ship meat at a lower cost than applies in any other meat works in Queensland. The tendency in all countries is to use cattle as a stepping stone to something else. In our inland parts of Australia cattle have proved to be the stepping stone to sheep. In our coastal countries they have been the stepping stone to dairying, particularly in New Zealand, where the growing of cattle merely for the export of beef will probably become extinct, and the land will be used to get very much more valuable dairy produce. When the dairying industry which we have in the north coast of New South Wales and the southern portion of Queensland, is likely to extend right along the coastal countries, Queensland will probably produce on that portion of her territory less cattle for beef than even now. I think in the future it will be found that the Northern Territory will be the last stronghold in Australia of the cattle industry The tendency is always to drive cattle further and further back. They are driven back by sheep. The latter are driven back by wheat. If you examine the history of New South Wales for 80 years past you will see that that has been the tendency all the time, and I think it will continue, because it is dictated by economic reasons, viz., the greater value of output. Therefore, the tendency throughout Australia is to drive the cattle further and further back into our great inland stretches The charge of £1 11s. 6d. a ton for handling transhipment cargo at Darwin at present is made up as follows:—Labour on the wharf, loading into trucks, carriage to the shed, unloading at the shed, and sorting, 10s. a ton; shed hire, 9d. a ton; wharfage, 3s. 6d. ton; shunting, 1s. 6d. ton; total, 16s. 9d. The whole thing being reversed when the goods have to be moved from the shed to the coastal steamer, this cost is simply doubled, making a total of £1 11s. 6d. If shed accommodation was provided on the wharf, this cost would be reduced to not more than 10s. a ton. All unnecessary handling would be avoided. Simply to discharge goods from the steamer into a lugger would cost not more than 10s. a ton. The cost of conveying goods to the town is 15s. 9d. a ton. I think that at least 5s. 9d. could be saved on goods going to the town or into the interior. With the meat works closed the volume of trade at Darwin is about 300 tons a month, but that is Darwin's quietest period. With the meat works in full swing we have done about 40,000 tons. If you leave Darwin as an idle and deserted port, the tonnage will be so low that there will be no need to make a wharf The existing conditions amount to more than a tax of 5s. a ton on goods handled, and they are one of the factors which make it impossible to run the meat works I do not think that dairying is likely to develop as an export industry in Darwin, because the cost is prohibitive. Undoubtedly it could be carried on. As to whether we could hold our own against Argentine, the meat industry has always been subject to fairly constant fluctuations, the causes of which it is very hard for one individual to give an opinion on. However, it seems perfectly clear that the Continental demand which has sprung up, particularly during last year, and almost entirely since the war, is likely not only to continue, but also to grow. But as in all other trades it is only likely to grow at a price. All these countries would cease buying if the price were doubled. Therefore, at a price I think the demand through the world will grow It has also to be remembered that it is quite possible for a big demand to spring up from Japan and other eastern countries. These factors you can only estimate, and not for many years ahead, but I think the future of beef export is assured at a price in which the product will bear some relationship to the price of other things. For instance, if you go to the butcher's shop, and find that beef is 9d., and lamb 1s., you may buy either, but if beef is 1s., and lamb is 4d., you will not buy beef. The cost of living in all these countries comes into account. I do not think that beef will double its price in the Argentine or anywhere else But at a reasonable price which the consuming population of the various countries can pay, I think the demand is likely to increase. One of the most absurd things throughout the slump in England was that people there were willing to pay 1s. 6d. a lb. for lamb when they could get beef for 6d Our bullocks are heavier than those at Townsville. If Townsville can pay 19s. a 100 lb. for good bullocks, Darwin could pay, not 19s., but possibly 15s. Let us take 15s. as an estimate. That price would enable us just about to carry on. It would not be a sufficient inducement to the pastoralist

to increase his herds, or proceed with the settlement of the Territory. Vesteys will always keep their works open if they can. They have sunk nearly £1,000,000 in the works at Darwin, and it gives them no pleasure to see them lying idle, and, in fact, costing money for upkeep. The driving force is always to open the works, but not at a loss. I was not in Darwin when the last complaints about the thawing of meat were made. I am perfectly certain that the complaints did not arise from the fact that the meat had not been properly chilled. Our meat is kept at a colder temperature than in any other meat works in Australia. For many months of the year Townsville is quite as hot as Darwin. In future we shall tender our frozen meat into refrigerated trucks which the railways supply to us in the expectation that it will arrive at the ship's side in a hard, frozen condition. If that is done we shall have no complaint. If it is not done we shall simply wait to see. We can supply the Home market with meat equal to that supplied by any other country in the world except that other countries market chilled meat. We can undoubtedly freeze meat as well as it can be done by any other nation on earth. If we can economize costs from the time the bullock is killed until it reaches the Home market we are likely to open up a big trade in the north. We shall do so once we can give the producer a few shillings a head more profit. If we can do that he will grow cattle. The tendency of late has been to get rid of cattle and go in for sheep and get more money for wool, but if the producer can get a profit on cattle he will grow more cattle. If the driving force of a profit is there, undoubtedly we can grow vastly more cattle than we are growing to-day.

75. *To Senator Reid.*—I am quite certain that cattle will be the principal product of the Northern Territory for a number of years. I do not know anything about mining. I believe that cotton can be grown, and I understand that on a small area it will produce enormous wealth. But for the huge expanse of country cattle is the only thing for the Territory. While I should very much like to see railways pushed ahead, there are lots of things I should like to see done first This proposed wharf will cost the equivalent of 11 miles of railway, but I should rather have the wharf built than 100 miles of railway, even if the line were going right into our own portion of the Territory. I should rather have roads and telegraph lines built before railways. Cattle can walk. If we have good stock routes so that the cattle will have plenty of water when they come into the rail heads, and if we have good roads so that we can convey material to places 300 or 400 miles from a railway at a reasonable cost, we can manage very well. No one would be more pleased than I should be if a railway were put through our country, but I should be sorry to have it at the expense of other developments which I think should come first, these developments being wharfs, roads, means of communications, and stock routes. The new wharf will be much more valuable to the Territory than any 10 miles of railway would be A stock route means the provision of water along a route. If Vesteys were prepared to spend an almost unlimited amount of money in the improvement of their property, principally by the provision of water by boring, they could double the carrying capacity of their runs But there is a great big area of country along the coast of the Northern Territory which the people who live there say will grow an enormous number of cattle. This country will not require much improvment because it is already well watered. In view of the new demand in Europe, I think about 20s. a 100 lbs. would be sufficient to encourage small men to go ahead. It would encourage them to breed more cattle and put their sons and their friends into the business. It would undoubtedly lead eventually to a flow of land-hungry people to the Territory where there is plenty of land available. If there was a regular market in the Territory for cattle at £6, practically nothing could keep its progress back. A man has to go pretty hard to double his herd in six years It would probably take him eight years or longer to do so. But once the Territory turns the corner and gets on the up grade, like every other thing on earth, it will soon accelerate. The difficulty is to turn the corner or get the £6, or, if you cannot get the £6, get the costs down to enable a good living to be made at £5 a head. Our great difficulty at the present moment in regard to the export trade in live cattle is to keep it as high as 1,000 head a month. The market for live cattle is very limited. Travelling cattle alive on board ship is a very uneconomical way of conveying meat. The destination of our cattle is the Philippine Islands. We do not pay the freight, the buyer pays all costs. If the freight is 4d. a lb. it does not compare favorably with the rate of seven-eighths of a penny for frozen stuff. On the other hand, however, there are native populations in the east who, for religious or other reasons, will not buy frozen meat at any price. That is how the demand for the shipment of live cattle arises. They must have cattle to kill them on the spot. Apart from these people, the trade in large cattle does not in any part of the world I know of compete with that in frozen meat. The export of live cattle has been a precarious and uneconomic trade, and I think it always will continue to be so. Burns, Philp, and Company's steamers are passenger vessels. A meat carrier is a cargo steamer solely. Whereas Burns, Philp, and Company's steamers would draw about 24 feet, a cargo carrier submerged to her plimsoll mark would draw as much as 30 feet. It is therefore important that there should be at least 29 ft. 6 in. of water at the Darwin wharf to accommodate the type of vessel used largely on the Australian coast, and such as we would make use of probably once a month. We have had as many as five steamers in the course of the season at Wyndham, and Darwin will no doubt have from three to five steamers every season, depending on where the meat is required. If you have 2,000 tons in store, and you want 1,000 tons for Italy and another 1,000 tons for Japan, obviously you will require two steamers to convey it out of Darwin. If London is to take all our meat then we may put 3,000 tons into one steamer. But that is unlikely. I should say that, roughly speaking, we shall probably have from three to five steamers calling into Darwin to take frozen meat in one season. Burns, Philp, and Company's steamers call at Darwin twelve times a year. The Western Australian Government boats call there four times a year—two or three coal steamers call and four or five meat steamers. There are also the steamers that call for live cattle. There is quite a lot of shipping at Darwin even now.

76. *To Senator Barnes.*—The charge of £1 11s. 6d. a ton to which I have referred does not apply to meat. It is true that if the excessive costs which I have pointed out were wiped out it would not amount to more than a few thousand pounds a year, but the whole object is not to save £1 11s. 6d. a ton, it is so to cheapen costs throughout the Territory, so that the meat works and any other industry, cotton, if you like, can carry on. The saving to the meat works by the construction of a new wharf will be tremendous. It will make all the difference between working and not working, and all the difference between giving the pastoralist a fair price for his beef, and an unpayable price, because eventually it is the pastoralist who pays the piper.

77. *To the Chairman.*—If the users of the new wharf are to be compelled to pay charges which will be sufficient to met interest and sinking fund charges on the cost of the work it might just as well not be built, because the whole crux of the matter is the necessity for reducing costs at Darwin. Some figures I have—I cannot guarantee them to be accurate because they were hurriedly jotted down—give an idea of how much the charges for the use of the wharf have been increased. I estimated that we would have had to pay £1,000 in 1914, £2,000 in 1919, and £2,500 in 1923, for services on the same quantity of goods. These costs were not

affected by labour, but solely applied to the use of the old and inefficient wharf provided for the handling of our products. We want those charges reduced. If you add another £20,000 a year, or whatever it may be, to that which the users of the wharf now pay, you might just as well not build it. There is no hope of this additional charge being paid The Government will have to give the wharf absolutely free to the people of the Territory as their contribution towards reducing the cost of handling goods in the Territory. I give the assurance now that it is the wish of Vestoys, and their intention, to start boiling down operations this year and freezing operations next year. We are to get help in several directions. The provision of oil tanks is one direction, and we gave an undertaking to the Minister for Home and Territories that if he did certain things we would open the works. The difference in the cost of handling cattle between Darwin and Townsville depends entirely on extra costs we have to incur as against those that have to be met at Townsville. I should say that the difference was about 4s. or 5s a 100 lb., or approximately 35 per cent. The late Mr. Justice McCawley fixed our wages at 25 per cent. higher than those he fixed for Brisbane. He did so on the ground that our cost of living was 45 per cent. higher than that of Brisbane. If our cost of living is reduced we can get our wages down, but our cost of living depends largely on items of carriage. It is the high cost of carriage that is killing us. We get our men from Queensland. They are provided and controlled by Queensland unions, and they are accustomed to Queensland conditions. I think the Government are about to take action in regard to the Buffalo fly, which is undoubtedly a great difficulty in the Territory and a menace to the rest of Australia. The Commonwealth Government and the Western Australian Government have provided equal amounts of money to send out a competent entomologist to the north for two years to study this pest. Advertisements have been called for applicants to the position. The contribution of the pastoralists will be in the direction of affording transport to the investigator and providing cattle for experiments. Sir Harry Chauvel, who is naturally interested in the supply of horses for defence, had an opportunity of seeing not far from Darwin, the ravages of the Buffalo fly on cattle and horses, and I believe that he is a strong advocate that something should be done to try and eradicate the pest. I think something will be done.

(Taken at Melbourne.)

MONDAY, 24TH AUGUST, 1925.

Present:

Mr. Gregory, Chairman;

Senator Barnes	Mr. Mackay
Senator Reid	Mr. Mathews.
Mr. Cook	

John Robert Woodman Hyde, constructional civil engineer, Brisbane, sworn and examined.

78. *To the Chairman.*—I came to Australia in 1908. I was appointed assistant engineer to the Victorian Railways, and, as Officer-in-Charge, constructed the first 30 miles of the Ouyen railway. I left for Queensland in 1910, and was connected with the Queensland railways for less than a year. Since then, I have specialized in design, construction, and maintenance of wharfage. I was engaged on the construction of the Howard Smith wharf, Brisbane, in 1912. It is 480 feet long, and was built on mahogany piles, with a timber top. In 1913, I had a contract to construct the extension of the Stevedoring and Wool-dumping Company's wharf, at New Farm. The piles, which were ironbark sheathed with muntz metal, driven there were as long as 100 feet. In 1914, I had a contract with another man to build a wharf at South Brisbane, at a cost of £11,000. Mahogany piles were used. I was in the army, but on home service. Later, I was engaged by the Brisbane Stevedoring and Wool-dumping Company to repair the piles of their wharf at New Farm. This wharf is used by the Orient liners, the Commonwealth and Dominion ships, the Port and Bay boats, and other vessels. Ships of 20,000 tons berth there. It was when I was engaged on this work, in 1916-17, that I discovered the great harm caused by the teredo, and the failure of the muntz metal to protect the piles. I then made a special study of the whole matter, and later on I took out the patent, which I now propose to explain to you. Muntz metal is approximately 60 per cent. copper and 40 per cent. zinc, with a few minor metals in the composition. Electrolytic action occurs in salt water, and a compound of zinc is formed. This zinc compound is soluble, and ultimately only the copper is left. It becomes porous and spongy, and falls off. I have known muntz metal to be effective for about 30 years; but the muntz metal supplied recently is not as good as that supplied 30 years ago. I submit that my system of sheathing is superior to it. Once muntz metal is broken, the teredo can get into the timber of the pile. It makes a small pin-hole entrance; but once it gets in it honeycombs the timber. Swamp mahogany and bloodwood resist the teredo in Brisbane waters. I know that bloodwood that was driven in the Brisbane River in 1914 for fender piles is still in good order. You can get bloodwood piles up to 70 feet in length. They are easy to get, and straight. I think they are stronger than swamp mahogany, which is liable to be twisted, and in long lengths to get thin at one end. It is also hard to get. I am told that turpentine wood resists the teredo in Sydney Harbour. I have had no experience north of Brisbane. In addition to the works I have mentioned, I designed and carried out the construction of jetties at Red Cliff and Woody Point, which cost £22,000. One was 900 feet long, and the other 850 feet long. During the past eighteen months, I have been engaged at the New Farm wharf, which has a frontage of 1,037 feet. It was a reconstruction job. The timber was in bad order. We had to sheath the piles and remove the decking and superstructure, and replace it. For the railway line, we used 60-lb. rails, and made all the points and crossings. I have a knowledge of the conditions at Darwin. I claim that my process is applicable to them. My plan is to put a concrete cylinder around the timber pile. That, of course, is not altogether new. It is my method that is new. When concrete cylinders were put round timber piles, the work was done on the ground, and then the cylinder or pipes had to be lifted over the top of the pile, placed in its position, and driven. My system is to cast the cylinder round the pile after it is in position. I build a framework around the pile, and work in 4-ft. 6-in. sections. I build the first section around the pile above low-water mark. I place a wrought-iron ring in the frame. Then I bring my ⅝-inch round steel reinforcement rods up, and wind, in spiral fashion, steel wire around this, with 4-inch intervals. In addition, I tie wire vertically to keep the spiral in position. I then fill the concrete into the mould over the reinforcement, and leave it there, during which time the whole thing is immersed by the tide. After 48 hours it is ready to be lowered. This is done by means of steel wire ropes. These are passed through iron rings at the bottom of the section, and the section is gradually lowered. When it has been let down a distance of 4 ft. 6 in., I begin work on the next section. The vertical reinforcement rods which were put in the first section were bent over during the making of that section, and for the making of the next section they are straightened. It will be realized, therefore, that the vertical rods are continuous, and not broken at each

section. When I am ready to make the second section, I have the vertical rods straightened, and the spiral wire is again wound around at 4-inch intervals for the next section, and it is tied into position. The concrete is left rough after the making of the first section, and when the framework is ready to take the next section, the concrete, which I have very wet, is poured into the mould. The joint is left rough each time, so that there is good adhesion. The second section is left for 48 hours, so that it also is submerged by the tide, and then it is also lowered 4 ft. 6 in. by the steep ropes, so that the work is ready for the third section. I work under that system until I get a cylinder of the required length constructed. The longest cylinder I have made so far is 41 feet; but I can see no reason why cylinders should not be made even 100 feet long. I wish to make it quite clear that there is no joint in the cylinder The work is built up continuously, just as a concrete wall is built. The irregularities in the concrete, as each section is made, ensure that there is good adhesion, and the reinforcement is, of course, continuous from the bottom of the cylinder to the top. When the first section of the cylinder is constructed, it is lowered to about 6 inches above low-water level, and then the next section is made. When the complete cylinder is ready, it is lowered to the ground, and it sinks. The weight of the cylinder is usually sufficient to ensure that it will sink into the ground. On two occasions, I have had to force the cylinders down. In those instances I used jacks. After the cylinder is in position, it is filled with sand. If, for any reason—poor workmanship, for instance—it is not sound, it will not hold the sand. That is discovered when we attempt to fill in the sand. I have used this plan to place cylinders around 300 piles in the New Farm wharf, and it has been found to be thoroughly satisfactory. The work is done by gangs of two men. It is possible for two men, under the Brisbane conditions, to put on, regularly, about 11 feet of casing a day. Some days only 10 feet may be constructed, for the tidal conditions may be adverse. I should imagine that, under the conditions at Darwin, it would be possible to do even more than 12 feet a day. I pay the leading hand of the gang 23s. and the other man 20s. a day. In one of the cases in which I had trouble, the men were not reliable. I found that the sand was running away. I reported the matter to the management, although it was my "pigeon," and he said, "You will have to get a diver." I did not do that. I simply had the cylinder withdrawn from the water. I broke off lengths until I found the fault, and it was in the bottom section. There was a hole in it. Having found the trouble, I set to work to have the cylinder reconstructed. I have a system of wedges and hooks which hold the frames in position. The cylinders are about 3½ inches thick. The inside frame is left in position for some time, but it is taken out before the cylinder is complete. I have a method under which, by using pieces of galvanized iron with a timber beading, I am able to complete the cylinders in position after the inside casing has been removed. To make the joint as complete as possible between the sections, I use puddled clay, which has been through the machine. I have found brickmaking clay to be most satisfactory for the purpose. The outside frame is taken away after one day. The inside casing is left until the cylinder rests on the ground. It is taken away then, because it would be more difficult to get out after the cylinder had been allowed to sink into the mud. About 3 inches of sand is allowed for between the pile and the cylinder. Of course, some piles are larger than some others, but that is what we aim at. If I have an extra large pile, I make my frames larger so that there will still be the 3 inches for sand in between. The cylinder sheathing is uniform in thickness from top to bottom, and we aim at allowing a cover of about 1½ inches on each side of the steel reinforcing. I have not seen the slightest sign of rusting on any of the 300 piles we have sheathed at the New Farm Wharf. There is no reason, of course, why a covering of 4 inches should not be put on, if that were considered desirable. The company fixed the price of this sheathing at 16s. a lineal foot. It is conceivable that under some conditions the work might cost a good deal more than that. In some localities cement, gravel, stone, and labour may be more expensive than at Brisbane. I would be quite prepared to undertake to put this sheathing on piles for a Darwin wharf. I do not think the fact that the piles would need to stand so high out of the ground would be a detriment I understand that it might be necessary for them to be 60 feet out of the ground, but I am still satisfied that this sheathing, on wooden piles, would give a satisfactory job. I believe that if the wooden piles could be satisfactorily sheathed, it would be advisable to build a wooden jetty at Darwin. Wooden piles are less expensive, they can be driven more easily, and there is a certain amount of spring in them which is not in a concrete pile. I quite realize that if a ship bumped a cement pile, a wooden pile, or a concrete-sheathed pile, damage might result. I believe that every wharf ought to have fender piles. I recommend the use of bloodwalings should extend down the piles for a wharf under the Darwin conditions, is most important. I have been in a punt carrying a ton of sand under a wharf which has bumped piles which have had my cylinders on, and there has not been any vibration, whereas the vibration on an unsheathed pile was serious. The pile is, of course, strengthened according to the thickness of the concrete. For that matter, we could fill concrete in between the cylinder and the pile, instead of sand. I do not think it would be necessary to use walings on a wharf such as it is proposed to build at Darwin, except near high water mark. I consider that my system of encasing the pile in the cylinder would be sufficiently strong. Of course, if cement were filled in between the wooden pile and the cylinder, the cylinder would be there for all time, whereas when sand is filled in, it is possible to lift the cylinder to do any repair work that might become necessary through accidents. If fender piles are put in, the position is reasonably safeguarded. It is not a very serious matter to take out a broken fender pile and put in a good one, but it is to take out a main pile and put in another. The fender piles, of course, are a cushion between the main piles and the ship. I have seen piles 100 feet long driven at New Farm with a 35-cwt. monkey. We had no trouble in the work. The piles were spliced with a steel sleeve, and were driven into the mud until they reached the rock, and made the monkey jump. The depth from the ground to the deck was about 30 feet. The lowest waling was about 10 feet from the ground. There was some waling about 30 feet from the ground, but the teredo got into it, and it had to be removed. I would bring the waling along the top of the cylinder. If lower walings were necessary at Darwin—though I do not think they would be—they could be bolted on to the cylinders at the necessary place. That would give strength. As an engineer, I assert that under my system a satisfactory wharf could be built at Darwin of timber piles, even if it were 60 feet from the ground to the top of the wharf.

79. *To Senator Reid.*—It is hard to say how long steel used for walings between wind and water would last. I know that some old railway rails were used in the Brisbane River in 1912, and they are still good. They are submerged by the tide twice in every 24 hours. The walings I mentioned as having been affected by the teredo were useless If necessary a concrete casing could be put around the steel waling.

80 *To the Chairman.*—I am quite satisfied that concrete cylinders could be put on timber piles for the Darwin wharf. The cylinders could be made as strong

as was desired. Of course, if more concrete were used the expense would be a little greater. I advocate my system because of its economy. Timber piles are cheaper than concrete piles. They are much more easily handled and much more easily driven. They are also much more resilient. The cylinder casing costs 16s. a lineal foot in Brisbane. The process has been patented. A wooden pile costs in Brisbane about 7s. a lineal foot. The prices of a 60-ft. wooden, concrete-sheathed pile, at Brisbane, would be £53; made up as follows:—60-ft. wooden pile, £21; 40 feet of concrete sheathing, under my system, at 16s. a foot, £32. A 60-ft. concrete pile at 27s. a foot would cost £81. A 75-ft. pile would cost at least 30s. a foot in concrete, which would total £112 10s. A 75-ft. pile, sheathed under my method, would cost £81 15s., the details being, 75 feet of wooden pile, at 9s. a foot, £33 15s.; 60 feet of cylinder, at 16s. a foot, £48. Another advantage of my system is that if a cylinder is damaged as it is being let into position, the damage becomes apparent when the sand is being filled in. If a concrete pile is damaged under water, in the driving, nobody knows about it. A damaged cylinder could be repaired easily, but a damaged concrete pile could not be. My trouble in placing my cylinders in position is not to get them to sink far enough into the mud, but to prevent them from sinking too far. I have not yet interviewed Mr. Cullen, the Chief Engineer of Harbours of Queensland, about my scheme, but I propose to do so when I return to Brisbane. I know several Queensland harbour boards are constructing reinforced concrete piles. I have laid my system before Mr. Hill, the Commonwealth Engineer of Works and Railways, and he was impressed with it. Mr. Cullen has had a long experience of wharf work. I have been doing nothing else but wharf work for the last thirteen years. I have seen timber piles and timber head-stocks in Melbourne covered with concrete. The work was being done a year ago. I took the opportunity the other day to go and have a look at it, and the concrete was quite satisfactory. Although Mr. Goudie, of Bowen, favoured a concrete top where there were concrete piles, I have seen concrete satisfactorily used on timber.

81. *To Mr. Mathews.*—My cylinders add strength to the piles and combat the teredo. If teredo get in the mud, they are suffocated. If they were to get into sand between the cylinders and the piles, under my system, they would also suffocate.

82. *To Mr. Mackay.*—The longest period that my cylinders have been on piles is three years. I have been at this work continuously for three years. I had charge of the extension of the stevedoring company's wharf at New Farm. I have seen no sign whatever of any rusting through the cylinders on that wharf. At Bulimba, in Queensland, timber piles are sheathed with short concrete pipes. This left the joints in an unsatisfactory state. The pipes were only 1½ inches thick, and rust showed through in a very few weeks' time. The advantage of having my cylinders filled with sand as against concrete is that if any alterations take place in the bed of the river, it is possible for the cylinders to adjust themselves to the new conditions, whereas, if the cylinders were filled with concrete, and the bed of the river altered, the cylinders would be left in their original position.

83. *To Mr. Cook.*—I have seen muntz metal taken from piles which had been in position for 20 or 30 years in the Brisbane River. The metal was good, but thin. I have heard theories expressed as to the reason for the deterioration in muntz metal, but I have no desire to express an opinion on the matter. I have had no experience at Fremantle, but I should think that timber piles would be cheaper anywhere than concrete piles. In 1920 I was engaged by the South Australian Company to advise them as to the condition of their wharfs, at the time they were resumed by the South Australian Government. The company was claiming £750,000 from the Government. During my inspection, I uncovered some sheet-piling at the back of one of the wharfs. It had been in the ground a long time, but the part that was in the ground was as good as the day it was put in, whereas the part above the ground had been seriously damaged by the teredo. I submit that if sand is filled into the cylinders around wharf piles under my system, it will always be in practically the same condition as timber which is driven into the ground. The teredo make no inroads in timber driven into the ground, and I cannot see that they will do any damage to timber which was continually under the conditions that I have explained. I have heard that teredo attack concrete, but the suggestion makes me laugh. When I first began work on the Brisbane Stevedoring and Wool-dumping Company's wharf at New Farm, I used the Monier process, but it was expensive. I was encouraged by the company to develop my ideas.

84. *To the Chairman.*—The reinforcement is held in position carefully, while my cylinders are being constructed. The concrete covering is about 1½ inches on either side of the steel. I use 3 to 1 concrete, with Ace brand Queensland cement, and carefully graded gravel. I train my men myself. I understand that Mr. Boult, the harbour engineer at Cairns, said that he would make concrete piles 24 inches by 24 inches if he could handle them. That would mean that a 60-ft. pile would weigh about 15 tons, which is a tremendous weight to handle. My experience is that a 1½-in. covering of the reinforcements, with good cement, is sufficient to prevent rust. Assuming that the Committee decided to recommend that my system be adopted at Darwin, I should be content for it to say what royalty could be paid me for the use of my patent. I should take it as a compliment if the scheme were adopted, and would be content with a reasonable return.

85. *To Mr. Mackay.*—The wharfs in the Brisbane River are generally of timber construction. The Commonwealth Works and Railways Department has decided to adopt my scheme for the Naval wharf in the Brisbane River. I shall have charge of the work. I already have the contract.

86. *To Senator Reid.*—I mix my concrete with fresh water, and use washed river gravel and sand. The Brisbane River gravel is salty, but I have not found that that makes any difference to the quality of the concrete. I always specify that fresh water shall be used. I do not know whether salt water would be less effective, but I am not prepared to take the risk. Each section of the cylinder as it is constructed is submerged by the tide, but I have not found that to make any difference to the joint for the next section. I use round steel, but I should be quite prepared to use square if necessary. We take considerable pains to ensure that the reinforcement shall be in the middle of the casing, and so in the middle of the concrete. I certainly hope that other wharf-owners will adopt the scheme. If they are wise they certainly will do so.

(Taken at Melbourne.)

THURSDAY, 27TH MAY, 1926.

Present:

Mr. MACKAY, Chairman;

Senator Barnes	Mr. Gregory
Senator Lynch	Mr. Lacey
Senator Reid	Mr. McGrath
Mr. Cook	Mr. Seabrook.

Joshua Fielden Ramsbotham, Director of Lighthouses, sworn and examined.

87. *To the Chairman.*—In 1924 I was instructed to prepare a scheme for improved wharf facilities at Darwin, and gave evidence with regard to my proposal before the Committee in March, 1925. The desire was expressed that I should visit Darwin and submit a further report after viewing the wharf, and, if necessary, obtaining further data, and at the same time modifying, if required, any of the conclusions submitted in my report of 17th October, 1924. Fortunately, Mr. G. Whiteford, the Secretary of the Committee, was able to accompany me and witness for himself some of the data I was able to collect, particularly in relation to the direction of the flood tide. I arrived in Darwin on *R.M.S. Murella*, at half-past 8 a.m. on 14th October, 1925. The weather conditions being favorable, no difficulty was experienced in berthing the vessel. When confronted with any abstruse problems, it is always a good thing to discuss such with experienced specialists who have had actual experience in the difficulties with which you are confronted. Amongst others, I consulted Captain Edwards, who has had extensive experience at Darwin, and, although he is now a very old man, his brain is clear, and his knowledge is most interesting, and he directed my mind and thoughts into channels which were well worth developing. Captain Edwards told me that the tides at Darwin are crazy, and that there are three tides all at the same time. In reply to my question as to silt being carried in suspension in the wet season, he said there was very little discoloration and very little siltation. I asked him who was responsible for the present layout or direction of the present wharf, and he replied that a deputation of master mariners had decided that question, and that they had been wrong. This was interesting, and showed how very careful engineers must be in finally deciding such problems. Time after time I have found, when confronted with the problem of deciding on the location of a new light, that hardly two mariners ever agree, so one has to use one's own judgment. Captain Edwards' contention with regard to the three tides or direction of the current of the flood spring tide, opened out an important avenue, and his further contention that there is an ebb tide for one and a half hours at the jetty whilst the flood tide still continued to make outside the jetty required some careful investigation. I took evidence also from Louis Roman, a seafaring man who works for the Railway Department in Darwin, and, when required, acts as a diver. He struck me as an observant man and one who knows the local conditions. He stated as follows:—

A cyclone took place in Darwin on 6th January, 1898. It commenced blowing in the east-south-east, working to south-west, the greatest force coming from the south. All boats in the harbour were smashed. Heavy blows took place in 1913 (at the end of the year), and in February, 1916, April, 1916, and on the 9th March, 1918. The last blow commenced at 5 p.m. on 9th March, 1918, the wind coming from the east-north-east. The greatest force was at midnight from the south-east, finishing from the west. The cyclone blew itself out at 5 p.m. on the 11th March. There was a big sea in the harbour, which damaged the promenade at Fort Point, and also the abutment of the viaduct to the jetty.

This information was of first class importance. Evidence of the damage done was observable. It points to the advisability of taking full advantage of the natural protection afforded in the bay, and to the wisdom of getting ships right into the bay, instead of leaving them exposed to the full fury of the tempest outside the headlands. For observation purposes, I had some floats made of oregon, 15 ft. x 4 in. x 4 in., suitably weighted, so as to float perpendicularly, leaving 12 inches above the surface of the water. There was a very light north-west wind. The tide was about half flood, and the depth of the water when the float was put in was 43 ft. 0 in., its position being 650 feet south from Fort Point light. The float travelled in S. 87° E. direction, at the rate of 1½ knots. Other floats were also put in, and all acted precisely the same way. In addition, concentrated aniline dye mixed with fresh water and poured over the side confirmed the direction of the floats, but it did not travel with the same speed. This was interesting, as it showed that the wind did not influence the speed of the floats, and that the velocity of the water underneath the surface was slightly greater than on the surface. There is clearly an area in the vicinity of Fort Point where slack water is prevalent, but the main conclusion demonstrated was that the direction of the flood tide is S. 87° E. This being so, it is evident that the main direction of the flood tide is away from the present jetty, and that the fear of siltation on the flood tide is an imaginary, and not an active, factor. I was considerably surprised, and naturally pleased, on this being demonstrated, and the reason is obvious. The chart shows that at the head of the bay there are three inlets or bays, viz., east arm, middle arm, and west arm. Roughly, the areas of middle arm and west arm combined are three and a half times greater than that of east arm. Consequently what is sometimes called the tidal prism, or volume of water from low to high tide, fills up east arm some considerable time before the middle and west arms. This accounts, not only for the draw or direction of the floats on the flood tide, but also is the solution of the ebb commencing at the jetty whilst the flood tide is still running towards middle arm. In addition, it explains Captain Edwards' very pertinent remark—"The tides at Darwin are crazy." I unreservedly agree with him. I am satisfied that the direction, as already given, for the ebb tide is correct in the vicinity of the jetty. However, the time at my disposal at Darwin was limited. Without doubt, to clearly define the demarcation of the currents means some months' work. Nevertheless such work should be done, and permanent data established. Although the extent of my data was limited, yet what was obtained was of a definite character, and I submit that the conclusions drawn are correct. The oldest recorded tide table is in the British Museum. It was published in the thirteenth century. The Admiralty published the first modern tide table in 1833, and the United States of America commenced publishing tide tables in 1853. The study of tides is a very important branch of applied science. The publication of tide tables would be of inestimable value to mariners and engineers. One so often hears the expression, "Catching the tide," that it needs no stressing on my part, beyond stating that knowledge beforehand of the time of high water results, not only in the saving of time and money, but possibly in the safety of a ship. At the recent conference of the port authorities of Australia, the following resolution was carried:—

That the members of this conference consider it desirable that tidal information available in Australia should be included in the Admiralty tide tables, and to enable this to be carried out they are prepared to recommend to their authorities that the necessary information should be forwarded to the Hydrographic Branch, Department of Defence, for transmission to the hydrographer, Admiralty, London.

Australia has accepted nationhood, and to my mind one of the many responsibilities involved is the collecting and tabulating of the tides around the coasts of Australia for the benefit of ships of all nations. The proper person to do this important work is the hydrographer, Navy Office. The cost involved would be small, and the benefit correspondingly great. I am glad to say that the hydrographer has the matter in hand. Mr. Mehaffey, in his report to me of 29th July, 1924, states, in paragraph 30—"I was informed that during the wet season the ebb stream is much discoloured, indicating considerable quantities of sediment in suspension." I could obtain no confirmation of this statement. Captain Edwards was emphatic that very little discolouration took place, and Mr. Bell, Commonwealth Assayer and Analyst, said that the discolouration was so small, even during the wet season, that he would be unable to measure it with a percentage glass, and would require a filter paper. Mr. Bell was asked to obtain samples during the forthcoming wet season. He forwarded two samples, but unfortunately one bottle

was broken. The sample which I produce was taken outside the end of the jetty at high tide on the ebb for about 30 minutes. Mr. Mehaffey's report also states, *inter alia*, in paragraph 23—"As this relatively steep slope is at the edge of the tidal stream, and is maintained by the stream, it appears probable that any area in the harbour not scoured by the tide will tend to rapidly silt up, and to approach a state similar to that now existing in the bay." This is an arbitrary statement, based largely on assumption and wrong premises. When, on 1st April, 1925, correcting the proof of my evidence as given before the Committee, I took strong exception to this statement, after digesting what was really meant. Assuming that Mr. Mehaffey is correct, it means that, unless the Government is prepared for heavy maintenance dredging, they must build their extensions in the stream, depending on the scour of the tide for maintaining the depth of water. The first principle of harbour design is to get the ship into protected waters. Even if Mr. Mehaffey is correct in his assumptions, which he treats as probabilities instead of possibilities, I say deliberately that the safety of the ship is the first consideration, and that the cheap and economical loading and working of the ship is the second consideration. Both these features are obtained in the proposals I have submitted, and I still maintain that, whilst a certain amount of siltation will take place, it will be limited in extent. Mr. Mehaffey has made several counter proposals, or schemes, which possibly may be worth studying. I disagree with those proposals, because the safe working of the ship has been made secondary to wharf considerations, and, although dredging costs may possibly be avoided, heavy costs in repairs to the wharf and ships will inevitably result. In particular, I take strong exception to any proposal to build a wharf from Fort Point in a line with the existing jetty. Railway communications would be bad and expensive to build, the wharf would require initial dredging near Fort Point, and, if discolouration or silting takes place, maintenance dredging would be required, as slack water is found in that vicinity, the current commencing some 400 odd feet north-east of Fort Point light. Inevitable berthing difficulties would be experienced, with corresponding expense in repairs on the ship and wharf. In addition, the ultimate future growth of the port would be retarded and cramped, as only quayage of 1,650 lineal feet could be provided, whereas my proposals provide for 5,615 lineal feet of quayage. I submit that, as no man can foresee what the future of the Territory will be, a wise man will jealously conserve every available foot of possible quayage. With the exception of the 11 feet width added to the back of the jetty (which has wooden piles and was built during the war), the wharf is in good repair, and, if anything, I should say that Mr. Hobler's estimate of 25 years for its life is a conservative one. At the same time there is evidence of severe treatment from ships, so that its future is problematical. As it stands, it certainly does very great credit to those who designed and carried out the work, and also to those who maintain it. It would be little short of lunacy to dream of removing the structure. The turntable is certainly a drawback, and if any delay is going to take place in the future extensions, then I most certainly urge that 120 feet radius curves and additional decking be at once authorized and executed. The Administrator informed me that Vestey Brothers were going to close down entirely and cut their loss. No doubt, steps will be taken to confirm this before making extensive additions to the port. I gave my evidence with regard to the caisson on 16th March, 1925. Since then, I have, as a matter of interest, developed the design of the caisson and gone into the problem in some detail, as shown in the accompanying plan. In my previous report to the Committee, I mentioned that any uplift due to water under a dock was neglected entirely at the port of Liverpool. It is admitted that there are differences of opinion, and I have endeavoured to find some modern authoritative statements on the subject. I found, in the *Proceedings of the American Society of Civil Engineers* for August, 1925, in the discussion of the "Final report of the special committee on stresses in structural steel," that a Mr. Edward Godfrey stated, *inter alia*—

> Witness the long-established practice of designing dams in total disregard of under-pressure and pressure in the horizontal joints, and the long list of failures of dams because of the reality of this pressure; then witness the recent flouting of underpressure as an element in the design of dams by authoritative utterances. . . . To show justification for radical change in design, there must be some strong reasons set up—something that will stand the light of analysis. Judgment is not a reason. Majority vote never made a truth nor repealed one.

It will be noted that I have quoted an authority who holds views contrary to my own, but, at the same time, Mr. Godfrey admits that the majority of engineers are of the same opinion as myself. I can only reiterate that my views were accepted by the eminent engineer under whom it was my good fortune to serve, and further, as already mentioned, they have been supported by practical experience. It will be noted that the main alterations to the caisson are the subdivisions into what might be called "small boxes," and the increasing of the width of the base to 26 feet, and making the face of the walls perpendicular. By this means the intensity of pressure on the toe of the wall has been slightly decreased, and the buoyancy of the caisson increased. Both considerations are of value. The weight of the caisson in the dry before launching is 1,623 tons. The draft after launching will be 23 ft. 4½ in., giving 12 ft. 7½ in. of freeboard. This will enable 5 ft. 3½ in. of concrete being placed in the caisson before it takes the ground. It is pleasing to be able to say that the amended design will result in a slight saving, and I am satisfied that if the working drawings are made they will approximate the plan and design now submitted. It would be mere repetition for me to dwell any further on the proposals, but I submit and emphasize that it is not size that makes a port, but efficiency and convenience of lay-out, adequately assisted by cargo appliances. This will demonstrate itself forcibly in time. Everything points to the fact that severe competition can be expected in the near future, so unless cargo can be handled both cheaply in and out of ships, both the manufacturer and producer will be penalized to such an extent that ruin will face the community, and the natural development of the country will be strangled. If possible, I should like to see branch dock A B C entirely completed, with dock walls built on caissons, but I fear that is out of the question. At the same time I desire to modify my proposals for quay "B," as I consider that if a ferro-concrete jetty were built it would possibly be damaged by the violence of the cyclones, and certainly would be damaged if a ship happened to be moored there during such a storm. In its place I recommend a solid wall built on caissons as recommended for quay "A." This would mean an increased cost of £4,446, bringing the total cost of quay "B" up to £90,042. If a really violent cyclone should take place minor damage might be done to the pitched slopes. The damage would be local and easily repaired. For that reason I should like to see the whole dock completed with solid walls, as then there would be no fear of any damage from ships or wave action. The whole problem has been a most interesting one. I am glad to have been able to carry out the desire of the Committee, and visit Darwin, so as to be able to speak with first-hand knowledge, and I cannot help thinking it was most fortunate and wise to permit Mr. G. Whiteford, secretary to the Committee, to accompany me. His knowledge of the problem and his co-operation in gathering data were helpful throughout the whole of my consideration of this problem. I am not endeavouring to bolster up my own proposals and seek, possibly, some credit if my scheme be accepted. I can only add that if "the floats" had taken a contrary direction on the flood tide I should unhesitatingly have sought permission to amend my proposals, as after all one's own ambitions and desires must be secondary to what will be beneficial to the country. The moment that a harbour engineer ignores the wonderful and merciless laws of nature he sins against the light, and not only are the results disastrous to his reputation, but they leave behind for all time a load of debt which it is seldom possible to remove. I am satisfied, from what I saw at Darwin, and from the data collected by Mr. Mehaffey, that all the information requisite for the formation of a definite opinion was obtained. My mission was to inquire definitely into the danger of siltation, and, of course, to study the currents. I do not say that it will not be necessary to dredge, but in my opinion only a limited amount of dredging should be required. The closing down of Vestey Brothers' works has materially affected the entire scheme. If those works remain closed the need for such a scheme will not be so urgent. I met Sir George Buchanan, who was instructed by the Government to inquire into Australian ports and harbours, and I gave him the benefit of my knowledge of Port Darwin. He had a copy of my report. I told him that, as an engineer, I should be only too happy to discuss the Port Darwin problem with him. He agreed that such discussion might be desirable, but I did not see him again. I have not the slightest idea what Sir George Buchanan will recommend, but I am inclined to think, from what Admiral Hall-Thompson told me, that Sir George is not in favour of my scheme. I understand he apprehends some danger of siltation. I shall be severing my connexion with the Public Service in the near future, as I intend to engage in business as a consulting engineer. If my scheme is adopted I shall be available, if required, to carry it out. It is the custom to retain the services of an engineer whose scheme has been approved.

88. *To Mr. Gregory.*—Stone for the concrete work is readily available. The material from Stokes's Hill will be suitable for filling, but it will have to be faced with harder stone. In a harbour like Darwin, which is subjected to heavy tropical storms, it will be necessary to use heavy stones for the facing, particularly near the end of the mole. I do not think that any appreciable degree of siltation will take place. My observations have led me to the conclusion that the construction work, as designed by me, will have the effect of pushing the current further out. A certain amount of dredging will, of course, be necessary; and I suggest the use of a bucket dredger. Later a small suction dredge should meet all requirements. I anticipate no damage to caisson construction through electrolysis. As the structure will be absolutely solid, its permanency should not be affected in any way. I do not approve of galvanized steel as reinforcement material. The essence of ferro-concrete work is that there should be no skin between the cement and the reinforcing material. Therefore, galvanizing of the steel rods introduces an element of danger. In this respect I differ absolutely from the opinion expressed by Mr. Adams, of Sydney. My late chief almost would have fainted had any such proposition been made to him.

89. *To Senator Reid.*—I do not agree that, in the process of reinforcement, the galvanizing material becomes part of the metal itself. This question has been raised before. Whilst I was resident engineer at the Port of Liverpool a contract was let for the erection of three-storey ferro-concrete warehouses. The contractor was late in getting his steel on the job, and when it came to hand it had the "bloom" on it. The port of authorities made the contractor wait until the "bloom" had rusted off, because of the risk that unless the cement could adhere to the steel itself serious trouble, if not a disaster, might occur at a later stage.

90. *To Mr. Gregory.*—In the event of Vestey Brothers closing down definitely, and assuming that the Government does not authorize expenditure on a new scheme at Darwin, it should be possible for a comparatively small expenditure to improve existing facilities. This work could be done by the existing staff. I should say that the present jetty should last fully 25 years. The cast-iron piles should have a long life. Where necessary, the bracings could be repaired. The condition of the jetty reflects credit on the staff there, and shows that they have the interest of the Commonwealth at heart. I cannot say definitely what it would cost to get rid of the turn-table and put in the 120-ft. radius curve, but the expenditure should not be very considerable.

91. *To Senator Reid.*—Being an officer of the department, the scheme which I have prepared belongs to the Commonwealth. If the Government adopts it I shall be available to supervise construction if my services are required. Although I may have done a little extra work in connexion with it, it has given me a certain amount of pleasure. The Government is at liberty to do anything it likes with the scheme without further consideration for me. My scheme is based upon Mr. Mehaffey's borings. Generally speaking, borings to test the nature of the bottom for harbour works are not necessarily conclusive. The practice at Liverpool, when I was employed there, was to put down a shaft and ascertain beyond all doubt the character of the ground. It would be too costly to put down a shaft at Darwin, because the tide comes fairly well up. From my observations and from data obtained, I am satisfied that the work could be undertaken on the basis of Mr. Mehaffey's borings. I think that most of the trouble experienced when the existing wharf was constructed was due to the fact that the stone filling was deposited on a deep strata of mud which shifted under increasing pressure. The only thing to do in such circumstances is to keep on tipping the filling material until all movement ceases. Provision is made for a considerable extension of my scheme, and should future requirements warrant the additional expenditure, the present proposal will, I understand, meet the needs of the naval authorities A modern cruiser could berth there, and although the stern might project a certain distance beyond the end of the wharf, the vessel could be handled satisfactorily.

92. *To Mr. Seabrook.*—The cost of quay "A" is estimated at £223,034. It is difficult for me to say whether the expenditure would be justified in the event of Vestey Brothers closing down definitely, but the problem has been altered considerably since I presented my report, owing to the decision of Vestey Brothers to close their works. I do not care to say if the existing facilities will meet requirements for the next ten or fifteen years in the event of Vestey Brothers deciding not to reopen their works. If the Government decides on certain railway proposals in the Northern Territory, there will be a considerable amount of traffic in rails, sleepers, and other material, and possibly improved harbour facilities will be necessary. We have to remember also that if nothing is done there will be less prospect of increased trade.

(Taken at Melbourne.)

TUESDAY, 1st JUNE, 1926.

Present:

Mr. MACKAY, Chairman;

Senator Lynch	Mr. Gregory
Senator Reid	Mr. McGrath
Mr. Cook	Mr. Seabrook.

Rear-Admiral Percival Henry Hall-Thompson, First Naval Member, sworn and examined.

93. *To the Chairman.*—I am aware of the proposal to construct additional wharfage accommodation at Darwin. I have visited Darwin, and am acquainted with Mr. Ramsbotham's proposals for a wharf, using concrete caissons. If Darwin is to be considered a port, I consider that the proposals of Mr. Ramsbotham are essential. At present the tides run through the piles of the existing wharf, and considerable difficulty is experienced in securing a vessel to, or in taking it from, the wharf. That is because of the range and strength of the tide, which has a rise and fall of 26 feet. I am impressed with the plan prepared by Mr. Ramsbotham, which is the best I have seen. I have discussed this matter with Sir George Buchanan and, while I do not know what his scheme will be from the conversations I had with him, I feel that he will not improve on Mr. Ramsbotham's plan. It is hard to say whether silting will take place between Fort Hill and Stoke's Hill, because the effect of an alteration of the natural run of the tide is hard to estimate. Personally, I think that the effect of carrying out this proposal will be to throw the tide further out to sea, and that the most of the silt will be taken with it. In the dock itself there will be practically dead water, and very little silt. Whatever silt might accumulate there could easily be removed by dredging. For naval purposes the existing wharf could be used, but it would not be satisfactory. It would be too small to accommodate a modern cruiser. Mr. Ramsbotham's proposals will not provide a wharf of sufficient length; but I think the difficulty could be overcome by extending the two wharfs to a point or by placing a mooring pylon where the two wharfs, if extended, would meet. For the new 10,000-ton cruisers, a wharf 630 feet long is necessary. For our purposes, a concrete wharf would be better than one of timber. The chief difficulty at Darwin is due to the rise and fall of the tide, and the current running through the piles not parallel with the wharf. The turntable now on the wharf is a decided disadvantage. The depth of water at low tide is about 30 feet, which is ample. I am not sure that vessels could be so easily secured under existing tidal conditions to a concrete wharf as to one of timber, where the vessels are secured to a ring at a level midway between high and low water; but it would be much easier to come alongside, or leave. I prefer the Stoke's Hill site to the Fort Hill site for a wharf at Darwin. The oil tanks at Darwin are being constructed for the Navy. They are being placed at Stoke's Hill. The necessary material for filling could be obtained easily at Stoke's Hill. The construction of a wharf at Fort Hill would be more expensive than one at Stoke's Hill, and, in addition, there would be more silt. Moreover, the existing facilities would not be utilized. While it is always an advantage to have a crane handy to ships at wharfs, the Navy does not anticipate undertaking any large repair work at Darwin. As a commercial proposition, something should be done with the existing turntable. I have not made a close inspection of the existing wharf, but I have been in a vessel which has laid alongside it for four or five days. So far as I saw, it was a sound wharf, showing no signs of deterioration. I should say that its condition was almost equal to that of a new wharf. I did not notice any wooden piles near the shore. I recommend a wharf of concrete construction, especially as it would have the effect of throwing off the tide and making still water in the dock. It is difficult for me to say anything regarding the urgency of this matter without disclosing naval secrets, but I can say that it is an urgent necessity for Australia to have some protected harbour of refuge in the north. Darwin is the best place from a naval point of view, although Napier-Broome is probably a better harbour. The hinterlands there, however, are mountainous and rough, and it will probably be a long time before there is any connexion from the land side. Darwin appears to be the place where railway connexion from the south will terminate. It also will probably be the port of call for airships. On my return from the Singapore Conference, I called at Darwin with two cruisers—the *Sydney* and the *Concord*. Some inconvenience was experienced when leaving the wharf, although we got alongside easily. I do not suggest that the present jetty is in the wrong position, but the tide running through the piles of the wharf has a bad effect. A solid concrete wall would obviate that. When leaving the wharf, one of the after wires jammed, and the ship's bows swung round violently. The position was made worse by the fact that off the end of the jetty there is a shoal. I do not think that any direct representations regarding this wharf have been made by the Navy Department, but a great many recommendations have been made regarding the desirability of developing Darwin from a naval point of view. I do not know whether the provision of additional wharfage facilities has actually been recommended in writing, but it has entered into many conversations. While I do not say that it would be impossible to get the new 10,000-ton cruisers alongside the existing jetty, the task would be extremely difficult, on account of the scend of the tide and the jetty being insufficiently long.

94. *To Mr. Seabrook.*—The tide at Darwin moves at probably 2½ to 3 knots an hour. If this wharf is constructed, I understand that the intention is to fill in at the back. Mr. Ramsbotham informed me that if Stoke's Hill were cut away, sufficient good filling would be obtainable. Any dredging necessary would be done before the wall was built. In that case, the material obtained by dredging could not be used for filling. After the construction of the wharf, I should not anticipate much trouble from the current causing siltation. With dead water inside the dock, there would not be much silt. The wall would stop the current. Including naval vessels, the average number of vessels which tie up at the Darwin wharf in a year would probably be about 70. They would be vessels similar to the *Marella*, with a displacement of about 4,000 tons. Those vessels call with mails. When I recommend the construction of a wharf at Darwin, I speak entirely from a naval point of view. I should say that, for commercial purposes, the existing wharf is sufficient for present requirements. From a naval point of view—the defence of Australia—a new wharf would be a great asset. In peace times the 10,000-ton cruisers would probably not visit Darwin on many occasions. The provision of additional accommodation to suit the cruisers is a war precaution. So long as there is little or no trade at Darwin, no special wharfage facilities will be necessary from a commercial point of view; but I consider that the turntable adds about 10s. a ton to the cost of handling goods on the wharf. The absence of sheds is also a disadvantage, because all goods requiring protection have to be transported from the wharf to the town. If they are reshipped, they must be taken back again. I suggest that if this work is carried out, the sheds should be on the wharf. I do not recommend additional cool stores, as they are not wanted.

95. *To Senator Lynch.*—Under existing conditions, no other port would serve the purposes of the Navy so

well as Darwin. Napier-Broome is a better harbour, but everything seems to point to Darwin as the future centre of activity in the Northern Territory. The superiority of Napier-Broome as a port is chiefly due to the rise in the tide there being 6 feet only compared with 26 feet at Darwin and 27 feet or 28 feet at Broome. The entrance to Napier-Broome offers no objection; it is a good harbour, as is Darwin also. For the purposes of the Navy, Darwin is the right place to be developed. Darwin provides good anchorage, and, moreover, the harbour is well concealed. A large fleet could be anchored and protected there, if necessary. As a harbour of refuge for the Imperial Navy, it would be invaluable. The only existing reason for additional wharfage accommodation is to facilitate ships taking in oil. Repair work will probably be done by a repair ship, and not at the wharf. For serious repairs, vessels would have to be sent south or to Singapore. If Darwin were developed considerably, and workshops and other facilities provided, ships could be repaired there; but I should not suggest the provision of such facilities until there is considerable development in the Territory. It would depend on the progress made in the north whether repair ships were sent there or accommodation on land provided. I have consulted with Mr. Ramsbotham regarding the dovetailing of naval and commercial interests at Darwin.

96. *To Mr. Cook.*—I consider that Darwin is the best port in the north, from a Navy point of view, and that the expenditure involved in the construction of this jetty would be justified. I have no expert knowledge of concrete wharfs, as I am not an engineer; nor have I any knowledge of the possible future development of the north, other than that which I have gained from reading and conversations with various people. From a naval point of view, the wharf would be a great asset, though not absolutely necessary.

97. *To Mr. Gregory.*—I have seen the plans prepared by Mr. Settle many years ago. His idea was to overcome the difficulties caused by the tide by providing locks. From a naval point of view, that system has many disadvantages. With a lock system, vessels can only get away at high tide. Naval requirements necessitate vessels leaving at any time. I consider that Mr. Ramsbotham's scheme is satisfactory from both the naval and commercial stand-points, although I consider that quay A should be a little longer. The flow of the tide is from the direction of quay A. The Navy Department has fairly full reports of the tides at Darwin. A survey ship is there now, but she is surveying the outer approaches. Mr. Ramsbotham's scheme has not been examined by the officers engaged in the survey. If the construction of this wharf is delayed, the Navy would have to make the best use of existing facilities. It would be very awkward, however, with the existing facilities, to deal with large stocks of oil. I do not anticipate another harbour being selected in place of Darwin. The oil tanks were originally intended for naval purposes only; but we have now agreed to supply the people in the interior with oil and petrol, so long as a sufficient reserve for naval purposes is maintained.

98. *To Senator Reid.*—In times of peace, the Darwin harbour would probably be used very little by the Navy. With the existing wharf, vessels can take in oil at certain times only, because they can only go alongside at certain times. The existing light cruisers could be accommodated at the present wharf, but the new cruisers, being longer than the present wharf, would be awkward to handle. Apart from oil, the Navy does not require stores at Darwin in peace times. There are no stores there now, except a certain stock of coal. Although Darwin is subject to cyclonic disturbances, she has been fairly free from actual cyclones. Oil would be supplied to vessels by means of pipes or hoses. Darwin might not be the best strategic position for a harbour, but is the best one available. Gladstone, on the Queensland coast, is not so well situated from a strategic point of view. Wherever there is a big rise in the tide a good deal of disturbance in the water takes place, and there is always the possibility of silt. At Darwin, the water is rather muddy. There is not much silt in dead water. This plan provides for dead water in the dock. The scheme submitted would improve conditions vastly, so far as bringing in vessels is concerned. I do not think that there would be any current across the mouth of the dock. From that point of view, the position would be greatly improved by these works. The British Navy is almost entirely composed of vessels using oil as fuel. There is not the slightest chance of naval vessels reverting to the use of coal. It is impossible to predict any engineering advance which would get more from coal than is obtainable from oil. Anything in that direction would have to be in the nature of the distillation of coal into oil. I am not a man of commerce, and, from a purely commercial point of view, I do not know what should be done at Darwin. It might be desirable to provide greater facilities in order to encourage further development. I do not, however, suggest that this expenditure should be incurred solely from a commercial point of view.

99. *To the Chairman.*—The existing wharf might be satisfactory from a commercial point of view. From the naval stand-point, I consider the expenditure involved in providing extra wharfage accommodation is warranted. Its construction would probably assist in the development of the Northern Territory. My attendance here to-day is the result of a request from the Committee. It is not due to any desire on the part of the Naval Board to make direct representations here regarding the necessity for additional wharfage accommodation at Darwin, although such is the considered opinion of the Board.

100. *To Senator Lynch.*—The removal of Stoke's Hill would be a distinct advantage from a naval point of view. In reality, Stoke's Hill is not a hill, because its summit is about level with the rest of the surrounding country. Between Darwin and Stoke's Hill there is a ravine or gully. With Stoke's Hill cut away, there remains a well-protected position for the oil tanks. The removal of the hill would be an advantage rather than a disadvantage.

101. *To Mr. Cook.*—I have no suggestion to offer for the improvement of the design, excepting that I should like to see the wharf a little longer.

(Taken at Sydney.)

THURSDAY, 24th FEBRUARY, 1927.

Present:

Mr. MACKAY, Chairman;

Senator Barnes	Mr. Gregory
Senator Payne	Mr. McGrath
Senator Reid	Mr. Seabrook.
Mr. Cook	

Robert Limond Ranken, Chief Engineer for Existing Lines, New South Wales Railways, sworn and examined.

102. *To the Chairman.*—I have been associated with railway engineering in connexion with the New South Wales railways system, which is, of course, on the 4-ft. 8½-in. gauge, for 37 years. I understand the Committee is conducting an investigation into the wharfage accommodation at Darwin, and that some information is desired concerning the desirability of dispensing with the turn-table connecting the two wharfs. I have studied the plans in relation to the proposal and am fairly conversant with the position. In connexion with curves, I may state that the

sharpest curve on our 4-ft. 8½-in. gauge is of 132 feet radius, such as we have in the abattoirs, over which our rolling-stock can pass quite comfortably when shunting I understand that the Commonwealth Railways Commissioner has expressed some opposition to the use of a curve such as that proposed. Our trucks are 20 feet in length over buffers, about 16 feet long over the body, and are of from 8 ft. 4 in. to 8 ft. 9 in. in width. We have, also, 40-ton bogey trucks measuring 40 feet over the buffers, which would negotiate such a curve more readily than an ordinary four-wheel truck, which is more rigidly built. I understand that Mr. Bell has also stated that it would be impracticable for his locomotives to negotiate a curve 120 feet in radius, and, of course, I am not in a position to say whether that is so, or not. I may state, however, that none of our standard locomotives would go over our cross-overs on the abattoirs line. I could not give you any help concerning the possibility of Commonwealth locomotives negotiating such a curve, because I am not conversant with their construction. Provision could, however, be made for the use of oil-driven shunters, two of which we have at the Clyde works, for shunting purposes, which can haul a load of from seven to eight full trucks. Such a shunter would be suitable for the work which has to be undertaken at Darwin, if it could be profitably employed on other work when it was not required on the wharf. I am of the opinion that the trucks in use on the 3-ft. 6-in. gauge could negotiate a curve of 120 feet radius, and that the difficulty in connexion with locomotives could be overcome. I do not think Mr. Bell has stated that the trucks would not go around the curve; I understand he refers more particularly to locomotives. The scheme, as set out in the plan before me, is far preferable to a turn-table, and would be, I think, in the opinion of any competent railway engineer. I could not say what expenditure would be involved in substituting a curve for a turn-table, but a rough estimate might be from £8,000 to £10,000. The saving in time and money affected by this proposal would have to be compared with the capital cost of the scheme. It is a financial proposition, but it would be infinitely better to work under the scheme proposed than to continue using a turn-table. It would appear that, by substituting a sharp curve, ships would have to be taken more to the centre of the wharf, and that the accommodation would be decreased from 500 to 400 feet. I do not think that any difficulty would be experienced in the matter of cross-overs or the working of the trucks if the proposal set out in the plan was adopted. The trucks are placed on the wharf empty, and later loaded. The trouble to be overcome in all cases of this kind is in getting the loaded trucks clear of the empties, and the question of sufficient cross-overs on the wharf is one that is governed by the position of the hatches, which position can be altered by moving the vessel. According to the plan, there might be a slight hold-up at one of the hatches on a vessel with three hatches. In connexion with loading wheat, we have installed a system of capstans with cross-overs at fairly close intervals, so that the supply of trucks to the ship may be regulated according to the distance these cross-overs are apart. I should say that the proposal in this instance is for each section to hold about five trucks, measuring 20 feet over the buffers. According to the plan, roughly scaling the distance, five empties would be shunted to the dead end, five more put in between the cross-over, and five more left for the forward or after hatch, whichever might be the case, although I take it that the ship would come in bow first. It might be necessary to alter the position of the cross-overs and put in more, but that would not be a very big matter, as that has to be done repeatedly in connexion with wharfage arrangements to expedite the work. At the Sydney wharfs we have to deal with large White Star liners, which have four hatches, which makes it rather difficult when arranging for the supply of the necessary trucks and the despatch of the full ones without interfering with the arrival of empties.

103. *To Mr. Gregory.*—The advantage of traversers is that the truck can be transferred immediately to the relief road without the loss of space taken up by cross-overs, but that is rather an expensive way compared with an ordinary cross-over. I should not think it necessary to incur the expense of traversers at Darwin.

104. *To the Chairman.*—The cost of laying a new track would not be great. It is the re-arrangement of the wharf that would cost the money. Roughly speaking, 440 yards of line would have to be altered and relaid, which here would cost about 17s. a yard, but probably it would cost £1 a yard at Darwin, making £440 for altering and relaying the line. I do not know whether the points and crossings at present in use could be utilized, and, therefore, cannot say what the cost in that respect would be. From this plan it would appear that two new sets of points and crossings would be necessary, and possibly £600 might cover the cost of rails and relaying them. A rough estimate of the cost of the conversion would be £8,000. With all the trucks man-handled, as I understand they are at present, a turn-table is a slow and expensive method. I would not expect any difficulty in handling rolling-stock over 120 feet radius curve, but I am not in a position to express any definite opinion as to how Commonwealth locomotives could negotiate the curve.

105. *To Senator Reid.*—As 4ft. 8½-in. rolling-stock can easily negotiate a 2-chain curve, rolling-stock working on a gauge of 3 ft. 6 in. should be able to use a curve of 120 feet radius. I take it that the speed in shunting would not exceed 10 miles an hour, as to do so would be dangerous. The cross-overs would probably be negotiated at 4 or 5 miles an hour.

106. *To Mr. Seabrook.*—In my estimate of the cost I allowed for cast-iron cylinders in conformity with existing design of the wharf. If timber piles are in use it could be cantilevered off the wharf with a few additional piles, but, to make a good job of it, it would need proper piling. I do not like timber piles cased with a concrete tubing, as we have had very unsatisfactory experience with concrete sleeves in consequence of the piles swelling; the concrete has cracked, allowing the teredo to commence its destructive work without our knowledge. Quite a number of our bridges were treated in that way, and we have, therefore, had to dispense with concrete and sheath our piles with muntz metal. Quite a number of piles have been destroyed by the cobra. I would favour the use of timber for the beam and decking.

107. *To Mr. Cook.*—If the interest on the capital cost of the proposed scheme exceeds the saving to be effected in labour, it is not a financial proposition. I do not know much concerning the details, but I am in favour of direct communication rather than the use of the turn-table

107A. *To Senator Payne.*—Considering the matter from a railway point of view, you will have to be guided by the trade offering at the port, but if that is sufficient the direct route is preferable. The turn-table should not be dispensed with unless it is fully justified, but I could not say that should be done in the absence of details concerning the volume of the traffic handled.

108. *To Mr. Gregory.*—On a 3-ft. 6½-in. gauge, a smaller curve can be negotiated than on a 4-ft. 8½-in. or 5-ft. 3-in. gauge. It would be possible to use a locomotive specially designed for wharf work and for hauling traffic between Vestey's works and the wharf, which, I understand, is a distance of 4 miles. It is largely a matter of tonnage and continuous work. The type of shunter I mentioned was an internal combustion engine which could haul half a dozen trucks and similar to that used in the Clyde works. Turpentine

piles, properly protected, would easily last from 8 to 10 years. The muntz metal supplied during the war deteriorated very rapidly, but it has improved considerably in quality of late. Care has to be exercised, however, in purchasing this material, because there is a tremendous lot of inferior stuff on the market. In the circumstances, I would recommend the use of turpentine piles with muntz metal sheathing.

109. *To the Chairman.*—Where suitable power is available capstans render very efficient service. When we first installed capstans on the wheat wharfs at Darling Harbour, they would be started and expected to haul a whole train, and some of the men could not conceive that capstans capable of hauling only three or four trucks would be installed. We found, however, that we could go on increasing the power of the capstans until we found the most economic type was one that would move almost a whole train-load. The Committee would not be justified in recommending the installation of electric power on the wharf at Darwin if there were only two boats a month. I do not know the capacity of a 16-ft. truck, but I suppose it would be 8 tons. A ship with three hatches would want ten trucks per hatch, which would occupy 200 feet, thus leaving only 100 feet between the cross-overs. The trucks would have to be divided into two shunts for each hatch or six shunts for three hatches If each truck, when empty and loaded, has to be man-handled at the turn-table, it is not an up-to-date method, and there is no doubt that a curve would be a vast improvement. I think the scheme is practicable, and it is purely a matter of cost, in which I cannot help you at all.

110. *To Senator Reid.*—I have not had any experience of railway or wharf work at Darwin, but I believe that a locomotive suitable for work on the wharf could be profitably used in other directions, say, at Vestey's, but I could not say that the expense would be justified. If an alteration such as is proposed would be of assistance to a big industry, by enabling them to operate economically, the introduction of a curve seems to be worthy of very careful consideration.

(*Taken at Melbourne.*)

MONDAY, 28TH FEBRUARY, 1927.

Present:

Mr. MACKAY, Chairman;

Senator Barnes	Mr. Gregory
Senator Payne	Mr. McGrath
Senator Reid	Mr. Seabrook.
Mr. Cook	

Norris Garrett Bell, Commonwealth Railways Commissioner, sworn and examined.

111. *To the Chairman.*—I am acquainted with the scheme prepared by Mr. Ramsbotham, for the improvement of the wharfage facilities at Darwin, but I have not examined closely the proposal prepared by Sir George Buchanan. The wharf is controlled by my Department, and I think is adequate to handle the present volume of trade. The tonnage passing over it varies considerably, and has shown an increase during recent months on account of the large quantity of railway construction material that has been landed there. So far as goods consigned to the interior are concerned, the extra cost of handling due to the use of a turn-table is very slight; the cost of goods for Darwin itself is increased, not so much by the presence of the turn-table, as by the absence of a wharf shed. The present wharf accommodation is not modern, but it meets all requirements to-day. I have never been asked to prepare a scheme of wharf improvements, but I think that the wharf could be made more convenient by making a dray approach to the wharf, closing the inner berth, and building a shed on the back of the wharf. Occasionally both inside and outside berths are in use; on several occasions a cattle boat and the usual monthly passenger boat have been on the outer berth of the wharf at the same time It would be impossible for the *Marella* and the *Malabar* to berth simultaneously on the front of the wharf, but both these vessels belong to the same company and are never at Darwin together. I have had no complaint of silting of the outside berth, but I saw recently a newspaper statement that a vessel carrying oil had refused to go alongside the jetty because the depth of water was only 20 feet. I immediately telegraphed to Darwin for information, and was informed that although the vessel had departed without discharging its cargo the complaint about insufficient depth of water was not justified. In regard to the proposal to construct a new approach to the jetty across the interior angle formed by the wharf and the viaduct, I consider that a curve of 120 feet would be unsafe and unworkable. The only locomotive that could be safely worked on such a curve would be a small shunting engine. In any case, the proposed approach would offer no economy of either time or cost. Although the turn-table is blamed for the delay and cost of handling goods on the wharf, the real cause of the delay is the double-handling involved in loading from the ship's slings into a truck, hauling the goods half a mile, discharging them into a sorting shed, and then reloading them on to the consignees' vehicles. That could be obviated by building a shed on the wharf so that the goods would be delivered direct from the ship's slings into the shed and thence into lorries which would take them into the town. Goods for up-country would be loaded direct from the ship into trucks and pass over the turn-table as at present. By that scheme the cost of handling should be materially reduced. The expenditure that would be involved in carrying out Mr. Ramsbotham's scheme is not warranted by the present trade of the port.

112. *To Senator Payne.*—I do not think that goods could be handled more economically over the proposed curve than over the turn-table. Certainly the wages of the man operating the turn-table would be saved, but they do not amount to very much per ton. I am not aware that the provision of a shed on the existing wharf has ever been proposed to the Government. All schemes that have been advanced by different experts have provided for an entire re-arrangement of the wharf. The construction of a shed would entail considerable expenditure and the closing of portion of the inner berth, and the present railway approach would require to be extended to permit drays to approach the shed. So far as one can foresee the development of trade at Darwin, the present wharf, if improved in that way, would be adequate for all needs for the next ten or fifteen years.

113. *To Mr. Gregory.*—The control of the Darwin wharf will remain with the Commonwealth Railways Department until the Minister for Home and Territories gives six months' notice of the intention of the North Australia Commission to assume control. The present volume of traffic over the wharf is too small to warrant even a commencement with either of the schemes suggested by Sir George Buchanan or Mr. Ramsbotham. There is little likelihood of the Darwin Meatworks re-opening for some years; I understand from Mr. Conacher that that firm has made other arrangements for the disposal of the cattle raised on its stations. For several years only about 6,000 head of cattle have been shipped from Darwin per annum. A roadway to a shed on the wharf would be provided by widening the present railway approach, and by reducing the number of lines on the wharf. The width of the wharf is 43 ft. 6 in. A long, narrow shed would be most suitable. It could be built on half the width of the wharf, to which an addition could be made at the rear in order to provide a roadway for drays and

lorries. The roadway should be at least 20 feet wide. The extra width of wharf could be built on wooden piles. Each year we replace a few of the wooden piles in the 11-foot extension that was erected a few years ago. The reason for that is that owing to the difficulty of obtaining metal during the war the piles used in that extension were not sheathed. The substituted piles are being copper-sheathed, and are expected to last for many years. The minimum width of the curve that could be used for slow traffic depends largely on the character of the rolling-stock employed. In slow shunting a 4-chain curve could be negotiated with safety, or even a 3-chain curve at not more than 4 miles an hour. There is at Darwin one small shunting engine that could be used on sharper curves than most of the other rolling-stock there could negotiate. Railway construction material should be taken direct from the ship's side to the rail head, and could not be loaded into small shunting trucks; with care the rolling-stock at Darwin could be safely used on a 3-chain curve. If a shed were built on the wharf the sorting shed would be eliminated. I shall let the Committee have an approximate estimate of the cost of the alterations I have suggested. The electrical power-plant and capstans which were installed on the Darwin wharf some years ago are still at that port. When that plant was installed, Vestey Brothers were doing all the stevedoring and controlled the waterside workers. The men employed on the wharf refused to use the electric capstans, and the armatures were actually sawn through. This was an act of sabotage. Shortly afterwards the trade of the port began to decline, and we decided that it would not be economical to use that plant for lighting purposes only, and it was accordingly dismantled. Vestey Brothers claimed that the capstans operated too slowly, but I showed conclusively that their speed was equal to that of similar plants on other wharfs. If the trade at Darwin ever develops sufficiently to warrant the re-installation of a plant, it will be available for use. The minimum depth alongside the wharf at the date of the latest sounding was 22 feet. Larger vessels than that which recently refused to go alongside are constantly using the wharf, and, so far as I know, they do not lie in the mud. I have never examined carefully the various schemes that have been propounded by experts for the improvement of the port. When giving evidence before this Committee on a previous occasion, I pointed out that I am not a harbour engineer, and I suggested that the Government should obtain the services of a harbour expert. I am quite prepared to criticize the railway features of any scheme, but I do not pretend to be able to design a wharf. I have no objection to the arrangement of the lines on the wharf in Mr. Ramsbotham's scheme, but the proposed 2-chains curve would not be safe. Even if it were safe to work, it would not be economical, because of the heavy wear and tear and additional shunting. The alterations entailed to the sidings on the wharf would make shunting more difficult.

114. *To Senator Reid.*—The disadvantages incidental to a sharp curve would out-weigh the inconvenience and costliness of the turn-table. It would not be possible to put in a flatter curve because it would occupy almost the whole of the wharf and make shunting impossible. If my suggestion for a wharf shed were adopted, the town trade would be taken away by horse or motor vehicles and the country trade would go round the railway turn-table as at present. However, I do not think that the cost of even that temporary expedient is justified by the present trade of the port. The interest on the cost would more than counter-balance any economics in handling. The future of Darwin as a port for Northern Australia is uncertain. From time to time the provision of harbour facilities at Pellew Islands has been discussed. That place is hundreds of miles nearer than Darwin to the Barkly Tableland and other rich portions of the Territory, and if a harbour were built there most of the traffic to and from those areas would go through it. Experts have declared that a harbour could be made there, but at considerable cost. I understand that the North Australia Commission is now considering that scheme, and if it be proceeded with Darwin's trade is not likely to expand to any extent in the near future. I am not able to recommend any expenditure on the Darwin wharf at present other than for maintenance.

115. *To Mr. Seabrook.*—The present wharf has a length of about 560 feet, and is capable of handling all the shipping that goes into the port. I see no likelihood of the cotton industry being established in the Territory to such an extent as to appreciably affect the trade of the port during the next ten years. Therefore, there is no need to erect a shed on the wharf in anticipation of the shipment of raw cotton. The outward trade of the port is not nearly as great as it was when the mining industry of the Territory was more active, or as it was later, when Vesteys' Meatworks were operating, and I can see no reason to anticipate any increase in the next decade.

116. *To Mr. Gregory.* I know of no place where a curve of 120 feet radius is used on a 3-ft. 6-in. gauge. The sharpest curve in use in Queensland is 2½ chains. The proposed harbour at Pellew Island will not come within the region of practical politics until the Barkly Tableland develops.

The witness withdrew.

Thomas Hill, Chief Engineer, Department of Works and Railways, sworn and examined.

117. *To the Chairman.*—I have had experience of wharf construction, but not of a work as large as that proposed at Darwin. I have, however, studied the subject as part of engineering practice. I am aware of the condition of the existing wharf. I have seen Sir George Buchanan's report. The type of construction he recommends is practically the same as that employed in the Singapore wharf. It might almost be said that the suggestion for Port Darwin is a copy of the Singapore design. Sir George Buchanan favours steel cylinders filled with concrete. The cylinders are 5 feet in diameter. The tidal range at Singapore is not so great as at Darwin. The length of steel affected is from 5 ft. 6 in. above ordinary low-water level to a few feet below; whereas at Port Darwin the range of tide is about 30 feet. In any remarks I make as to the relative merits of different forms of construction, that fact has to be borne in mind. A committee of the Institute of Civil Engineers obtained valuable reports from many countries, tropical ones in particular, regarding the value of different forms of construction. The reports covered the value of timber as a material for marine structures, resistance to white ants, the effect of marine boring animals, and the corrosion of iron and steel. The Institute obtained a mine of information from the officers in charge of the works. Singapore wharf, in particular, was mentioned. A report on Singapore and Penang harbours was presented by Sir J. R. Nicholson, Chairman of the Harbour Boards at Singapore and Penang. Mr. F. G. Wilson, M. Inst. C.E., member of the special committee, dealt particularly with Singapore, and discussed at length the use of steel cylinders, the effect of corrosion, and the protective measures necessary. The report was made in 1920, and in the course of it Mr. Wilson said:—

> *Iron and Steel.*—In the works already referred to, a large quantity of steel and wrought-iron was used; notably in the construction of a deep-water wharf, which was constructed of wrought-iron cylinders filled with concrete having a superstructure of steel girders covered with steel trough deckings, finished off with a concrete surface. Galvanized wrought-iron ladders and railings were also placed at various places throughout the works as required. The following extracts relating to the condition

of the steel and iron are taken from the report of the Resident Engineer:—

> "*Wrought-iron Cylinder Construction*.—The western portion of this wharf has been completed for about seven years; the inner portion forming the west side of the wet dock entrance was completed three to three and a half years ago. The steel work in girders, troughing, &c., is in very good condition generally, and is painted when any rusting is observed, say, once in two to three years.
>
> "On the wrought-iron cylinders, struts, valves, &c., there is a coating of small oysters, barnacles, and other shell fish and marine vegetable growth from the level of +5.50 or about the level of h.w.o.n.t. down to ground level; this coating completely covered the metal, being thickest about the area between +2 and −15 feet, and gradually diminishing down to the ground level.
>
> "The coating adheres strongly to the metal, and on removal by the chipping hammer or scraper it comes away accompanied by a fairly hard black scale from 1-16 inch to ⅛ inch thick, leaving a dull black surface on practically bare metal.
>
> "I collected some of this scale and find that, on exposure to the air for a day or two, it turns a brownish red, and as on testing it with hydrochloric acid it gives off sulphuretted hydrogen, I assume it to be, at least partly, ferrous sulphite.
>
> "About the level of +5.50 there is some rusting on the western and older portion of the work, but nothing that could not be prevented by chipping and painting once, say, in two years. I examined several places on the cylinders and sleeves, both above water and down to ground level, and found very few signs of corrosion, the edges of all plates when scraped were clean and sharp, and rivet heads were of full size. There are a few small irregularly shaped pittings on the upper surfaces of struts, but only to the depth of, say, 1-16 inch, and a few rivet heads are slightly reduced in size.
>
> "The worst corrosion observable is on the lower fender brackets near l.w.o.s.t., at the western end of the wharf, where in some cases they have had the coating of shells removed from the front edges, probably through small craft, ships' fenders, &c., coming into contact with them, and when bared the remainder of the bracket shows considerable corrosion. On the front edge the metal has been reduced to ⅛ inch from its original thickness of ½ inch; the angles also are wasted to a small extent—the fibres of the metal showing clearly. Nothing has been done below the level of +5.50 in the way of painting or tarring the metal, and the coating of shells, &c., is left undisturbed.
>
> "The galvanized iron work in many cases is not standing well, all boat-step hand-rails are badly rusted, and also the lower portion of all ladders which have been more than two years in the water.
>
> "On the quays and sea faces of the piers the lower bands securing the fendering are all in very good condition; on removing the shells the galvanized coating appears quite intact, but the centre bands, which are above the shell level, and even the upper bands, are badly rusted. Inside the tidal basin the only corrosion observable is on the centre bands, which are badly rusted. The rusting of the upper bands on the sea faces of the piers and quays is evidently due to their being wetted occasionally by spray from waves striking the wall at high water, as there is no sign of rust on the corresponding bands inside the basin where the water is always smooth. The excessive rusting of the boat-step hand-rails is, no doubt, also due to the same cause, as even on calm days there is always a certain amount of wave motion and splashing against the steps.
>
> All galvanized work above cope level in hand-railing stanchions, &c., is in excellent condition."

The writer was himself quite recently in Singapore on a visit of inspection to the works, and he can entirely endorse Mr. Paterson's observations, and was much struck by the preservation of the material which appeared to be afforded by the coating of shells and marine growth alluded to. Reinforced concrete has been used to a considerable extent in connexion with the works at Singapore, for deep-water wharfs and piers. The writer, during his recent visit, made a careful examination of this work, and is able to state that he found it all in most excellent condition, and he could discover no signs of rust or deterioration. It should be noted, however, that this work has only been constructed within the last five years. . . . .

It appears to the writer that with regard to reinforced concrete in sea water, the following are two salient facts—(1) Deterioration due to corrosion of the reinforcement seldom takes place below the level of between half tide and h.w.n.t.; and (2), if the concrete be made watertight, corrosion will not take place at all.

With regard to watertightness, suitable proportions and very careful mixing and depositing will no doubt effect a great deal, and subsequent coating with tar or other material may effect the rest that is required to produce permanently sound work.

That is the position in which I find myself with regard to the Port Darwin wharf. The larger tidal range at Port Darwin would necessitate looking after the steel cylinders unless the marine growth occurs there to protect them. I do not see why the marine growth should not take place, and apparently it affords ample protection. There is no difficulty in the matter of a steel superstructure. That part of the proposal is excellent. There would be no difficulty in keeping it in good condition by coating it with "Siderosthem" or bitumen. Reinforced concrete cylinders would need to be at least 60 feet long, and at least a foot thick, and they would weigh at least a ton to the foot run. They could be filled with a mixture of three parts of stone, two parts of sand, and one part of cement, and could be coated with bitumen. Once placed in position and filled with concrete they would be quite good, but the cost would be heavy. It is not an easy job to place into position cylinders weighing from 60 to 70 tons. Guide poles would have to be put in. Still, it could be done. But I estimate that the extra cost would be £50,000 on the £587,657 estimate. That assumes the retention of steel for the superstructure, and other excellent characteristics of Sir George Buchanan's design. In view of what has happened at Singapore, the comparative ease with which steel cylinders can be handled, and the extra cost, I should support Sir George Buchanan's choice. The Hawkesbury River bridge, which is of wrought iron, is quite good and sound. It is in salt water, but is not exposed to the tidal range or intense heat of Port Darwin. The practice throughout Australia is in favour of reinforced concrete cylinders. It is not necessary to reinforce when steel cylinders are used. The piers for the George's River bridge consist of 10-feet diameter cylinders, the bottom portions being 30 feet to 40 feet deep, with 9-inch shells. The concrete was a 1—2—3 mixture. The cylinders above 40 feet height are of the same diameter reinforcement, and contain the same mixture of concrete, but the shell is increased to a thickness of 2 feet. In constructing recently a sewer across Sydney Harbour, 100-feet long tubes of reinforced concrete were used. Therefore there would be no difficulty in using reinforced concrete at

Port Darwin, but the cost would be more. Sir George Buchanan's scheme appeals to me more than any other, if the trade of the port is held to justify it, and the money is available. The approaches are good. I particularly like the tidal dock. It is the only design that has really appealed to me. I have never visited Darwin, but I know the conditions there very well. Extending the present wharfage accommodation does not appeal to me. The question is, does the trade of the port justify the proposed expenditure? If the trade is expected to develop it would be better to construct something permanent. If anything is done, it should be done with a view to the future, and the work should be of such a character as to form part of a continuous scheme, such as that put forward by Sir George Buchanan. Not only the wharf, but the arrangement of the railway tracks approaching it, should be considered. I cannot see that an expenditure of £30,000 or £35,000 would be justified. I understand that the present wharf is able to deal with cargo as fast as a ship can take it. Mr. Bell claims that he can deliver from the meat works as fast as the cargo can be placed on board. It is true that the present turntable is expensive, but is the cost sufficient to justify an expenditure of from £30,000 to £35,000? I should suffer what I have at present rather than spend any large amount of money.

118. *To Mr. Cook.*—The present wharf is sufficient. I do not think that a better wharf would encourage development. I would not favour any greater conveniences until the trade justifies them. If anything is done at all, a definite scheme should be adopted.

119. *To Senator Reid.*—I know Darwin very thoroughly from plans, and I have a good knowledge of the Territory. I would rather keep the money, and interest on it, until such time as it can be expended with a definite object.

120. *To Senator Barnes.*—If the steel casing corroded and fell away from the concrete, the structure would be in danger. The steel is the reinforcement, and it must be preserved. That could be done. A 5-foot thickness of concrete, without the steel, would not be safe. There must be a steel reinforcement, either embedded in the concrete or in the form of a ring round it.

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