1924.

NEW ZEALAND

PUBLIC WORKS STATEMENT

BY THE HON. J. G. COATES, MINISTER OF PUBLIC WORKS.

MR. SPEAKER,—

In placing before you this my fifth annual Statement of the activities of the Public Works Department, I desire at the outset to emphasize the fact that if more money could reasonably be placed at my disposal, works in hand could be finished in less time, and others, which cannot now be commenced, might be added to the year's programme of work.

Much as we all desire to see public works of every description expeditiously carried out, great care must be exercised in selection, and decisions arrived at only after ascertaining both the advantages to be derived from the completed works and the country's ability to meet the cost. Furthermore, New Zealand is now practically in the stage when all its able-bodied competent workers are fully employed. To increase the rate of expenditure means increasing the number of men employed by the Department on public works. This can only be achieved by taking men out of other avenues of employment, which would inevitably result in wage competition. Those who carefully observe what happened in the two years immediately following the war—the high cost of works and the small output of labour—will not, in the general interests of the people, willingly allow such a state of affairs to recur. It seems to me an economic necessity that growth of production, population, revenues, and capital expenditure out of borrowed money should at least march together, but it is undeniably better for the future of the country that capital expenditure should be kept strictly in arrear of the other factors.

Works of development are necessary in order to increase production, but very careful consideration must be given to so balance the developmental work with the man-power available that the development of new works shall not be hampered and yet at the same time that the country shall not arrive at a stage where a considerable proportion of its breadwinners shall look upon borrowed money as their regular source of livelihood.

Before dealing with the construction work of the Department in detail I wish to express my appreciation of the excellent work done by the Engineers and their staffs, and of the loyal assistance they have invariably given me. By every means in their power they have been indefatigable in endeavouring to obtain the best results. To the men who have toiled, in all weathers, often in inaccessible localities on the outskirts of civilization, I also wish to convey my thanks. They have made a splendid response to the call upon their energy and endurance. They are men whose work does not come much under the public eye, yet it is largely through their efforts that we are able to provide the last link in the line of communication between the hard-working pioneers of the backblocks and the markets of the world. By their work we are able to increase the number of people in the rural areas and lay the foundations for the larger population to follow.

It is especially worthy of notice that during the past year there has been an absence of serious difference between the Department and its workers. In place of trouble there has been reason and understanding, to the mutual advantage of all concerned.

During the past year the Public Works Department has proceeded vigorously with the multifarious activities within its sphere, and substantial progress has been made on railway, hydro-electric, irrigation, and road construction. Proportionately good progress has been made in the other directions, which, though less in volume, are equally indispensable.

As a result of improved working and living conditions and more efficient organization of work the world's prices for plant and material are tending to become stabilized, though they have not receded, except in a very few instances, to the pre-war level.

The average amount of work done by the men employed is steadily increasing, and this, added to the fact that the number employed throughout the year was considerably in advance of that for the previous year, has brought about the favourable results referred to.

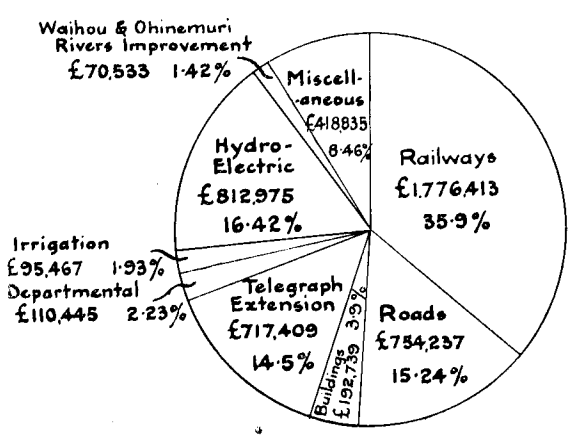
As a rule, the district officers are called upon to carry out expenditure in accordance with the amount of money placed at my disposal by the Government, but in detail have a considerable amount of independence of action, and the highly practical and energetic way in which the staff sets out its programme of work and co-ordinates the various items of each construction-work, large and small, shows that the organization functions well and gives excellent service.

PROGRAMME FOR THE FUTURE.

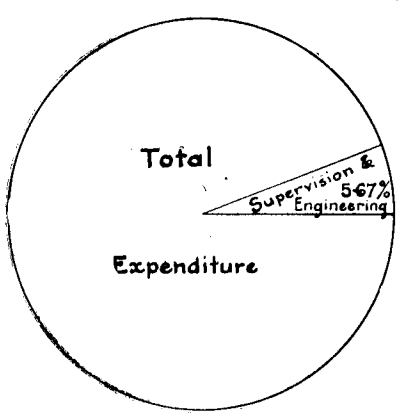
After having considered the matter from all points of view, I am of the opinion that it would be unwise to spend more this year than £1,200,000 on railway works, £832,000 on roads under my control, £500,000 on main highways, and £1,133,146 on hydro-electric development. In order, however, that works may be laid out in advance, and arrangements for money, men, and material may be systematically made, I have prepared a co-ordinated programme extending over a number of years, and in accordance with this programme I propose to proceed.

RATIO OF EXPENDITURE.

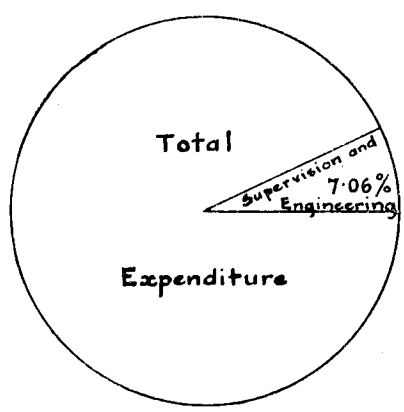
The diagrams below show the ratio in which the money was expended on the various main activities during the year 1923–1924, and also the ratio which the cost of engineering, accounting and supervision, &c., bore to the total expenditure controlled by the Public Works Department for the year 1923–1924, compared with for the year 1913–1914.



1923–24.



1923–24.



1913–14.

Supervision includes Engineering, Accountancy, Correspondence, Stores Control, and administration generally of works in progress, and also Engineering investigation of works proposed or contemplated, which may or may not result in expenditure.

Full particulars of works carried out by the Department are to be found in the reports of the Engineer-in-Chief, Government Architect, and Chief Electrical Engineer respectively, which form appendices to the Statement, and I refer honourable members to them.

RAILWAY-CONSTRUCTION.

During the past financial year a total length of 27 miles 31 chains of railway was handed over to the Railway Department for incorporation in the general railway system of the country. The details are as follows :—

	M.	ch.
Kaihu Valley Railway	4	54
North Auckland Main Trunk Railway (Okaihau Section)	8	20
Napier – Wairoa Railway	11	73
Greymouth – Point Elizabeth Railway	2	44

In addition to the lines actually handed over, rails have been laid on 31 miles 40 chains, and goods traffic has been carried on over a length of 31 miles 58 chains, while traffic of all descriptions has been run by the Public Works Department over 118 miles 4 chains, the two principal sections being between Huarau and Portland, and between Tauranga, The Mount, and Awakeri. It is frequently more economical to carry on traffic under the control of the Public Works Department than to hand any portion of the line, immediately it is completed, to the Railway Department. This arises from a twofold cause :—

(1.) The fact that the operations on portions of the line uncompleted require the running of ballast and other trains over completed portions, which, if these were under different control to the portions under construction, would be liable to lead to delays. Furthermore, it is frequently possible to work a restricted goods service in connection with the Department's ballasting and other constructional operations, thereby giving settlers facilities on the railway at the earliest date, and at the same time earning money with which to pay part of the interest-charges on capital which would otherwise be unproductive.

(2.) It has another advantage, which is that time is given for the revealing of weak spots, the settling of unstable country, and the removal of slips, &c., so that by the time the Railway Department is asked to take control it can be reasonably assumed that all expenses which should fairly be charged to capital have been incurred. The last consideration has resulted in a good deal less line being handed over than was expected when my last Statement was written. Honourable members will recollect that phenomenal floods occurred in various localities during the past twelve months, which so damaged the railway, both the opened and the unopened, and so saturated the whole country, that it was thought desirable to retain the line for a considerable time longer in the hands of the Public Works Department. Given a reasonably favourable season, I anticipate that the Railway Department's large locomotives and other rolling-stock will be able to run over the whole length of the line from the far North to Auckland within the next few months, so that the general public will obtain all the benefits of continuous mileage even though a portion of the line may still not be in the hands of the Working Railways Department.

The most important move in connection with railway-construction which has taken place during the year has been the letting by contract of a portion of the Tauranga Westwards Railway, 18 miles 18 chains in length, to Sir W. G. Armstrong, Whitworth, and Co. (Limited). There was a fair amount of competition for the work, and I have every reason to believe that the substantial and well-established firm referred to, which has international experience, will carry it

through with satisfaction and despatch. The necessary mechanical plant is to hand or is on the water, and the contractors are laying their plans for very vigorous operation during the coming summer.

The co-operative system, under which so much of the Government's works have been carried out for the last thirty years, has been the target of much abuse, particularly by those who are not in possession of all the facts. It is interesting to note that the contractors for this length of railway have already a large number of men employed on the co-operative system. The conditions of the contract safeguard the interests of the workers by requiring the contractor to provide housing accommodation and other facilities practically on an equality with those provided on the works which the Department itself directly controls.

The schedule attached gives a complete statement of the work on railways now in progress, and the extent to which it is anticipated it can be completed during the next two years, assuming that sufficient financial provision will be available.

North Island Lines.

It is anticipated that the Portland and Tauraroa Sections of the Whangarei Branch Railway will be completed and ready for handing over to the Railway Department by the first week in November, and that the remaining section of this branch railway to Waiotira Junction will be ready to hand over a little later on. The works on this branch railway required to bring it to completion comprise the finishing of station-buildings, stone drains for drainage in cuttings, and walls for protecting toes of slips which have been very persistent during the wet season. The weather during last winter was the worst on record, and though the line has been kept open while the length of working railways below Maungaturoto was blocked, the finishing-off work had to be delayed until slips were removed and drier conditions prevailed.

The North Auckland Main Trunk Railway from Huarau to Waiotira Junction suffered from the effects of the wet winter in a more marked degree than the Whangarei Branch Railway, and during this period all available men were occupied in removing slips and keeping the line open for traffic, so that very little permanent work except ballasting—and not very much of that—could be done in the winter. This line has consolidated, and permanent works to complete same are already in progress. It is hoped to hand it over to the Railways Department before the end of next March.

The extension of the North Auckland Main Trunk Railway northwards of Waiotira towards Kirikopuni, on the Wairoa River, has been vigorously carried over a length of 13 miles, through some heavy country.

It is anticipated that the long Omana Tunnel and the Tokatoka Tunnel will be completely lined at an early date, thus enabling the permanent rails to be extended north of Waiotira. It is hoped that by the end of June next all the bridges will be finished to Wairoa River, as well as the rail-laying and a certain amount of ballasting. The preliminary borings for the large bridge over the Wairoa River at Pukehuia have been taken to ascertain depths to which cylinders must be sunk to ensure safety. All steel, iron, and timber have been ordered for this bridge, which should be completed in about twelve months' time. The whole length from Waiotira northwards to the terminus should be carrying traffic within two years. Beyond the proposed terminus a modern road of good grades and curvature is being constructed to tap the fertile Mangakahia Valley and subsidiary valleys. The completion of this road will synchronize with the completion of the railway to its terminus.

The investigations referred to in my Statement of last year as necessary before a final decision could be made as to the point to which the railway could be economically carried beyond Okaihau on the North Auckland Main Trunk, are still in progress. In the meantime Rangiahua is the objective, and it is intended to put in hand shortly the preliminary work so that all will be in readiness to

concentrate men and materials on this section when works are nearing completion on the North Auckland Main Trunk Railway at Kirikopuni. The survey beyond Rangiahua is now being vigorously proceeded with, and when this and the estimates are completed I hope to be able to determine the point at which the railway will most economically link up with the proposed roading programme for the Far North.

On the East Coast Main Trunk Railway, from Waihi to Taneatua, construction work from Waihi to the 14-mile peg is in hand by the Department. Rails are laid as far as Athenree, and this section should be ready for traffic by the end of the year, and to be handed over to the Railway Department in June next; meanwhile it will be available for use by the contractor referred to in the next paragraph, and for ordinary goods traffic.

The contract for construction of a section of this railway for a distance of 18 miles 18 chains was let on the 27th March, 1924, to Sir W. G. Armstrong, Whitworth, and Co. (Limited), as already stated. As yet only preliminary work, such as clearing, fencing, preparation of stacking-yards, opening up of cuttings has been done. Practically the whole of the plant and material required is on order, and some of the major plant items are now arriving. Five of the six steam-shovels are now in the country, two of which are actually in position. One hundred and twenty men are at work, and it is anticipated that when the works are in full swing four hundred to five hundred men will be employed.

The following is a list of plant already ordered, two-thirds of which is now available in the Dominion: 6 steam-shovels; 7 small locomotives; 200 trucks; 24 ballast-wagons; 2 stone-crushers; 1 cable-way excavator; 1 10-ton crane for bridge-work; 2 50-ft. pile-driving outfits equipped with steam-hammers; 2 launches; 1 towing-scow; a number of punts; 3 motor-lorries.

From 35 m. to Tauranga formation is nearing completion, and the section from Tauranga to near Te Puna should be ready for goods traffic by end of July next.

From Tauranga to Pekatahi, a distance of 58½ miles, the line is completed except for final ballasting throughout and permanent bridges between Matata and Pekatahi. This section should be completed in two years and a half, by which time the whole line between Waihi and Taneatua should be ready to be handed over to the Railway Department. Beyond Pekatahi the Whakatane Bridge is in hand, and the line into Taneatua should be ready for traffic within twelve months' time.

On the Napier–Gisborne line work is being concentrated on the Tutira Section, so that this railway may reach as soon as possible a point where it will connect with the main road between Napier and Gisborne. This point lies near Tutira, and when the line reaches here the worst portion of the road between Napier and Wairoa will be cut out, and the road distance between these places shortened by about 26 miles.

It was hoped to reach Tutira by the end of next year, but serious floods have delayed the works for a few months. To overcome this delay, however, it has been decided to concentrate twelve steam-shovels on this section, and ten of them are now at work. In addition to this the tunnels are all well under way, and should be done as soon as the steam-shovels complete their work.

It is expected therefore that the date at which Tutira will be reached will not be much behind the specified time. Ahead of Tutira are several large viaducts, one of these (the Mohaka) being the largest in New Zealand. The designs for these viaducts are all nearing completion, and are now so far advanced that the manufacture and erection of the steel work can keep pace with the rest of the work on the railway.

On the Waikokopu line traffic is already being run by the Public Works Department, and ballasting, station-yards, and buildings should be completed by the middle of next year. The Waikokopu Wharf is nearing completion, and several vessels have been successfully worked at it.

On the Stratford–Main Trunk Railway, east end, the permanent line is laid to 14 m. 50 c. Beyond this point a temporary line suitable for ordinary railway rolling-stock drawn by a light locomotive is run, partly on the main road to the 16-mile peg, where a construction depot, dealing also with a goods and passenger service, connects by a metalled road with Ohura Township, 3 miles away. During the ensuing year it is hoped to complete the permanent line and bridges to Ohura Station (19 m.) and all station-yard structures along the length.

On the Stratford–Main Trunk Railway, west end, the construction of road and railway bridges on the Raekohua Section for which the material has already been obtained will be undertaken, and also the construction of a service tramway to the Tangarakau River, surveys for which are well in hand.

On the Opunake Branch Railway the whole of the formation and platelaying works will be completed, and tenders will shortly be invited for the erection of station-buildings at the first six stations. Others will be provided for during the year. The whole of the works on this line should be completed within eighteen months from the present time.

South Island Lines.

In my last Statement I advised that the Westport–Inangahua Railway should be one of those on which the expenditure of money available should next be concentrated. At the time that statement was made I anticipated that far greater progress would have been made with railway construction; but, as indicated previously in this report, a great deal of additional work still remains to be done on this and other lines not yet completed, and therefore vigorous prosecution of the Westport–Inangahua connection has been slightly delayed. The work done was more or less of a preparatory nature, pending further development of the coal-mines in the basin of Cascade Creek. Arrangements have been made to put in a temporary siding on the Westport side of this creek, to which point the miners are constructing a flume to transport coal. The formation has been cleaned up, and immediately the rails and sleepers (which are on order) arrive, the railhead will be pushed on from Te Kuha, the present terminus, to the Cascade Creek. When the work to this point is completed it is anticipated that surveys and plans will be sufficiently far advanced to enable systematic construction to be undertaken, with the object of completing the connection with Inangahua.

On the Glenhope–Murchison Section all formation work, culverts, and bridges should be completed as far as Kawatiri Station by the end of January, and it should be possible, say, at the end of November, to start laying rails. The Kawatiri Section should then be ready for opening by the 30th June, 1925. Authorization is being asked for from the Owen to Murchison. In the meantime survey parties are engaged upon locating the line to Murchison.

On the Beaumont–Roxburgh Railway (Miller's Flat Section) it is expected that platelaying will be completed by the end of November, and that ballasting operations will be well advanced by that date. It is proposed to provide for a goods service between Beaumont and Miller's Flat early in next year. The work then remaining to be completed will comprise the widening of cuttings and banks, final ballasting, erection of station buildings and platelayers' cottages at Craig Flat and Miller's Flat, and general finishing off. It is expected that this section will be completed during next year.

Orepuki–Waiau Railway (Orawia Section): The work to be carried out during the coming year is the completion of the platelaying and ballasting, and the erection of station-buildings. It is anticipated that the line will be completed by the 31st March next.

EXPENDITURE.

The total net expenditure under all votes and accounts appearing on the public-works estimates for the financial year ended 31st March, 1924, was £5,314,460. Of this sum £4,065,565 was expended out of General Purposes Account, and the balance, £1,248,895, out of special accounts.

A brief summary of this expenditure, as well as the total expenditure since the inception of the public-works policy to the 31st March last, is shown below in tabular form :—

Class of Work.	Expenditure.	
	Expenditure for Year ended 31st March, 1924.	Total Expenditure to 31st March, 1924.
Railways—	£	£
New construction	1,132,765	30,953,428
Additions to open lines	643,648	13,665,147
Payment to Midland Railway bondholders	...	150,000
Roads	754,237*	14,513,771
Public buildings	192,739	9,080,331
Immigration	92,600	2,689,075
Purchase of Native lands	...	2,061,739
Lighthouses, harbour-works, and harbour-defences	10,807	1,194,893
Tourist and health resorts	27,264	336,880
Telegraph extension	717,409	6,219,411
Development of mining	1,363	882,975
Defence-works (general)	4,931	1,091,942
Departmental	110,445	2,039,019
Irrigation and water-supply	95,467	493,217
Lands-improvement	18,182	195,505
Minor works and services	...	312,607
Plant, material, and stores	*Cr.* 52,772	363,142
Timber-supply and sawmills for Public Works Department	3,613	34,707
Motor Transport Services	962	23,641
Cost and discount, raising loans, &c.	311,905	1,801,842
Totals General Purposes Account	4,065,565†	88,103,272
Aid to Water-power Works and Electric Supply Account	812,975‡	2,923,856
Waihou and Ohinemuri Rivers Improvement Account	70,533‡	380,695
Totals Public Works Fund	4,949,073	91,407,823
Wellington–Hutt Railway and Road Improvement Account { Railway	...	228,374
Wellington–Hutt Railway and Road Improvement Account { Road	...	101,658
Railways Improvement Account	...	641,275
Railways Improvement Authorization Act 1914 Account	20,520§	932,662
Loans to Local Bodies Account—Roads to open up Crown lands	...	697,408
Opening up Crown Lands for Settlement Account—Roads to open up Crown lands	...	206,626
Land for Settlements Account—Roads to open up Crown lands	49,186	530,649
National Endowment Account—Roads to open up endowment lands	...	53,401
Education Loans Account	295,681§	1,424,831
Totals	5,314,460	96,224,707

* Includes £4,500 expended under section 16, subsection (1), Native Land Amendment and Native Land Claims Adjustment Act, 1923. † Does not include expenditure under the Ellesmere Land Drainage Act, 1905. ‡ Excludes interest during construction. § Includes proportionate cost of loan raised under these accounts.

WAYS AND MEANS.

	£	£
On the 1st April, 1923, the available ways and means for general public-works purposes were		441,554
Additional funds were received as follows :—		
(*a.*) Under the Aid to Public Works and Land Settlement Act, 1922		3,000,000
(*b.*) Transfer from Consolidated Fund in terms of section 14 of the Appropriation Act, 1923		1,000,000
(*c.*) Public Revenues Amendment Act, 1913, section 34—Proceeds of Treasury bills issued in anticipation of loans	1,000,000	
Less Treasury bills redeemed from proceeds of loan	500,000	
		500,000

	£
(*d.*) Recoveries on account of expenditure of previous years ..	9,142
(*e.*) Ellesmere and Forsyth Reclamation and Akaroa Railway Trust Account receipts	1,681
(*f.*) Miscellaneous receipts	1,650
Thus making available for expenditure under the General Purposes Account a gross total of ..	£4,954,027

The net expenditure on works and services chargeable against the General Purposes Account for the year was—

	£
(*a.*) Under appropriations	3,749,160
(*b.*) Under Ellesmere Land Drainage Act, 1905	439
(*c.*) Under New Zealand Loans Act, 1908 (Stamp Duty) ..	1,613
(*d.*) Charges and expenses of raising loans	310,292
(*e.*) Under the Native Land Amendment and Native Land Claims Adjustment Act, 1923, section 16, subsection (1)	4,500
Making a total of	£4,066,004

This left a credit balance in the account for general purposes at 31st March, 1924, of	£ 888,023
Less Treasury bills issued in anticipation of loan	500,000
	388,023
Legislative authority exists for raising a further	5,000,920
It is proposed to transfer from accumulated surplus to capital purposes to the extent of	1,000,000
And to ask for further legislative authority to borrow, when required	2,000,000
Thus making available for public-works general purposes a total of	£8,388,943

The estimated expenditure under the account for the current financial year is £4,618,500.

In addition to the requirements for general purposes there are a number of special accounts with separate ways and means. The most important of these are :—

Name of Account.	Balance available at 31st March, 1924.	Unexhausted Borrowing Authority as at 31st March, 1924.	Additional Borrowing Authority to be sought during Current Year.	Total available Ways and Means.
	£	£	£	£
Electric Supply Account ..	1,106,174	6,506,990	..	7,613,164
Waihou and Ohinemuri Rivers Improvement Account	1,661	64,000	150,000	215,661
Railways Improvement Authorization Act 1914 Account	831,475	1,458,310	..	2,289,785
Totals for these special accounts	1,939,310	8,029,300	150,000	10,118,610

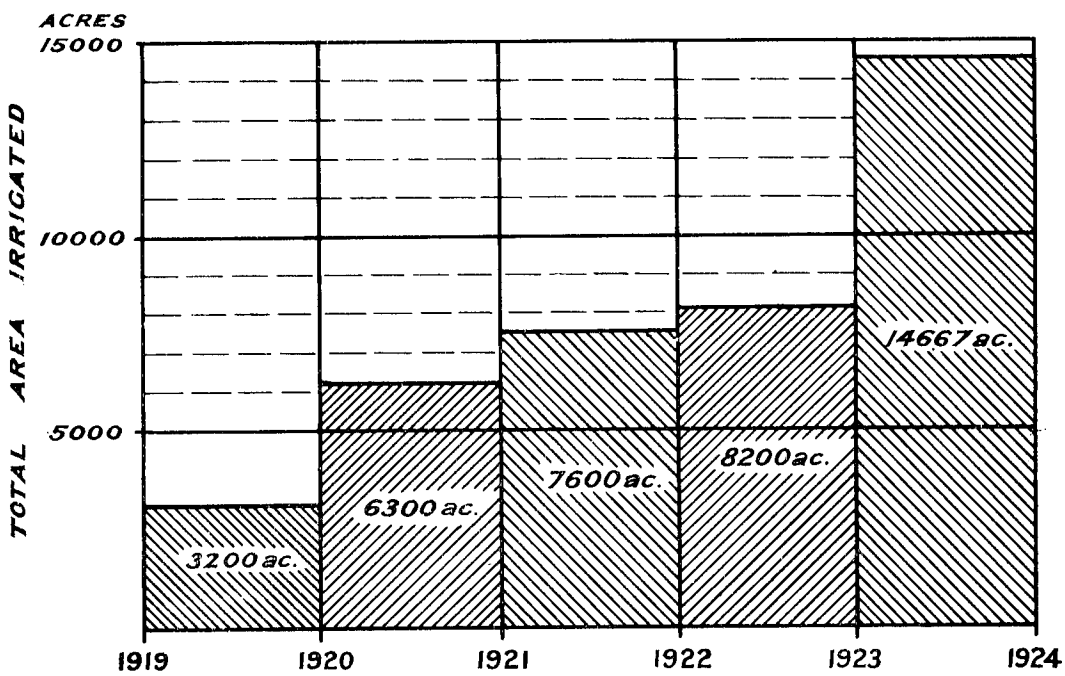
From these figures it will be observed that at the end of the last financial year the unexpended balance of the Public Works Fund for general purposes, plus existing and proposed authorities for raising further moneys, amounted to	£ 8,388,943
While the balance at the same date in respect to some of the more important public works under special accounts, plus existing and proposed legislative authority to raise additional loans, amounted to	10,118,610
Or a total of	£18,507,553

IRRIGATION AND WATER-SUPPLY.

Another step in the steady progress of irrigation development took place during the year just closed. No new construction works were started, but work was confined to pushing on and extending the several works previously in hand.

Although the profit on the older schemes is not expected to pay a high rate of interest on the outlay (owing to excessive war costs, &c.), an examination of their position shows that in due course they will pay a reasonable rate of interest, besides rendering enormous indirect benefits. All the later schemes, estimated upon steadier known costs and experience gained, are based on water rentals calculated to return sound rates of interest.

The actual area irrigated under all the Government schemes was 14,700 acres, divided among 200 settlers, as against 8,200 acres in the previous year. The graph below shows the growth of irrigation under the Government schemes for the past five years.



In their partial stages of completion the works were ready to serve 47,500 acres, but when completed towards the end of the current year the total area commanded by the Government supply will be increased to 61,400 acres.

As settlement increases and full advantage is taken of the water-supply available a great increase in the productivity of Central Otago would appear to be assured.

RESULTS ACHIEVED.

The business arising from the areas irrigated has greatly increased, as will be gathered from the statement appended below showing the business handled outwards at railway-stations Oturehua, Omakau, and Alexandra for the year 1913–14 as compared with the year 1922–23 :—

	1913–14.	1922–23.	Increase.
Sheep ..	46,000	70,700	54 per cent.
Goods ..	3,010 tons	6,200 tons	106 ,,
Passengers ..	5,900	7,452	26 ,,

The results of irrigation have everywhere been most satisfactory, and this is particularly noticeable on Galloway Flat. This small area of about 1,200 acres was previously useless, but is now supporting twenty settlers and regularly carrying and wintering fifty horses and 250 head of cattle, besides producing enormous quantities of surplus hay.

The Ardgour irrigation scheme was in working-order during the past season, and the results so far obtained have fully justified expectations.

The major portion of the Last Chance scheme is completed, and the main race is being extended to supply lands nearer Alexandra, which will permit of a few new Crown sections being thrown open for settlement. It is expected that the whole scheme will be available for the next irrigation season.

The construction work on the Tarras scheme is well advanced, and it is hoped that the scheme will be completed before the next irrigation season opens. Land of excellent quality is brought under this scheme, and lends itself well to irrigation. Favourable results may therefore be expected when the scheme is in operation.

The Teviot River scheme has been carried out in conjunction with the hydro-electric-power scheme supplying Roxburgh and surrounding district. The water is drawn from the Teviot River, and, after passing through the turbines in the power-house, is discharged into the irrigation-canals. The progress of work has been of a very satisfactory nature.

The Bengerburn scheme is supplying from the Bengerburn Stream at Ettrick, and was commenced at the request of settlers who were, at the time, applying for the forfeiture of certain private water rights held in the Bengerburn. An agreement was arrived at by which the Crown acquired portion of the water right, and construction work was commenced in November last. The work is now completed, and irrigation of 1,000 acres is assured.

Surveys for other schemes have been carried out, as well as the collation of much information relative to gauging of streams, investigation of rainfall, and other matters affecting irrigation possibilities.

Works to be undertaken.

The most important project investigated during the year was one for further utilizing the waters of the Manuherikia River. The present scheme utilizes the low-water flow on country lying in the triangle between the junction of the Manuherikia with the Clutha River. No storage is provided. The flow of this river fluctuates to an extraordinary degree on account of the nature of the watershed. If all the water falling could be conserved in reservoirs a great deal of additional land could be irrigated. Numerous dam-sites have been investigated, the most favourable of which now appears to be one at the Manuherikia Falls, in the vicinity of St. Bathan's. With the storage obtained in this reservoir it will be possible to irrigate 64,000 acres, and the revenue from this area, when settled, will be sufficient to provide for the upkeep of the works and leave sufficient over to pay interest on the cost of construction. In addition to permitting irrigation in the Manuherikia Valley itself, the storage of flow water for that purpose will permit of the diversion of the low-water flow for the principal reaches of a number of the tributaries being diverted into the upper Idaburn Valley and on to the Maniototo Plain between the Eweburn and Naseby by the present Mount Ida Race, thus still further extending the field of usefulness of this river.

The details of the scheme are not all worked out, but present indications are sufficiently favourable to justify the preparatory work in the direction of setting out the definite lines of races, so that settlers may see just where they will be supplied with water, and thereafter canvassing the settlers in order to obtain binding agreements with them to take the water after same has been made available. When the Government interests are thus secured I shall be in a position to recommend the issue of an Order in Council authorizing the commencement of the works.

The total cost of this development will be approximately £800,000, but I do not anticipate that any charges under the scheme will come to hand during the current financial year, and the works at present in hand will keep the staff fully employed for that period.

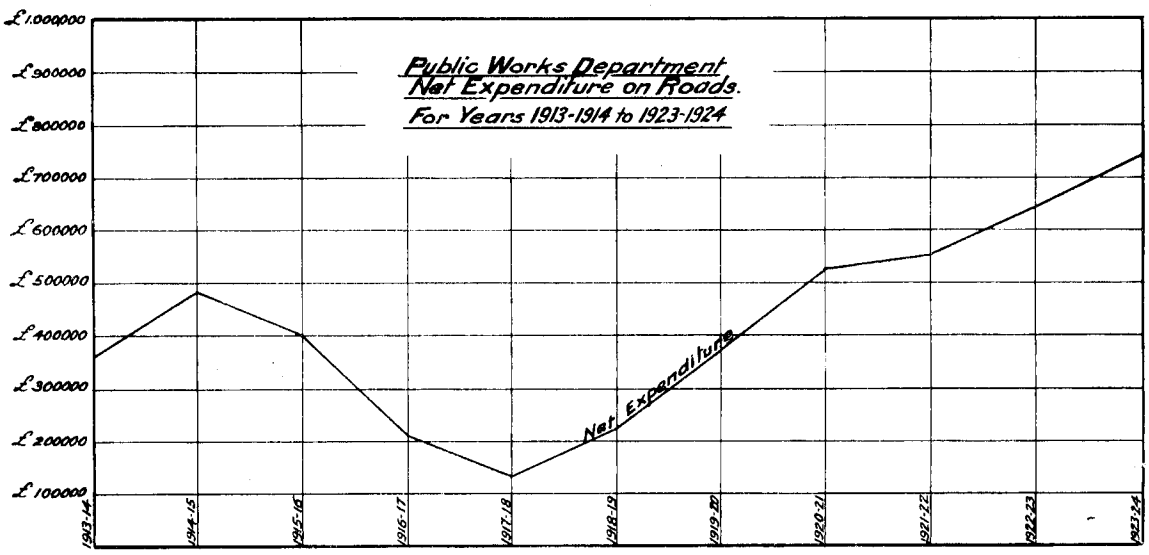
Officers to be sent Abroad.

To gain further information regarding the latest methods in irrigation, it is intended to send an officer of the Public Works Department who has had considerable experience in connection with the various schemes in Central Otago, together with an officer of the Department of Agriculture, to California, and

probably Canada, early next year. The subject will be studied from engineering, administrative, financial, agricultural, and marketing points of view. Not only the actual irrigation, but the preparation and levelling of the farms and drainage problems will be studied. The levelling of some of the farms belonging to Crown tenants in the Otago Central District is already under consideration, and it is proposed to make experiments to ascertain the cost which will be added to the valuations, and the rentals increased proportionately.

ROAD-CONSTRUCTION.

During the financial year ended 31st March, 1924, the expenditure on roads and bridges by the Department has constituted another record. Naturally, on account of the claims of settlement and the undeveloped state of the North Island as compared with the South Island, the expenditure has been much larger in the former. Even if present expenditure continued in the same proportions it will still be many years before the conditions as regards facilities for transport in the North Island can compare with those already prevailing in the South Island. The diagram below shows the trend of the Department's roading programme for the past ten years.



The progress made has, on the whole, been satisfactory. Many of the most important gaps in the arterial roads have been linked up, or improved to such an extent that early linking up is probable. Given similar progress for another year or two there is every prospect of there being roads passable all the year round to practically every settlement of importance in the Dominion.

In connection with access to the Waipu district, which originally was to have been by means of a railway, investigations showed that the amount of of business to be done was inadequate to provide working-expenses and interest on the cost of a railway. Protracted negotiations with the local people took place, and finally it was decided to discontinue the construction of the railway and to utilize the railway formation so far as constructed, and, for the rest of the distance, to improve the road to good grades and alignment, and to surface the whole with bitumen-sealed macadam. This work is in hand.

Special attention has again been given, particularly on those roads which are directly under the supervision of the Department, to the obtaining of grading, alignment, and curvature suitable to modern conditions. Every precaution has also been taken to secure the thorough drainage of the foundations of all roads on which surfacing is proposed, and also, after surfacing, the systematic rolling of the material. Adequate provision is also being made for maintenance, an essential feature, and without which the results of capital expenditure soon disappear.

In the past there has been some complaint by local authorities that the appropriations do not become available sufficiently early to take full advantage of the most suitable season for carrying out works. I am endeavouring to improve

this position by authorizing certain amounts for expenditure by the local authorities as soon as the estimates are framed. By so doing, certain urgent works can be put in hand several months earlier than if these works had to await the passing of the estimates before the works could be authorized.

The system of framing the allocations in accordance with certain factors such as area, population, estimates of completion of roads, values, undeveloped lands, &c., has again been adopted. There has been much satisfaction expressed at the adoption of the principle by which the local authorities and the officers of the Department mutually confer as to the interests of the districts concerned. By this means more cordial relations have been established, and by mutual agreement certain works that would under ordinary circumstances have been included in the estimates have given place to others having superior claims for inclusion.

In consequence of the diminished demand for sections in the backblocks, the expenditure in connection with the roading under land-for-settlements vote for the current year has been somewhat less than usual.

It is satisfactory that during the past year there has been less occasion to deal with unemployment than during recent years, and consequently the claims that works should be started to relieve the labour-market have been even fewer than during the previous year.

There are now in various parts throughout the Dominion lengthy sections of roads for which engineering surveys have been made, and which are ready for work when sufficient funds become available, or when labour conditions indicate that they could with advantage be put in hand.

MAIN HIGHWAYS.

In accordance with the Main Highways Act, the Main Highways Board was to have come into operation at a date not earlier than 1st April, 1924, but owing to various unavoidable delays it was the 9th June, 1924, before the principal schedule of main highways was declared. From that date the whole of these main highways came under the operations of the Act.

The length of main highways already declared is approximately 6,008 miles, of which a considerable number in sparsely settled districts have been declared Government roads, in order that the Board may be able to contribute to their construction and maintenance on a more liberal basis than is legally possible in connection with the ordinary main highways. There have been legal difficulties in the initiatory process incidental to the commencement of works, and certain amendments to the Act are required before the local authorities can proceed with their proposals. Everything is now in readiness to permit of works being vigorously prosecuted as soon as these legal difficulties have been overcome.

The Dominion has been divided into eighteen highway districts. For all of these districts Highway Councils have been constituted, and, generally, everything is in train for the carrying-out of the intentions of the Main Highways Act.

The actual proposals for work as a rule, and except in the case of Government roads, originate with the County Councils. These proposals are forwarded through the District Highway Councils to the Board. Already numerous proposals have been received, and in the majority of cases are for the surfacing of roads in a manner suitable for modern conditions. The specifications for such surfacing range from ordinary gravel to bituminous concrete, and in a few cases cement concrete.

In the majority of cases only provisional approval could be given to these proposals, as it was necessary to await the passing of the estimates for the current year under the Construction Account of the Main Highways Board.

There have been many applications urging the declaration of additional highways, as there have also been many claims that roads which have been declared main highways should also be declared Government roads, in order to secure more liberal treatment in terms of section 22 of the Main Highways Act; also numerous requests from boroughs that the Board should take over control of certain streets that have proved to be difficult to maintain on account of the excessive amount of foreign traffic. The first report by the Board will be due as soon as practicable after 1st April, 1925.

THE MAINTENANCE PROBLEM.

There has been an ever-increasing number of complaints regarding damage by motor-vehicles throughout the Dominion, especially in the North Island, where metalling is so expensive. The regulation of motor traffic is essential, otherwise much of the expenditure that has taken place during recent years, and is still taking place, will to a large extent be wasted. The roads are built for all, and it is unreasonable that a road which is adequate and economical for 95 per cent. of the travellers and transport organizations should be ruined by a few very heavy and rapidly-driven vehicles, in order that a few may make a little extra profit. The justice of these complaints has been recognized, and Parliament must give controlling authorities adequate powers to deal with the anomaly.

The necessity for improved maintenance cannot be too strongly stressed. Good work is done by local authorities and by the Government, but too often the belief seems to exist in the minds of those responsible that, having laid down a good road, there is no need to do anything more for years to come. Nothing could be farther from the truth and no belief more economically unsound. One of the provisions of the Main Highways Act, from which one may expect the greatest results, is that which authorizes the payment to local authorities of a subsidy of £1 for £2 on their maintenance expenditure. I hope that local authorities who are spending, say, £60 per annum per mile on their roads will not interpret and apply this section of the Act as relieving them of portion of their expenditure—in other words, that in future they should spend only £40 while the Highways Board provides the other £20. This may be reasonable in some cases, but my intention when framing this section was that the local authority would continue to spend its £60 and in addition another £30 provided by the Main Highways Maintenance Fund, and thereby much better roads would result, and heavy (in many cases) expenditure for reconstruction be postponed for years to come.

When we realize that per head of population we have twice as much roadway as there is in the United States and twelve times as much as in England, it must be admitted that a standard of construction per mile as good as exists in these older, more populous, and richer countries cannot be expected in New Zealand. Nevertheless, the results that have been obtained to date in New Zealand need give no cause for complaint. While the United States has only about 13 per cent. of its roads hard-surfaced, New Zealand has 40 per cent.

If we take the total areas of the respective countries into consideration, we find that the United States of America has less than one-eighth of a mile of improved road per square mile of territory, while New Zealand has nearly a quarter of a mile.

With the provision of a reasonable amount for opening up the backblocks, and the special funds made available under the Highways Act, I am confident that as the years go by New Zealand's position, both as regards the proportion of its improved roads and as regards the actual high standard of its more intensely trafficked highways, will be still further improved.

One of the Engineers of the Department has been abroad for the past twelve months obtaining first-hand knowledge of road-construction and administration methods throughout Europe and America. The information which he has obtained will be of considerable value both to the Government, the Main Highways Board (with which he is associated), and local authorities. A report of his investigations and conclusions is appended hereto.

FLOOD DAMAGE.

Honourable members will recollect that last year floods of an exceptionally severe nature were experienced, and it might reasonably have been expected that damage such as then occurred would not occur again for some time, but I regret to say that the phenomenal rains which occurred in the early part of this year, 1924, did damage to roads and bridges, and also railways, of quite an exceptional character. In many cases the cost of restoration was entirely beyond the means of local authorities, and substantial assistance by way of subsidy, and in some cases free grants, was found to be absolutely essential to open up and provide for the continuance of means of access to any districts where such serious damage was experienced. These works are still in hand, the main effort having been in the direction of re-establishing traffic with isolated districts.

HYDRO-ELECTRIC DEVELOPMENT.

In the Public Works Statement of last year there was presented a table showing an approximate programme of development for the following six years. This provided for an expenditure of £964,000 for the year ended 31st March, 1924, and of about £1,000,000 per year for the following five years on extensions of existing schemes and on new developments. During the year a substantial advance was made on various portions of this programme The total expenditure on extensions and new works amounted to £865,072, increasing the total capital invested by the Department on hydro-electric development from £2,170,100 to £3,035,172. This extra capital has been expended on the following main divisions :—

	£
Lake Coleridge	44,768
Horahora	79,795
Mangahao	682,310
Arapuni	57,707
Waikaremoana	497

As the Otago Electric-power Board had made arrangements to deal direct with the Dunedin City Corporation for a supply of power from the Waipori Station to supply their immediate needs, and as the Department is arranging to supply the Waitaki Power Board from the Coleridge system, the urgency for the proposed expenditure on transmission-lines in Otago has been reduced, and the proposed expenditure on this item has to some extent been put back.

Mangahao Power Scheme.

An expenditure of £682,310 has been made in connection with this scheme, and very substantial progress has resulted. The excavation and lining of the tunnels are nearly finished, the Tokomaru Dam has been almost completed, and, after many difficulties, the main dam on the Mangahao has been completed right across the stream and brought up to a height sufficient to allow water to flow through the tunnels. The power-house building, except for minor finishing details, is complete, and the erection of the machinery is well advanced. The main transmission-lines from Mangahao to Wellington, Hawke's Bay, Wanganui, and Wairarapa are well in hand, and substations are being built at Khandallah (for Wellington), Bunnythorpe, Mangamaire, Dannevirke, and Masterton. Others will be put in hand at an early date.

It is now confidently estimated that power will be available at the power-station by the end of October, at Khandallah by the middle of December, 1924, at Bunnythorpe by the end of January, 1925, and at the other substations at short intervals thereafter.

Practically the whole of the power that can be made available from Mangahao has now been allocated to the various Power Boards which can be supplied from the substations under construction. These Boards have entered into guarantees to the Department to pay for the whole of the output of Mangahao Power-station (24,000 K.V.A.) within five years, and the indications are that the whole of the power available will be taken up in less time than that. Before this station becomes overloaded a start will have been made with the main Waikaremoana generating-station, which is the next link in the Department's general scheme of development for the North Island. At present the Mangahao scheme is carrying the capital cost of an excessive proportion of the main transmission system, making the capital cost appear excessively high in proportion to the installed plant capacity. As the scheme becomes fully loaded and connected up with Waikaremoana on the north, part of the capital cost of the transmission system and of some of the substations will have to be adjusted to the Waikaremoana system.

Lake Coleridge Power Scheme.

An expenditure of £44,768 has been made on extensions to this scheme during the year. The plant has been built up to a capacity of 16,000 horse-power, which is the full capacity of the present tunnel and headworks. The original transformers, which were replaced by larger units, have been transferred to Timaru and to the Addington Substation.

A start has been made on the duplication works which will provide for an additional 20,000 h.p. in this station. Contracts have been let for the tunnel, pipe-line, power-house building, and machinery, and a programme of construction has been arranged which will enable this additional amount of power to be made available for the winter of 1926. Additions are being made to the main sub-station at Addington which will enable additional power to be supplied to the City of Christchurch and additional feeders to be run to Power Boards and other consumers in the adjoining districts.

During the year supply has been given to the Ashburton Power Board, the Timaru Borough Council, Malvern Power Board, and the Railway Department to enable the Department to operate its signalling-system on the Midland Railway.

Horahora Power Scheme.

An expenditure of £79,795 has been made on extensions and additions to the Horahora Power-station and to the transmission system radiating therefrom.

Contracts have been let for the supply of two additional 2,000 kw. units, which have now been delivered and are being erected. Additions to the power-house and enlargement of the head-race and tail-race are being carried out by the Department, and it is anticipated that this extra amount of power will be made available before the end of the present year. A transmission-line connecting Horahora and Auckland has been under construction during the year, and will be completed by about January next, when it will be possible to supply the Auckland Power Board with an additional 2,000 h.p. for reticulation of the southern area of their district, and to allow them to shut down portions of their steam plant at times when it may be possible to operate more economically with water-power.

Arapuni Power Scheme.

Early in the year tenders were invited in two sections for the construction of the complete headworks and power-station for the first instalment of this plant. This will consist of three units each of 15,000 kw. capacity. For the first section of the contract, which comprises the dam and headworks, three tenders were received, ranging in price from £610,375 to £931,951. For the second section of the contract, which comprises power-house building and the whole of the power-house plant, four complete tenders were received, ranging from £565,082 to £740,196.

The lowest tender in each case was submitted by Sir W. G. Armstrong, Whitworth, and Co. (Limited), and a contract totalling £1,170,891 has been made with this firm for the construction of both sections. The departmental estimate was £1,168,277.

This power plant, which will be considerably larger than anything previously operating in New Zealand, will be manufactured for the most part in Great Britain, although a portion of the electrical apparatus will be manufactured by the Swedish General Electrical Company, who are subcontractors to Messrs. Armstrong-Whitworth for this section of the plant. Special arrangements have been made whereby as much as possible of the plant supplied by this firm will be obtained in England. The Department was somewhat hesitant about awarding any section of this contract to foreign manufacturers, but, in view of the very favourable price submitted by Messrs. Armstrong, Whitworth, and Co., and in view also of the excellence of the plant and machinery submitted, had no option but to accept the lowest tender, although such tender involved the placing of a small proportion of the business outside Great Britain.

It is exceedingly gratifying to know that such satisfactory tenders were received for this work, and that it is to be carried out at a price almost exactly in line with the estimates prepared by the Department's Engineers. The whole scheme has been most favourably commented upon by the various experts who investigated it in connection with these contracts, and it is now assured that the Auckland District will be supplied for some years to come with power to meet all requirements.

In anticipation of the letting of this contract a large amount of work was carried out by the Department on the roads and bridges giving access to the locality where the works are to be. Work was also undertaken in connection with the village-site and the houses for the accommodation of the staff. As the result of this preliminary work the contractors have arranged to complete the main work in three years from date of signing the contract.

Operating Results.

Lake Coleridge Electric Supply.

The operating results for the year have again been satisfactory. The capital investment has been increased to £892,801. The financial results are summarized as follows:—

		£	£
Capital investment			892,801
Revenue			78,508
Expenditure:	Working-expenses	20,777	
	Interest	44,444	
	Depreciation	12,584	
			77,805
	Profit		£703

This has enabled the accumulated deficiency in the Profit and Loss Account to be reduced to £23,173. The State Supply of Electricity Act requires payment of 1 per cent. to a sinking fund after a scheme has reached a profit-earning stage, but we do not propose making any payment into this sinking-fund account until such time as the accumulated deficiency of the Profit and Loss Account has been wiped out.

During the year the water-supply to the lake has been well maintained, and with the Harper race there has been no difficulty in maintaining the requisite water-level of the lake. There has always been a considerable surplus of water allowed to run past the intake-gates on the Harper.

The plant has operated satisfactorily during the year, although a fault developed on the new 3,000 kw. generator after that unit had been in operation for a short time. It was possible at that time, however, to carry the whole of the load without the use of this unit, so no serious inconvenience was experienced whilst repairs were being made.

The load on the station has increased rapidly during the year, the maximum load for the year ending 31st March, 1924, being 10,800 kw., an increase of 1,410 kw. Since the end of the financial year a maximum load of 13,200 kw. has been reached on one occasion. It is anticipated that during the winter of 1925 there will be a still further increase in the demand on this station, and every effort is being made to get the plant into first-class condition for the overload, which we anticipate we will have to carry before the new units being provided in the duplication can be operated, which is anticipated to be during the winter of 1926.

Horahora Electric Supply.

Service has been satisfactorily maintained throughout the year, and the financial results have been very satisfactory. The position may be summarized as follows:—

		£	£
Capital outlay			474,817
Revenue			59,924
Expenditure:	Working-expenses	12,474	
	Interest	21,231	
	Depreciation	10,393	
			44,098
	Profit		£15,826

This has been expended in wiping out the accumulated deficiency of sinking fund, and the balance of £3,494 has been carried forward on the Profit and Loss Account, as it is anticipated that with the heavy expenditure on additions and extensions coming on during next year, and with special heavy depreciation charges on sections of the old plant, the financial results of the next two years may not be quite so satisfactory.

The maximum load was 7,400 kw., an increase of 500 kw. during the year. This might have been considerably increased had the additional operating plant been available.

Waikaremoana Power Plant.

A small plant has been installed by the Department at Waikaremoana for the supply to Wairoa Borough Council, and in anticipation of our requiring power for construction purposes on the main scheme of development. This plant has been leased to the Wairoa Power Board, and has been operated by them during the year. The results have been very satisfactory in supplying the needs of the Wairoa district, and in building up a load in that district in anticipation of a larger development. The plant has a capacity of 700 kw., and the maximum load reached during the year was 555 kw.

The financial results considering the plant simply as an operating-station are not very satisfactory, but as the plant is really an advance portion of the larger scheme of development at Waikaremoana the capital investment is considerably greater than would have been necessary if the scheme had been put in purely for its present purpose of supplying power to the Wairoa Power Board.

The capital outlay is £77,148. Capital charges (interest and depreciation) amounted to £5,574, and the revenue to £2,100, giving a loss of £3,474 for the year.

Future Development.

For the current year the main works under construction will comprise—

Mangahao.—Completion of present power-house to capacity of 24,000 K.V.A. Extension of transmission-lines to Napier and to Wanganui, and the completion of substations now in hand. The erection of further substations to supply the Hawke's Bay, Central Hawke's Bay, and Wanganui-Rangitikei Power Boards.

Lake Coleridge.—The duplication of the present plant. including a second tunnel, and an additional 20,000 h.p. of plant capacity.

A second transmission-line will be erected to Timaru, and an extension made from Timaru to Oamaru.

Horahora.—Completion of extensions to power-house, and erection of transmission-lines to give supply to Auckland, to Rotorua, and to Waitomo Power Board.

Arapuni.—The access roads and bridges will be completed during the year, and the contractor for headworks and power-house will have made active commencement on his contract. A substation will be erected at Penrose to give supply to the Auckland Power Board, and surveys made for transmission-lines and preliminary works necessary to give supplies to Franklin and Waitemata Power Boards. Surveys will be made and specifications prepared for a main duplicate transmission-line between Arapuni and Auckland.

Waikaremoana.—Detail plans and specifications will be prepared in anticipation of an active commencement of the major scheme at this place as soon as our staff are released from Mangahao, and the load on Mangahao indicates that an additional source of power is necessary.

Other Schemes.—In addition to the above, survey and other investigation work in connection with additional sources of power will be put in hand.

Future Policy.

The works now under construction provide for the requirements of most of the main centres of population. The requirements of others are being provided by plants owned or being installed by local authorities. Some criticism has been directed against the Department in regard to its policy of development in

Canterbury, but we cannot allow our general policy of supplying power in what is considered to the best interests of the country generally to be upset or modified by purely local considerations.

The Department's proposals for a general power-supply to Canterbury, Otago, and Southland provide for a main interconnected transmission system extending from Lake Monowai in Southland up through Otago and Canterbury to Christchurch, and linking up later with power sources farther north, probably on the Clarence River.

The nucleus of this scheme exists at present in the Government power-station at Lake Coleridge, with its transmission system to Christchurch, and to Timaru; in the Dunedin City Corporation's power-station at Waipori, with its lines to Dunedin and Mosgiel; and in the Southland Power Board's station at Lake Monowai, with its lines to Invercargill and Gore.

While the load at points between the main load centres at Invercargill, Dunedin, and Christchurch is comparatively small as at present, it is more economical to supply it by means of transmission-lines from existing stations than by building new power-stations, probably with further transmission-lines. In this connection £150,000 (£30 per kw.) would be a low capital cost for a hydro-electric generating-station of about 5,000 kw. capacity without allowing anything for transmission-lines that might be necessary to bring the power to the load-centre. For the same £150,000 capital cost a duplicate transmission-line of more than 5,000 kw. capacity could be taken 100 miles, and the cost of operation would be considerably less than the cost of operating the separate generating-station. Thus, so long as the existing stations have power available, and the intermediate load-centres are comparatively small, transmission from existing stations will remain the more economical method of supply until the existing sources reach the limit of economic development.

When the interconnected transmission system from Monowai to North Canterbury becomes loaded beyond the capacity of Lake Coleridge, Waipori, and Monowai, it will be necessary to develop further sources of power and to make them feed into the general system. Which scheme it will be most advantageous to develop next, depends partly on the relative cost of development of different sources, and partly on the magnitude of the growth of load, and prospective load, in different sections of the system. Beyond the duplication of Coleridge, and extensions at Waipori, further available power sources have not all been compared by the Department, but it is known that additional power can be developed in several places, including Lake Tekapo, the Waimakariri River, the Clarence River, the Teviot River, and the Waitaki River, while still further development is possible at Lake Coleridge, but until these schemes can be compared in detail no indication can be given as to which should be developed first.

In general, it might appear, on account of load in South Canterbury and North Otago being of medium dimensions at present, and at considerable distance from the existing sources of power, a development on the Waitaki or at Lake Tekapo should be the next to be undertaken. This would leave extra power available farther north for Christchurch from Coleridge, or farther south for Dunedin from Waipori. If, however, a much greater load than the capacity of Lake Coleridge were prospective in Christchurch, it would obviously be more economical, if the sources were, otherwise, of anything like equal value, to develop one of the sources farther north, such as Waimakariri. The time is opportune for investigation of the relative values of these different sources, and it is proposed to utilize some of the staff, released on completion of civil construction work at Mangahao in a few months' time for surveys in connection with this work.

Power Boards.

The Power Board legislation was introduced in 1918 to set up new local authorities whose special business it would be to distribute and sell electric power to the consumers in their district. With the large programme of development which the Department has in front of it, it is felt that this portion of the electric-supply business could with advantage be handed over to bodies having direct interest in creating and increasing the load which it is essential the Government schemes must secure if they are to become profit-earning at an early date.

The matter has been taken up so enthusiastically by the people generally that at the end of the financial year there were thirty-six Power Boards in existence. These Boards cover an area of 57,876 square miles, or 56 per cent. of the total area of the Dominion; the total population concerned is 679,748, or 53 per cent. of the total population of the Dominion; and the unimproved land-value included in the Power Board districts is £180,707,472, or 54·5 per cent. of the total unimproved land-value of the Dominion.

Of the thirty-six Boards, thirteen are already operating and supplying power, eleven have embarked on an active scheme of construction, whilst the remaining twelve have done only preliminary work.

At the end of the year the Boards had a capital investment of £3,212,296, and the ratepayers in their districts by a vote of 28,975 to 2,589 had authorized the raising of loans totalling £7,941,000.

General.—The enormous increase that is taking place in electrical development in New Zealand has necessitated a vast amount of work on the inspection of electric lines and plants of various local authorities. The question of adequate regulations to govern electrical work has received much consideration, and, following the publication of new regulations issued by the Institution of Electrical Engineers in London, it is proposed to issue a new set of regulations covering erection of electric lines in this country.

During the year a most important conference on power matters was held in London at which representatives from most of the power-using countries of the world were present.

New Zealand was represented at this conference by Sir James Allen and Mr. Evan Parry. A paper descriptive of the electrical development of the country was prepared by the late Chief Electrical Engineer, Mr. Lawrence Birks, B.Sc., M.I.E.E., M.Inst.C.E., &c., and presented at the conference. The late Mr. Birks also was to have represented New Zealand at this conference. With that object in view, and to study modern developments in Europe and America, he left this country in April last. Unfortunately his health broke down, and, on the advice of medical men in Australia, he returned to New Zealand. Though confined to his bed after a serious operation he continued to take a keen interest in the work of the Department until he died on the 25th July. Through his death the Government has lost a keen, able, and energetic officer, who put the utmost enthusiasm into all he undertook. He will long be remembered for the work he did in connection with the development of the initial hydro-electric schemes in this country. The works that have been carried out under his supervision will be a monument to his ability, his energy, and his enthusiasm.

To fill the position made vacant by his death, Mr. F. T. M. Kissel, B.Sc., A.M.Inst.C.E., A.M.I.E.E., has been appointed Chief Electrical Engineer. Mr. Kissel had acted for some years as principal assistant to Mr. Evan Parry and to the late Mr. Lawrence Birks, and has been intimately associated with all of the Government hydro-electric schemes. He recently spent a year abroad studying the latest developments in other countries, and as he is young and has shown undoubted ability he should be well able to carry on the important work now entrusted to him.

RAILWAYS.

Railways Improvement Authorization Act, 1914.

The expenditure under the Railways Improvement Authorization Act, 1914, amounted to £20,520 for new stations and station-yards, and terminal goods-sheds facilities at Wellington, Christchurch, and Lyttelton; grade-easements, Penrose–Mercer; new line, Auckland–Westfield; and signalling, interlocking, and safety appliances. The proportionate cost of raising the loan was £1,466.

Additions to Open Lines.

The expenditure out of the Public Works Fund amounted to £643,648 for the provision of additional rolling-stock; tarpaulins; Westinghouse brakes; steam-heating; electric headlights for locomotives; workshop machinery; improvements

and additions to station-buildings; extension of sidings; bridge-works; subways; cranes; weighbridges; additions to workshops; tablet, telegraph, and telephone facilities; additional dwellings; signals and interlocking; and purchase of land.

WAIHOU AND OHINEMURI RIVERS IMPROVEMENT.

In continuation of the substantial progress made on the Waihou and Ohinemuri Rivers improvement scheme during last year, the new suction dredge, to be electrically operated, is under construction, and it is hoped to commission it by March next. It will commence operations at Ngahina Bridge, and, working downstream, will, on three shifts, build the heavy stop-banks there at the rate of one mile per two months.

On the Upper Waihou section, Waihou dredge No. 1 will, within twelve months, nearly complete the remaining work on the section of the stop-banks between Mangaiti and Ngararahi.

On the Ohinemuri River the stop-bank system will be completed, and it is anticipated that the reconstruction of the Criterion Traffic-bridge over the Ohinemuri River, and also the reconstruction of the Ohinemuri River Railway-bridge, will be put in hand.

PUBLIC BUILDINGS.

In connection with the building activities of the Department, a rather damaging statement, prepared, I believe, by a member of the executive of the New Zealand Institute of Architects, was given a good deal of prominence in a periodical which published a special number in connection with the Wembley Exhibition, the inference in the article being that New Zealand did not obtain good results by the practice of preparing the plans and carrying out its buildings with its own staff.

Statements were made about monotonous uniformity and stereotyped methods of design. It is only necessary to mention such widely dissimilar designs as the Public Trust Building, the General Post Office, the Governor-General's residence, and the building in which we now sit, to negative any suggestion of uniformity. The photographs reproduced herewith, all of a number of post-offices completed during the year, will indicate to honourable members that our designs are not made by the mile and sawn off as required, but that each site and building is studied so that it may fulfil its requirements, and suitably harmonize with its surroundings in accordance with the best principles of architecture. I am by no means one of those who think that because a man works for the Government he must therefore be lacking in individuality and initiative.

Parliament Buildings, Wellington. — Furnishings and fittings required for the new buildings were purchased, and cellarage accommodation for use of Government Departments under the new buildings was provided. The completion of the new building cannot be deferred much longer, and is now under consideration.

Departmental Buildings.—Properties at Alexandra and Greymouth were purchased as residences for departmental officers. Provision was also made for a seismograph at the Hector Observatory, Wellington, and additions were made to the Lands and Survey Departments offices at Christchurch. Alterations were carried out at the Departmental Building, High Street, Auckland.

Owing to the expansion of business, and the need for additional accommodation for officers employed, temporary additions are to be made to the Departmental Buildings, Wellington, and the necessary provision has been made on the estimates. The erection of new permanent Departmental Buildings can be deferred for some time as a result of arrangements made for renting offices for the staff of some Departments, but the erection of a permanent building will require consideration at no very distant date. The existing wooden structure has been satisfactorily maintained in the past, but will have to be replaced before many years have passed.

Courthouses.

No new Courthouses were erected during the year. A site for a new Courthouse at Blenheim was secured. Necessary renovations have been carried out at the following: Kawakawa, Kaitaia, Russell, Waipu, Whangaroa, Cambridge, Onehunga, Otorohanga, Paeroa, Te Aroha, Te Awamutu, Rotorua, Taupo, New Plymouth, Waitara, Hawera, Opunake, Wanganui, Patea, Tolaga Bay, Taumarunui, Napier, Waipukurau, Dannevirke, Picton, Westport, Reefton, Clyde, Lawrence, Naseby, Roxburgh, Dunedin.

Prison Works.

The erection of necessary prison buildings was proceeded with during the year to the extent permitted by the funds available. Additions and alterations to the Women's Division of the Auckland Prison, including the erection of a suitable infirmary for female patients, were completed, and good progress made with the construction of two additional cottages, one of which is now in occupation. The development of the Tokanui Mental Hospital property by Waikeria Reformatory inmates has been continued, and improvements to the Reformatory farm and roads have also been carried out. A new sawmill, on modern lines, has been erected at Waikune Prison Camp, Erua, and the plant, which has now been in use for some months, is satisfactory in every respect. In addition to formation and repair work on the Waimarino–Ohakune section of the Main Trunk Road, the road from Waimarino to Tokaanu was maintained throughout the year by prison labour. The clearing and breaking-in of pumice lands at Houtu, near Tokaanu, progressed satisfactorily during the past year, and much valuable work has been accomplished. The erection of a new Trial and Remand Prison on Watts Peninsula, Wellington, is proceeding. An additional building to house women committed under the Reformatory Institutions Act is being erected at Point Halswell, and will be ready for occupation within a few months. The second cell-range at Paparua Prison has been completed, and the foundations of a new Administration Block have been laid. At Invercargill the construction of the rifle range has been further advanced, and the targets are now being erected. An additional cottage, constructed of concrete blocks, has been completed, and is now occupied.

Police-stations.

New stations have been erected at Devonport, Nuhaka, and St. Albans; the erection of a constable's residence at Clyde, a lock-up and office at Ruatorea, and additional office accommodation at Wanganui Police-station have been put in hand; houses for use as police-stations have been purchased at Henderson and Taneatua. Provision is being made in the current year's estimates for the erection of police-stations at several places where new buildings are long overdue.

Post and Telegraph Buildings.

The efforts of the Department to overtake the leeway in its building programme caused by the war and the subsequent financial depression have been successful to the extent of enabling increased or improved accommodation to be provided at many places at which it was urgently required. The expenditure on new post and telegraph buildings during the year far exceeded that of the previous year.

Owing to the great building activity in the Dominion, and the consequent difficulty in obtaining tradesmen, the cost of building is still comparatively high. The Department is therefore restricting its operations to cases in which improved accommodation is essential for the efficient conduct of its business.

During the year buildings were erected at the following places (the list includes a number of post-office buildings of the smallest type): Awakino (lineman's residence), Dannevirke, Stratford, Dunedin (automatic telephone exchange), Kopaki, Ngongotaha, Ohinewai, Onewhero, Patea, Springburn, Tinui, Waharoa, Waimauku, Waitoa, Wellington (store, workshop, and garage).

Additions were made to the post-office buildings at Inglewood, Kaiapoi, and Motueka, and to portions of the railway-station buildings used for post-office purposes at Midhirst and Normanby. At New Plymouth and Tokomaru Bay

internal alterations were made in order to incorporate in the post-office buildings accommodation previously occupied by another Department, and by the Postmaster as residential quarters, respectively.

It was necessary during the year to purchase at Maungakaramea, Plimmerton, Riccarton, and Waipahi buildings to accommodate the post-offices at those places. At Kohukohu a residence was bought for the Postmaster.

The extended use of motor-vehicles rendered necessary during the year the provision of workshops and garage accommodation at Invercargill, Palmerston North, Wanganui, and Wellington. Small garage buildings were provided at Matamata, Morrinsville, Opotiki, Papakura, Rotorua, Whakatane, and Whangarei; and a garage and store building was erected at Masterton.

A portion of the new building erected for the Department in Hereford Street, Christchurch, has been occupied by the Telegraph Branch, thus releasing for postal purposes accommodation urgently required in the chief post-office building. Necessary alterations are now being made to the latter building.

A portion of the old post-office building at Patea was moved to Whenuakura for use as a post-office.

At Lichfield and Okaramio small post-office buildings were provided by the settlers. In each case the cost of the work was subsidized by the Department.

In consequence of the opening of the Otira Tunnel, the post-office building at Otira was moved from a position near the western end of the tunnel to a site near the railway-station.

A building to house the automatic telephone exchange in Wellington is nearing completion.

The post-office building at Paeroa, which has served its period of usefulness, is to be replaced by an up-to-date structure on a new site.

Owing to increased business, additional accommodation for post-office purposes is required at Gisborne, Greymouth, Invercargill, Masterton, and Nelson; and the question of making additions to the post-office buildings at these places will require to be faced shortly. At Gisborne an extensive addition to the existing building is in course of erection.

Mental Hospitals Department.

At Auckland considerable maintenance work, together with minor alterations and improvements, has been carried out. Provision has also been made to light the institution with electricity supplied by the Auckland Power Board.

At Tokanui contracts have been let for the erection in brick of an admission ward for females, administration block, and central store, and work in connection therewith is proceeding.

At Porirua an additional area of farming lands was acquired during the year, and general maintenance work carried on as usual.

The expenditure at Nelson and at Stoke has been mainly on the lines of bringing the institutions up to date structurally.

Heavy expenditure at Hokitika is occasioned by the construction of an up-to-date reception ward, and by necessary alterations and removals to existing buildings, the whole being part of the general scheme for replacing the present old and unsuitable structures with buildings in line with modern ideas and requirements.

At Seacliff much maintenance work was carried out in addition to the provision of new bathrooms and lavatories on the male side and new airing-courts for female patients.

Buildings for Department of Agriculture.

For financial reasons the expenditure upon buildings, &c., at experimental stations has been restricted during the past few years to only the most urgent works, but provision is now being made for the erection of a residence and farm-buildings at Waimaunga, and up-to-date cattle-yards and slaughter-house at the Ruakura Farm of Instruction. The former buildings are being erected to enable dairying to be started and the farm to fulfil the purpose for which it was originally acquired. Provision is also being made for the erection of a residence and farm buildings at the Galloway Experimental Area, to enable dairying to be started for the purpose of demonstrating the best methods to employ in connection with the irrigation systems established in the district.

The machinery for the mixing of poison, and the buildings in which the work is performed, not being satisfactory from the point of view of the health of the workers in the depots, structural alterations to the buildings are contemplated, and also the purchase of new machinery.

Provision is also being made for the erection of a residence and stable at Lumsden, to replace buildings recently destroyed by fire; for the erection of residential and office accommodation at Roxburgh; for necessary farm-buildings at Puwera; for a portable glasshouse for seed-testing work at the Biological Laboratory; proportion of the cost of erection of a new fumigator at Auckland; and the installation of electricity at the Central Development Farm at Weraroa, in order that advantage may be taken of the power from Mangahao.

Hospitals and other Institutions.

The principal works desired to be put in hand during this year are the erection of a new women's hospital for neurological cases at Queen Mary Hospital, Hanmer; the conversion of existing buildings into the Nurses' Home; and the renewal of a pipe-line which gives the institute its water-supply. Various additions and alterations are contemplated at King George V Hospital, Rotorua, and at the Otaki and Pukeora Consumptive Sanatoria; whilst it is proposed to make additions at various St. Helens Hospitals. Additional accommodation is also required at the Leper Hospital, Quail Island.

Educational.

For primary education a considerable number of new schools have been erected, and a large number of existing schools have been added to. A fine high-school building, to cost £40,000, is in course of erection at Invercargill. Portion of the cost is being found by the Southland Education Board, but the plans were drawn and the building is being erected by Public Works Department, in accordance with the new arrangements whereby the Government will in future erect its own educational buildings.

The demand for increased secondary accommodation has been very pressing, and, in addition to buildings that are being enlarged, new schools are in course of erection or about to be erected at Dargaville, Whangarei, Tauranga, Hastings, Napier, Lower Hutt, Wellington, Christchurch, and Invercargill.

A large University building is being erected at Auckland, and grants were approved for the erection of new medical and dental buildings at Dunedin.

LIGHTHOUSES.

A temporary wireless radio beacon was erected at Cape Maria van Diemen, to work in conjunction with the direction-finding equipment aboard the s.s. "Tutanekai." The tests carried out proved entirely satisfactory. Apparatus for the conversion of light at Tiritiri from a watched light to an automatic light has been received. An automatic flashing light has been established on Ohena Island. A small automatic acetylene flashing light was installed at Kaipara South Head Beacon. The light at Somes Island was converted from a watched oil-burning to an unwatched automatic acetone-acetylene light, and handed over to the control of the Wellington Harbour Board. Two oil-engine hauling-winches were installed at Stephen Island. Apparatus for the conversion of the light at Anglem Point to an automatic flashing type has been obtained and installed.

HARBOUR-WORKS.

A crane-landing and approach bridge at the Flowerpot Rock at Bruce Bay has been completed. Wharves were erected at the following places: Whangarei, One Tree Point; Kaipara, wharf at Bradley's Landing; Naumai; and New Brighton, Miranda district. Repairs were carried out to the wharf at Whakapirau; improvements in the Mokau and Manawatu Rivers were carried out. A harbour for fishing-boats was constructed at Kaikoura, and the construction of a wharf at Collingwood was commenced.

TOURIST AND HEALTH RESORTS.

The principal expenditure last year was in connection with works at Rotorua, which consisted of the replacement of wooden with cast-iron water-mains, and the purchase of a Diesel engine standby plant for electrical purposes.

A building for massage purposes was erected at Te Aroha; a ladies' swimming-bath at Helensville; and additions to the Hostel and the installation of a heating service at Mount Cook Hermitage, in terms of an agreement entered into between the Government and the lessees. Additions and improvements at Morere and Maruia Hot Springs were other works carried out.

Provision is being made on this year's estimates for the continuation of the replacement at Rotorua of wooden with cast-iron water mains; additions, and installation of electric-lighting schemes at Waitomo Caves Hostel, and Lake House, Waikaremoana; extensive and necessary additions to the hotel at Te Anau; and improvements at the different resorts under the control of the Department.

TELEGRAPH EXTENSION.

The persistent demand for the quickest and most modern means of communication by telegraph and telephone, and the extension of the telephone-exchange system to all parts of the country, necessitates greater provision being made year by year for the fuller development of the telegraph and telephone services in New Zealand.

The past year's operations, which involved a capital expenditure of £717,000 on materials and labour, included, among other things,—

(1.) The connection of 11,000 new subscribers to telephone-exchange systems:
(2.) The establishing of telephone-exchange systems at Clydevale, Hawea Flat, Hinds, Karamea, Matakana, Paraparaumu, Plimmerton, St. Heliers, Uruti, and Waipiro Bay:
(3.) The prosecution of new automatic installations at Wellesley Street, Auckland; Ponsonby; Mount Eden; Remuera; Onehunga; Devonport; and Takapuna:
(4.) The conversion of the Wanganui Exchange to automatic working:
(5.) The extension of the automatic equipment at five exchanges:
(6.) The extension of switchboard accommodation at thirty-five manual exchanges:
(7.) The installation of underground and aerial cables at a number of the small exchanges:
(8.) The extension of the cable system at sixty-nine exchanges:
(9.) The reconstruction of the aerial system at a number of exchanges:
(10.) The installation of additional multiplex telegraph instruments at Auckland and Wellington, to provide for the linking-up of the more important provincial towns by means of the multiplex system of telegraphy:
(11.) The providing of direct communication over machine-printing circuits between Christchurch and Dunedin:
(12.) The replacement of the primary telegraph batteries at Christchurch by the installation of the universal battery system, the first of its kind in New Zealand:
(13.) The improving of the existing wireless stations in New Zealand and the Cook Islands by the installation of more modern equipment:
(14.) The erection of additional telephone and telegraph circuits between the following places:—

Auckland–Waimauku	Featherston–Cross Creek
Taipa–Parapara	Christchurch–Greymouth.
Hamilton–Cambridge (two)	Kumara–Otira
Hamilton–Ngaruawahia	Kumara–Hokitika
Taumarunui–Matiere	Ross–Harihari
Te Awamutu–Ohaupo	Amberley–Omihi
Stratford–Whangamomona	Christchurch–Ashburton
Wanganui–Raetihi	Christchurch–Prebbleton
Uruti–Urenui	Sockburn–Dunsandel
Tahora–Tatu	Fairlie–Te Kapo
Palmerston North–Shannon	Dunedin–Lawrence
Shannon–Levin	Lawrence–Heriot
Levin–Otaki	Balclutha–Clydevale
Otaki–Waikanae	Dunedin–Seacliff
Wellington–Palmerston North	Tapanui–Kelso–Heriot.

As stated in my report on the Post and Telegraph Department which was laid on the table of the House recently, provision will be made in this year's estimates for the purchase and laying of a submarine cable across Cook Strait which will provide telephone communication between the North and South Islands.

The buildings for automatic-telephone exchanges at Christchurch and Dunedin are completed, and the work of installing the apparatus will be put in hand at an early date.

Tenders have been invited for automatic-telephone exchanges at Hawera, Stratford, and Dannevirke.

CONTINGENT DEFENCE.

Owing to the pressing need for economy very little expenditure under this heading has been incurred since 1918, but the estimates for the current year show considerable extension. Provision is made for magazines for gun and small-arms ammunition; additional harbour-defence works; provision of new drill-halls and rifle ranges; water-supply, cookhouses, and mess-rooms for camps; quarters for Defence staff; and the provision of an aerodrome at Auckland.

All the works are urgent and necessary for the proper training of the Forces and the administration of the Department interested. Drill-hall accommodation either does not exist or is entirely insufficient at many centres. Existing magazine accommodation is insufficient, necessitating the temporary use of unsuitable buildings, and there is a danger of serious accidents and deterioration of valuable ammunition so long as such conditions obtain.

The provision of proper cookhouses, mess-rooms, and water-supply at command camps is necessary to ensure the comfort of troops and economical administration of the camps.

MECHANICAL APPARATUS.

In order to keep construction works adequately supplied with indispensable modern apparatus and plant, the equipment has been increased by the purchase of ten motor-trucks, seven light locomotives, two excavators, two petrol electric-lighting sets, one portable air-compressor, one traction-engine, and half a dozen other equally necessary labour-aiding machines.

Arrangements have been made to increase the mechanical staff, the new officers being directly responsible for the maintenance of mechanical plant in an adequate state of repair and as up to date as modern developments permit.

CONCLUSION.

In last year's statement I drew attention to the necessity of endeavouring to co-ordinate the expenditure on various transport-ways in order that, after allowing for main-trunk transport-ways, both railway and road, all other transport-ways should be complementary to one another, and all leading to support the most economical and efficient, instead of, as is too often the case, competing with one another. My observations on this subject were made in the hope that it would receive the thought and consideration of those concerned. Such a state of affairs as exists now is perhaps the inevitable result of the driving energy of a people whose efforts have brought about a rate of development which, I believe, has never been equalled in any other country. The multiplicity of local governing bodies is another factor which has contributed in marked degree. It is easy to be wise after the event. It is not so easy to discover the remedy, but it is never too soon to endeavour to do so.

As a premise to consideration of the subject it must be realized that the country's public indebtedness is not merely the public debt of the Government, but that debt plus the debt of every local body in New Zealand. For every pound of such debt the people must pay in one way or another.

While there exist so many authorities vested with borrowing and expending powers it is practically impossible to control the position or co-ordinate the result of such expenditure.

It is true that local body loans must have the sanction of the ratepayers, and that the ratepayers' land is held as security for loan charges. While I do not for one moment suggest that ratepayers' consent should be eliminated, I do assert that the ratepayer's vote is a poor and unsatisfactory system of control. It is common knowledge that a great many loans—I venture to say, a majority—are carried not only by a minority of the ratepayers, but that the total of votes polled for and against the proposal is a minority of the total number of ratepayers concerned. Too often proposals to raise large sums of money are put forward without any real investigation as to the general economic result of the expenidture and its real advantage to the district concerned. Not infrequently expenditure "schemes"—and I use the word advisedly—are put forward by enthusiastic "boosters" who entirely mislead the people, who will have to pay in the long-run. It is usually asserted that so long as ratepayers are prepared to tax their land the scheme must be sound, and in any case it is the ratepayers' concern. It is the ratepayers' concern if those who vote for the loan stay to pay its charges. I have little hesitation in saying that these works are often commenced to give an inflated prospective value to lands, which, having been created temporarily, the promotors sell out at enhanced value and leave some one else to carry the burden. I may be permitted to recall a case which is typical. The promoters of a big expenditure scheme were addressing a meeting of settlers with a view to obtaining their signatures to a statutory petition. One of the leading settlers assured the promoters that the settlers were willing to sign any petition and vote for any loan in order to get the railway which would enable them to sell their land. When I asked the promoters to produce the data on which they assured themselves that the railway would be a payable proposition, they had none to produce. Needless to say, that railway is still only a proposal. If the sum of all charges on land, and the capacity of the land to pay, to any degree approximate one another under prosperous or even normal conditions, it is obvious that under any condition of adversity the margin of security disappears. Unless there be some means of comprehensive survey and regulation of total public indebtedness to considerations of population, land-values, productiveness, and average value of products, the position will remain unsatisfactory and may even become one of grave concern. I do not suggest that such a position has been reached or anything approaching it, but I do suggest that it is better to plan now some method of control which will obviate such a possibility than to bewail when it is too late. I have sufficient knowledge of the wealth with which nature has endowed this country and faith in its people and their resource to believe that it can bear with comfort a considerably greater indebtedness; but the money must be spent wisely on a plan which has had the most careful consideration of the factors I have mentioned, and which fits in with a comprehensive scheme of development-work. What we cannot afford is piecemeal, ill-considered expenditure dictated by local ambitions and without reference to what work is being planned or under way in the next watertight compartment.

The Main Highways Act is the first direct legislative step in the direction I have indicated. Instead of each county working independently, the District Highways Council considers roading from the point of view of best serving the interests of a number of grouped counties, while the Highways Board is enabled to co-ordinate the work of groups. But this measure of control operates only in regard to one avenue of expenditure—namely, roadwork—and that only on roads which are declared main highways. There still remain all other roads.

I have great hopes, when once this scheme is in full operation, and its benefits realized, that it will result in amalgamation of many counties, even perhaps to the extent of amalgamation of all counties within the various groups. By this means it will be possible to vastly improve the standard of staff efficiency and organization, and that must surely result in better and cheaper work on a more comprehensive plan.

I believe it to be an urgent measure of local-government reform that we should reduce the total number of local governing bodies which exist within one another's boundaries, overlap, and to a considerable extent duplicate one another's work. As

an indication of this necessity I have but to point to the fact that we have one hundred and eighteen Boroughs and Cities, seventy-one Town Boards, one hundred and twenty-nine Counties, thirty-five Road Boards, fifty-nine Drainage Boards, and forty-nine River Boards, all with their separate staffs, plant, and overhead charges.

It is obvious that a very considerable percentage of these bodies could be done without and their work absorbed by the remaining local authorities.

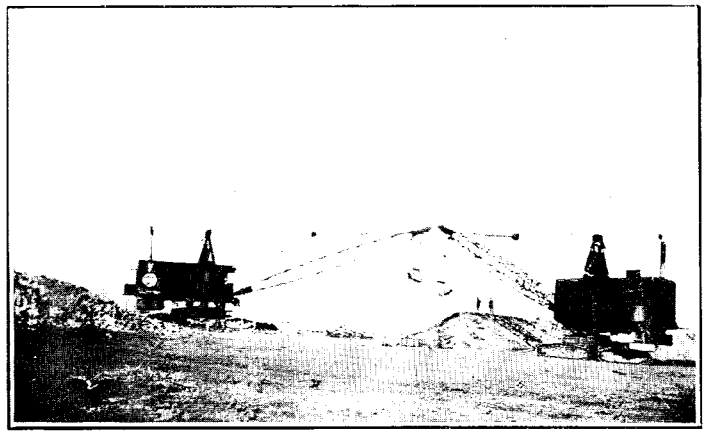
There are also some thirty-nine Harbour Boards in existence constituted as such by special legislation, and, in addition, there are fourteen other harbours in respect of which the local authority is delegated with and carries out the powers and functions of a Harbour Board. Even some of the specially constituted Harbour Boards could have carried on satisfactorily under the administration of an existing local authority.

Possibly the time has not yet arrived for the organization of a Local Government Board, but it does seem to me that we should take into early consideration the creation of a plan whereby no local authority may proceed with the raising of a loan until the proposal has been first submitted to experts for investigation, in order to ascertain whether (*a*) the work proposed is sound from an engineering point of view; (*b*) it is justified at the cost estimated, having regard to existing services; (*c*) it is economically sound, having regard to its value to the district concerned and the capacity of the district to pay for it; and (*d*) (if applicable) it fits in and forms part of a comprehensive plan of relative works. Assuming all these factors to be answered by the expert investigators in the affirmative, and the raising of the loan concurred in by the Treasury, who would maintain a record of all public loan indebtedness, actual and prospective, the way would then be clear for the local body to submit the issue to the ratepayers, who would have an assurance which they do not have now.

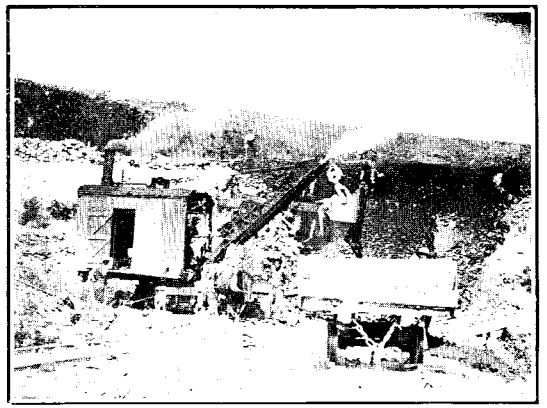
In conclusion, Sir, I have, assisted by the officers of the Department, endeavoured to so direct the forces under my control and the expenditure of moneys appropriated by Parliament as to obtain twenty shillings' worth of result for every pound spent. I have to the best of my judgment carried out the works which will return the best results in aiding general Dominion prosperity and in the improvement of the conditions and producing-powers of those who are not so favourably situated as those of our citizens who carry on their activities within easy reach of the well-established markets or lines of communication. Confidently I look forward to a year of satisfactory progress, during which I will again be guided in my administration by a determination to do all that is possible to produce the greatest good for the greatest number, while at the same time not forgetting the "under dog."

Schedule showing Particulars of Railway-lines under Construction at 1st April, 1924.

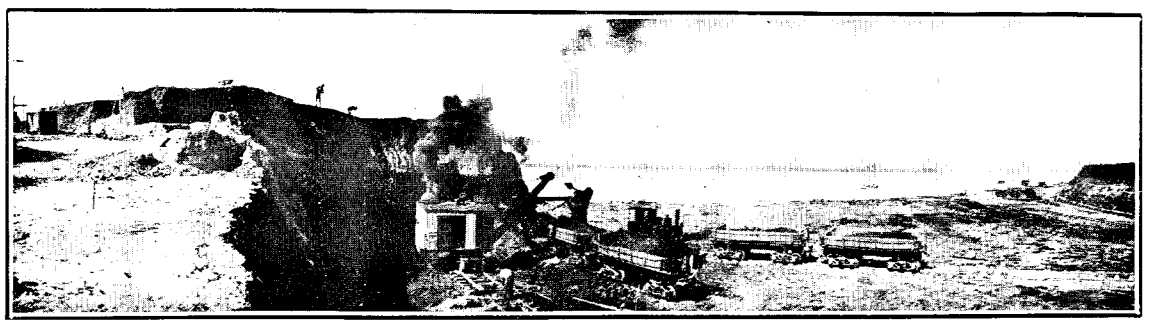
Railway.	Length of Section.	Length under Construction.	Handed over to Railway Department during Year ended 31st March, 1924.	Rails laid during Year.	Length over which Traffic is being run.	Length over which Goods Traffic only is being run.	Length ready for handing over to Railway Department.	Ready for handing over to Railway Department within One Year.	Ready for handing over to Railway Department within Two Years.	Amount spent to Date.	Estimated Amount to Complete.
	M. CH.	M. CH.	M. CH.	M. CH.	M. CH.	M. CH.	M. CH.	M. CH.	M. CH.	£	£
Kaihu Valley	4 54	..	4 54	..	..	..	..	..	..	..	1,300
North Auckland Main Trunk and Branches—											
Whangarei Branch	14 52	14 52	..	..	14 52	..	..	14 52	..	311,506	24,830
Okaihau Section	8 20	8 20	8 20	..	..	..	..	..	..	197,057	2,800
Okaihau–Te Tio	21 0	..	..	..	..	..	..	..	..	26,096	472,500
Huarau–Waiotira	15 70	15 70	..	..	15 70	..	..	15 70	..	642,394	68,776
Waiotira–Kirikopuni	14 0	13 0	..	..	..	..	..	..	14 0	311,198	414,366
Pukehuia–Dargaville	13 40	..	..	..	..	..	..	..	..	..	250,000
Huntly–Awaroa	1 60	1 60	..	..	1 60	..	1 60	..	..	71,044	6,000
East Coast Main Trunk and Branches—											
Waihi–Tauranga	38 25	38 25	..	2 0	..	..	..	..	..	250,316	589,639
Tauranga–Taneatua (including Mount Branch)	63 12	63 12	..	3 64	50 47	..	..	..	63 12	1,107,579	263,668
Taneatua–Opotiki	25 0	..	..	..	..	..	..	..	..	..	500,000
Gisborne–Wairoa	70 0	14 12	..	..	11 18	..	..	11 18	..	289,579	1,500,000
Wairoa–Napier	70 0	24 0	11 73	2 53	..	..	..	..	..	378,026	1,405,000
Waikokopu Branch	24 58	24 58	..	3 38	..	24 58	..	..	24 58	424,940	70,533
Stratford–Main Trunk—											
Kohuratahi–Tahora	5 14	5 14	..	..	5 14	..	5 14	..	..	218,361	6,000
Tahora–Ohura	24 0	..	..	..	..	..	..	..	..	23,587	750,000
Ohura–Okahukura	19 0	19 0	..	1 0	10 23	..	..	..	19 0	442,478	219,068
Opunake Branch and Manaia Branch ..	28 49	28 49	..	4 40	..	7 0	..	..	23 0	265,856	125,000
Rimutaka Deviation	13 24	..	..	..	..	..	..	..	..	..	970,000
Wellington–Tawa Flat Deviation	8 0	..	..	..	..	..	..	..	..	..	1,100,000
Midland—											
Glenhope–Inangahua	55 0	3 71	..	..	..	..	..	..	3 71	86,029	1,300,000
Otira–Arthur's Pass	8 40	8 40	..	..	8 40	..	8 40	..	..	1,502,672	50,000
Westport–Inangahua	22 0	4 0	..	..	..	..	..	..	..	154,374	600,000
Greymouth–Point Elizabeth	2 44	2 44	2 44	..	..	..	..	..	4 0	74,146	2,827
South Island Main Trunk—											
Wharanui–Parnassus	83 0	..	..	..	..	..	..	..	..	..	2,000,000
Lawrence–Roxburgh—											
Beaumont–Miller's Flat	15 0	15 0	..	7 33	..	..	..	..	15 0	172,766	73,854
Miller's Flat–Roxburgh	10 0	..	..	..	..	..	..	..	..	..	130,000
Orepuki–Waiau	8 24	8 24	..	6 52	..	..	..	8 24	..	75,805	14,897
Totals	..	311 51	27 31	31 40	118 4	31 58	15 34	50 4	166 61	7,025,809	12,911,058



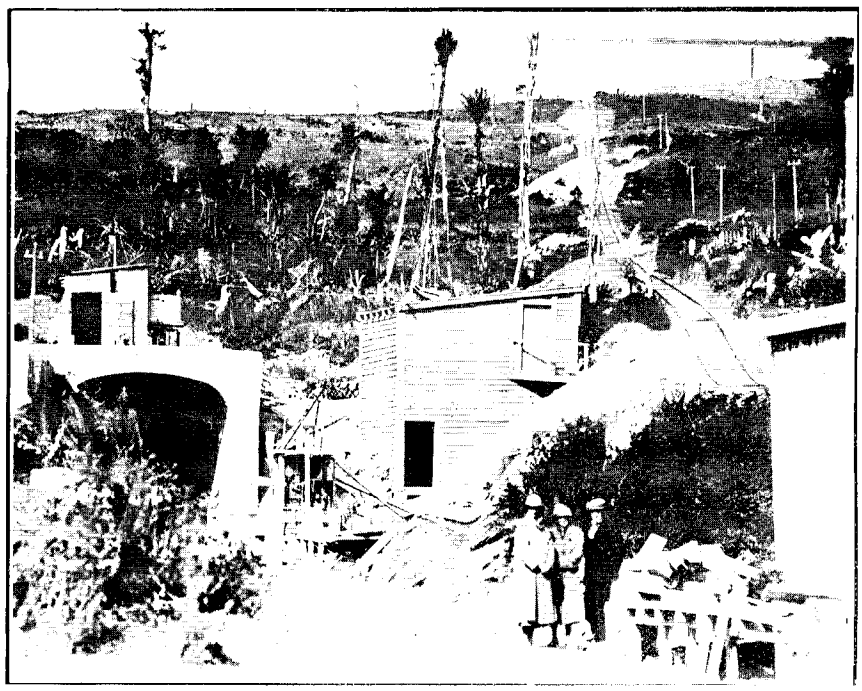
Waihou and Ohinemuri Rivers Improvement: Constructing Stop-bank with Drag-line Excavators.



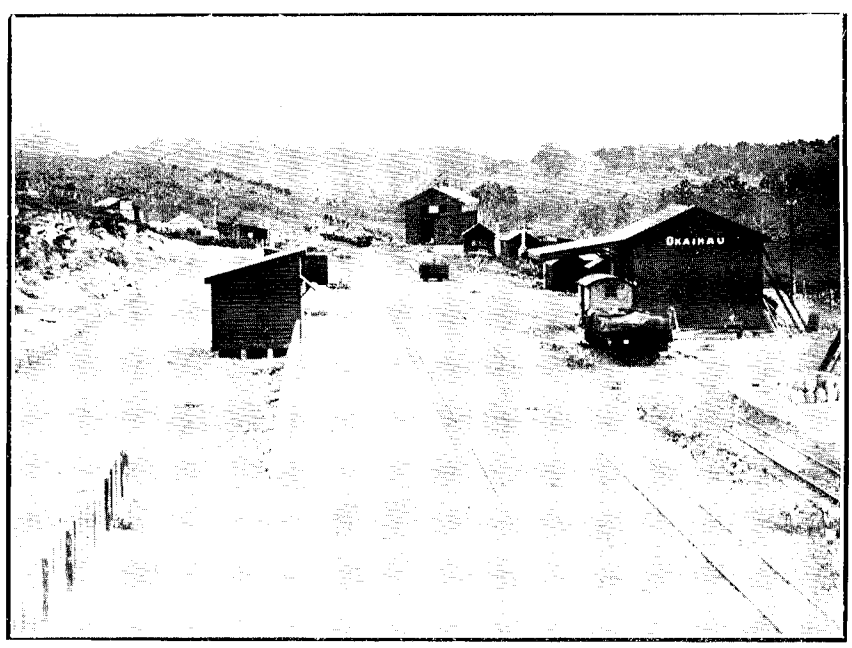
North Auckland Main Trunk: Steam-shovel near Kaikohe Station Yard.



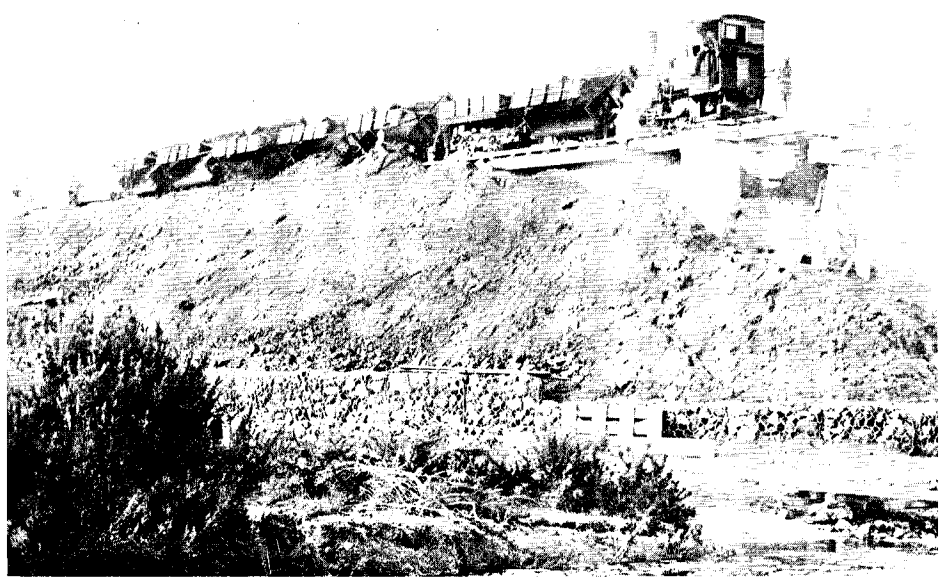
East Coast Main Trunk Railway: General View of Borrow-pit at 40 m. 23 ch.



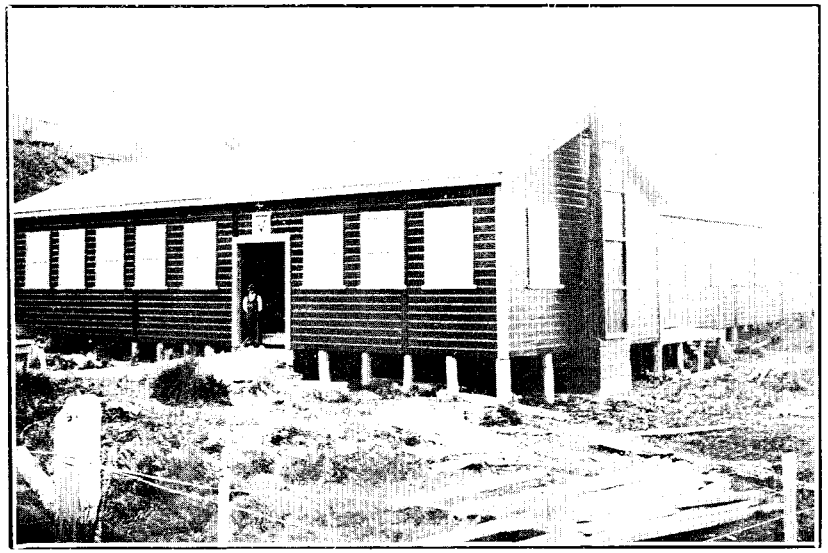
North Auckland Main Trunk Railway: View of Omana Tunnel Portal, showing Jig Line over Hill.



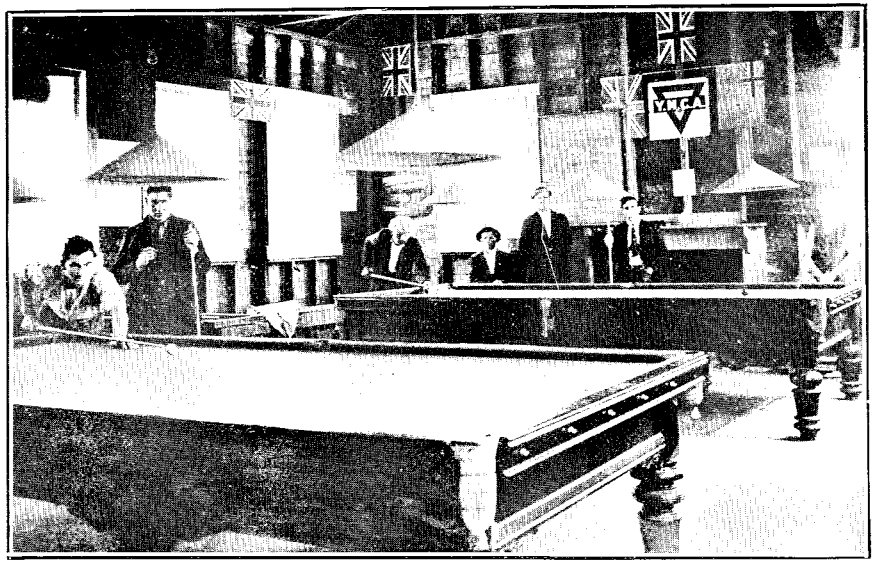
North Auckland Main Trunk Railway: Okaihau Station Yard. (Present Terminus.)



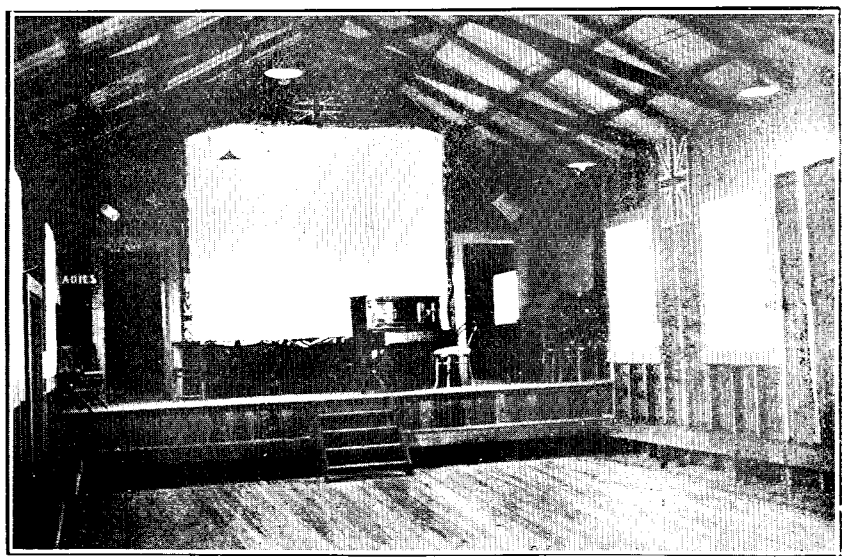
Opunake Branch Railway: Constructing Approach to Waiaua River Bridge.



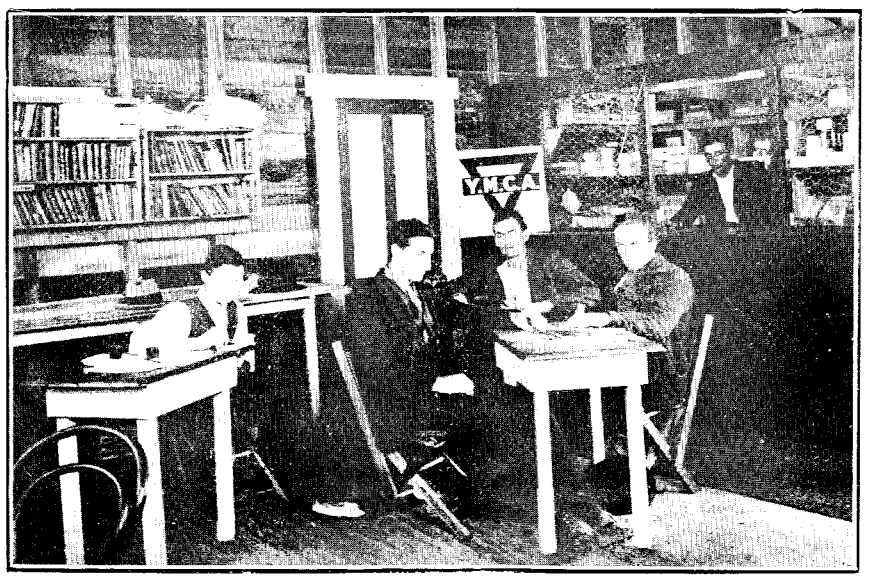
North Auckland Main Trunk Railway.—Mareretu Tunnel: Y.M.C.A. Hut—Exterior View.



North Auckland Main Trunk Railway.—Mareretu Tunnel: Y.M.C.A. Hut—Billiard-room.

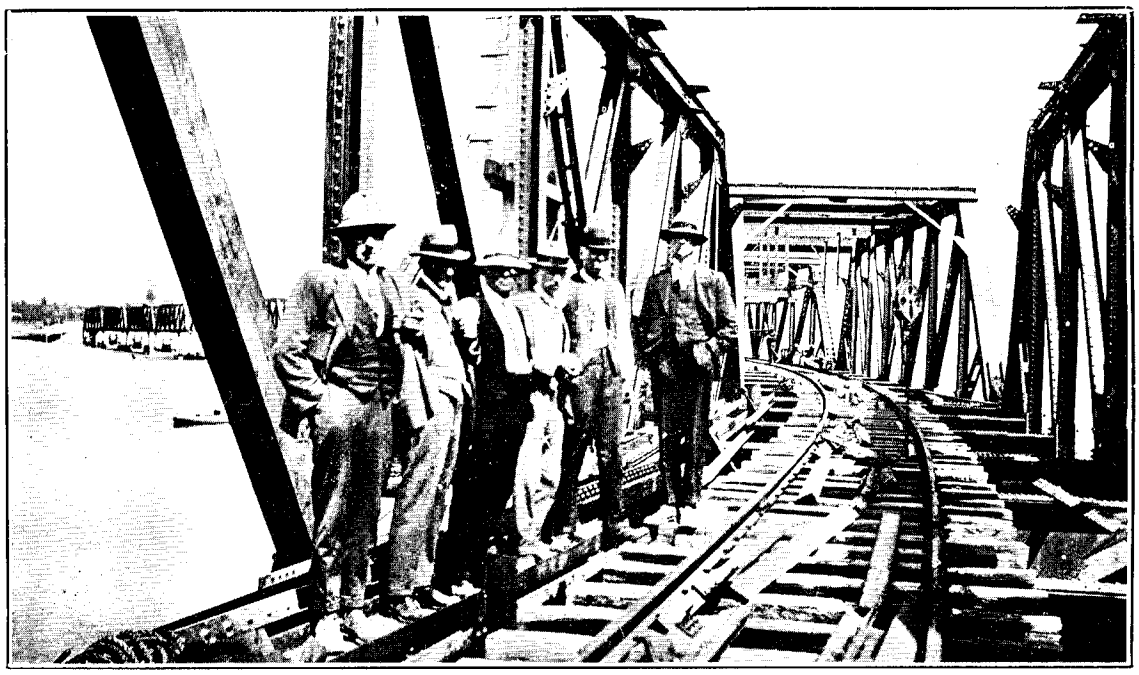


North Auckland Main Trunk Railway.—Mareretu Tunnel: Y.M.C.A. Hut—Social Hall.

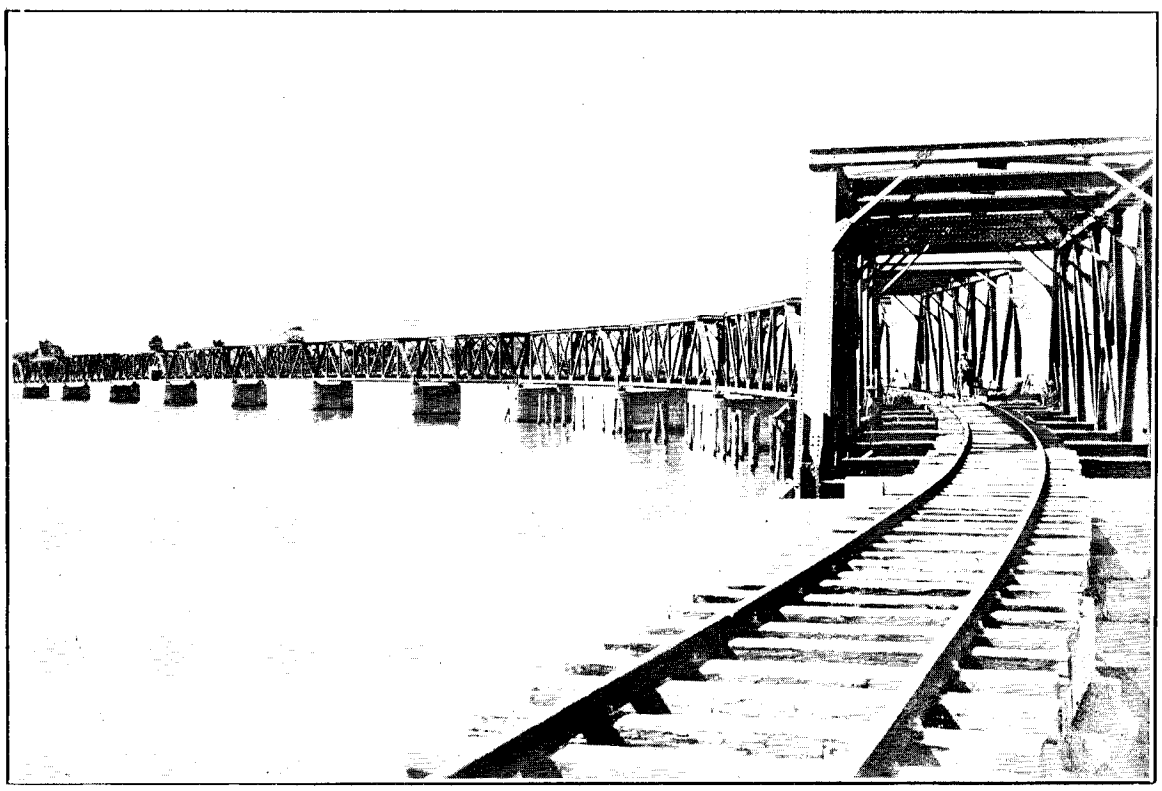


North Auckland Main Trunk Railway.—Mareretu Tunnel: Y.M.C.A. Hut—Reading-room and Canteen.

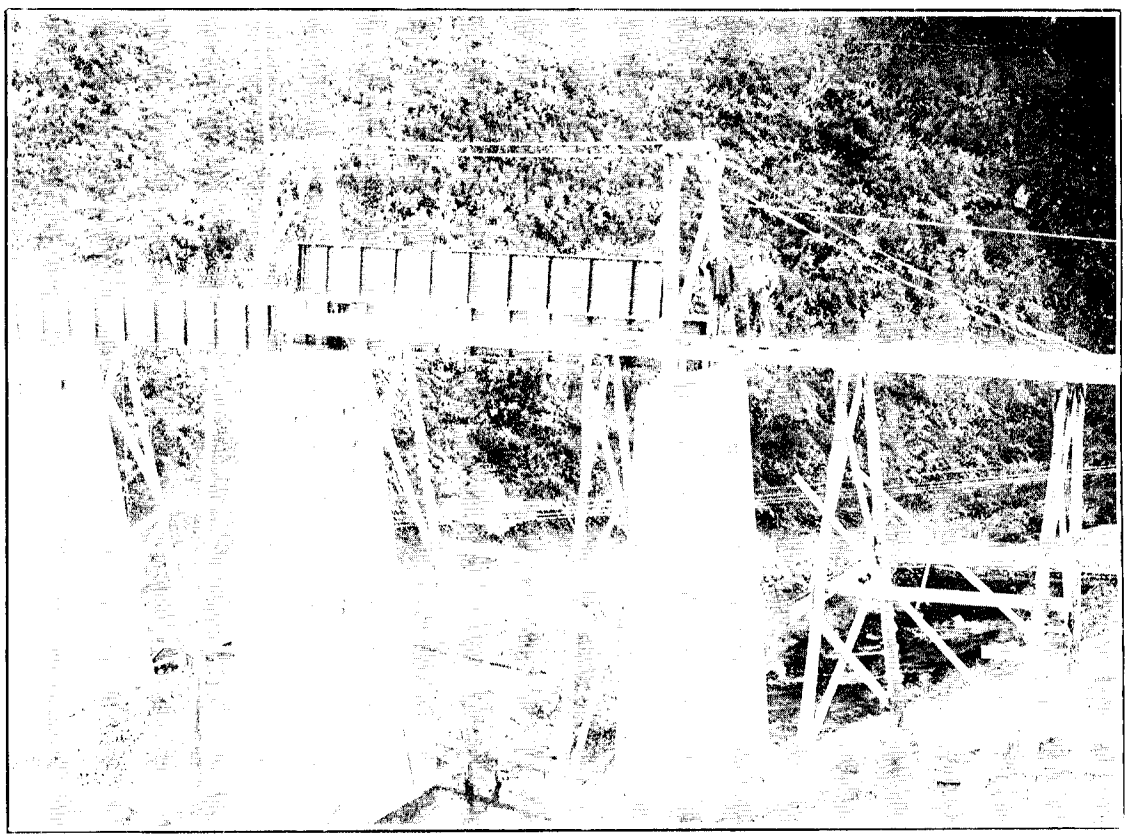
HOW THE DEPARTMENT CATERS FOR THE SOCIAL SIDE ON ITS WORKS.



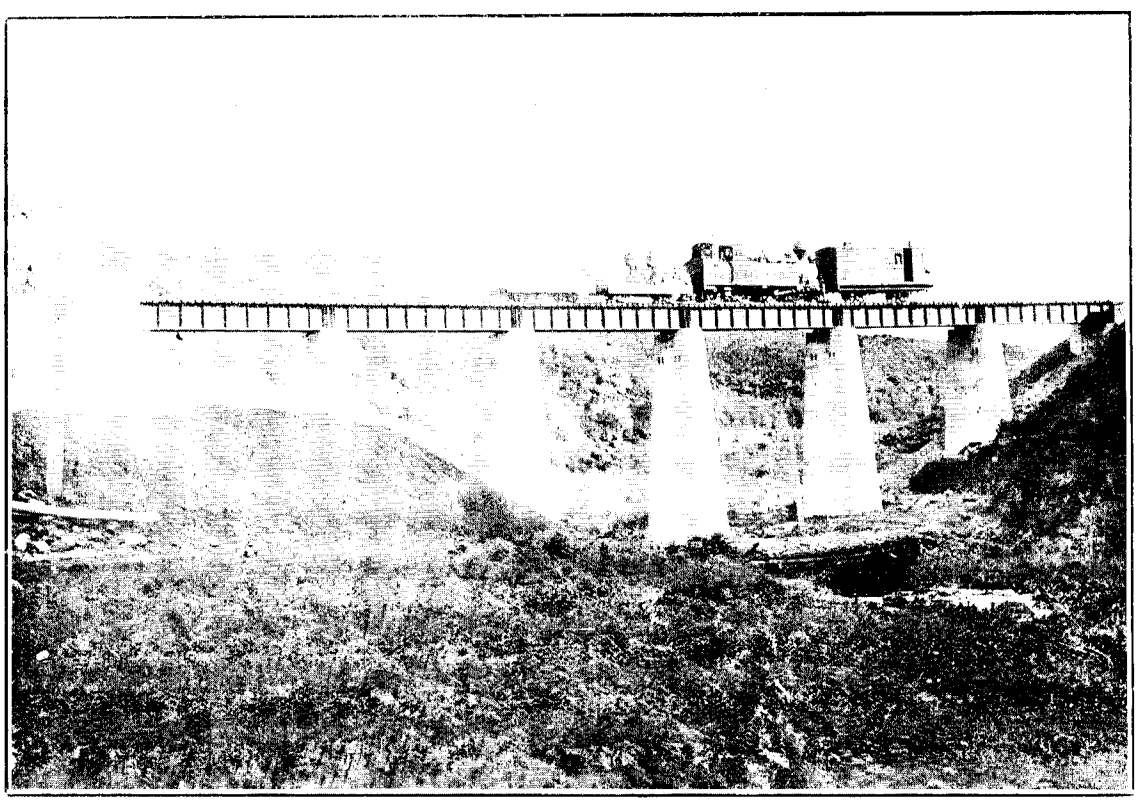
East Coast Main Trunk Railway. Tauranga Harbour Bridge: View showing 105 ft. Span on Curve.



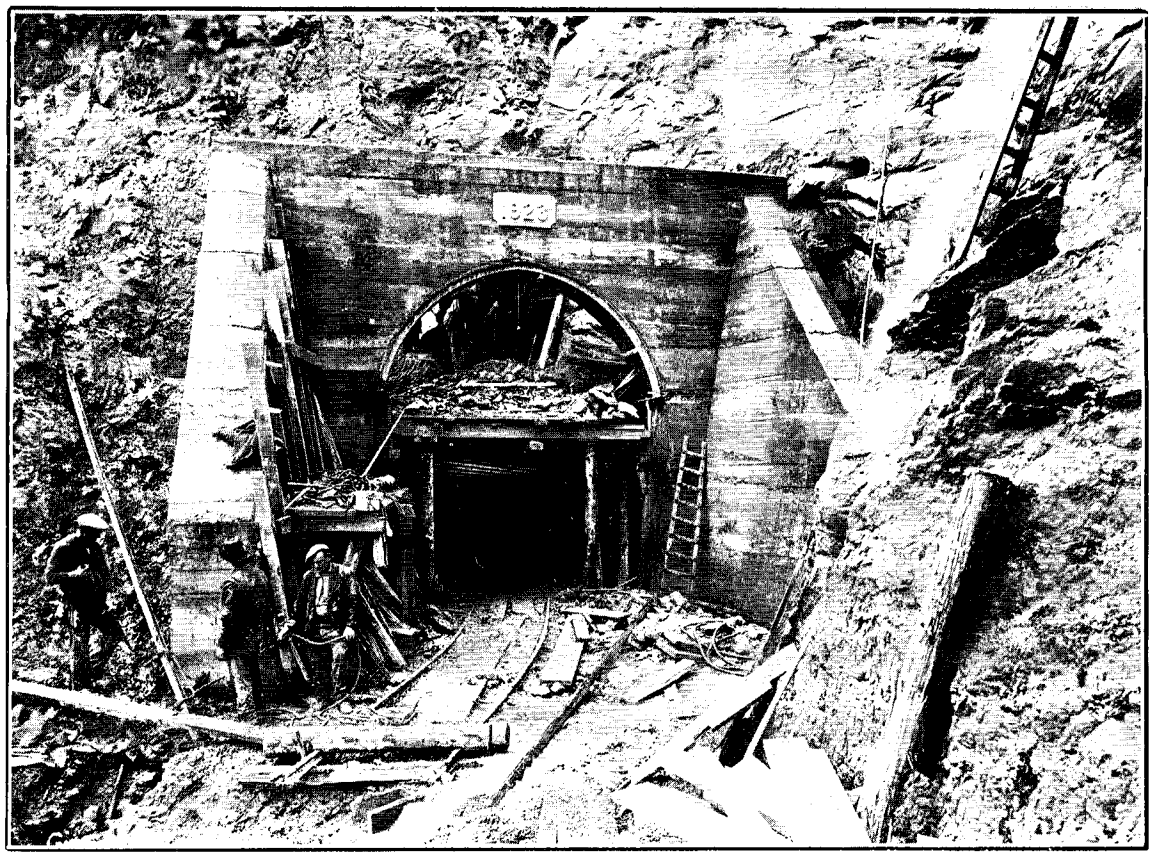
East Coast Main Trunk Railway. Tauranga Harbour Bridge: General View of Bridge from Tauranga End.



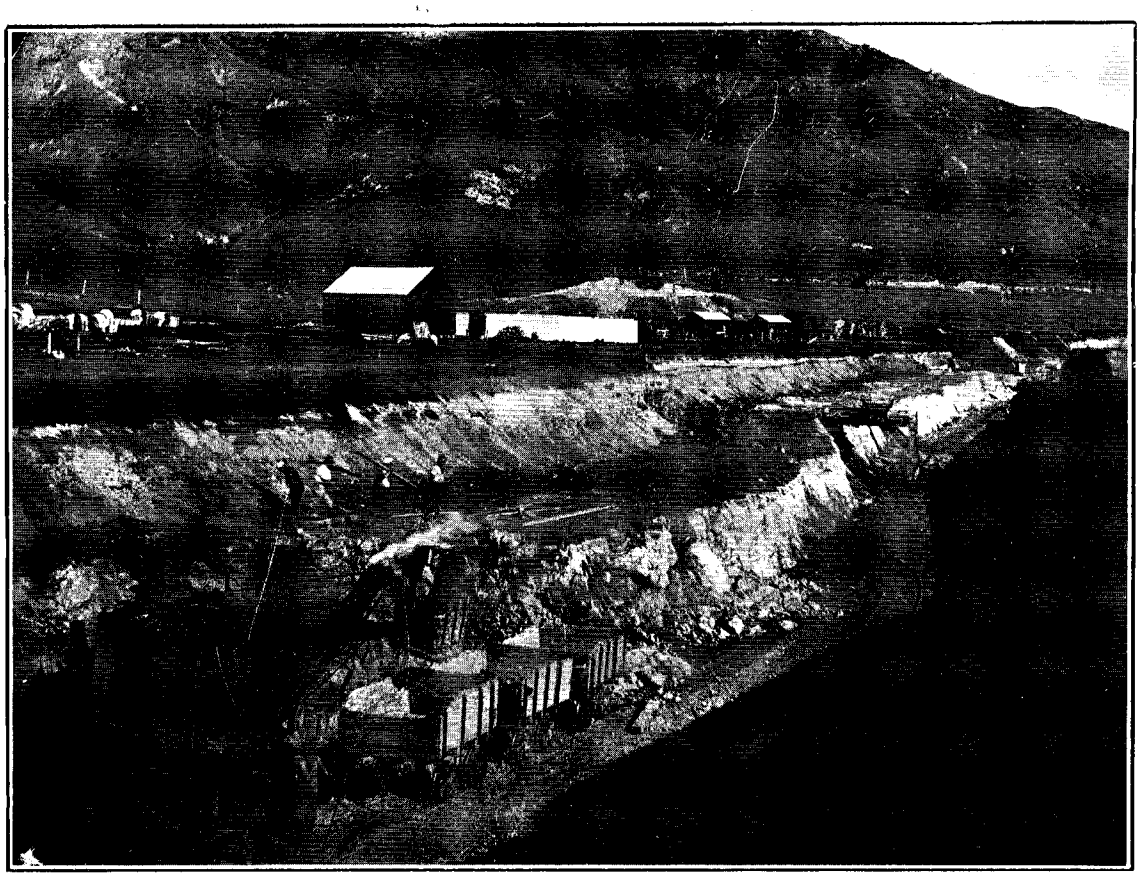
East Coast Main Trunk Railway.—Athenree Section: Bridge at 6 M. 60 Ch.—View showing Placing of Girders.



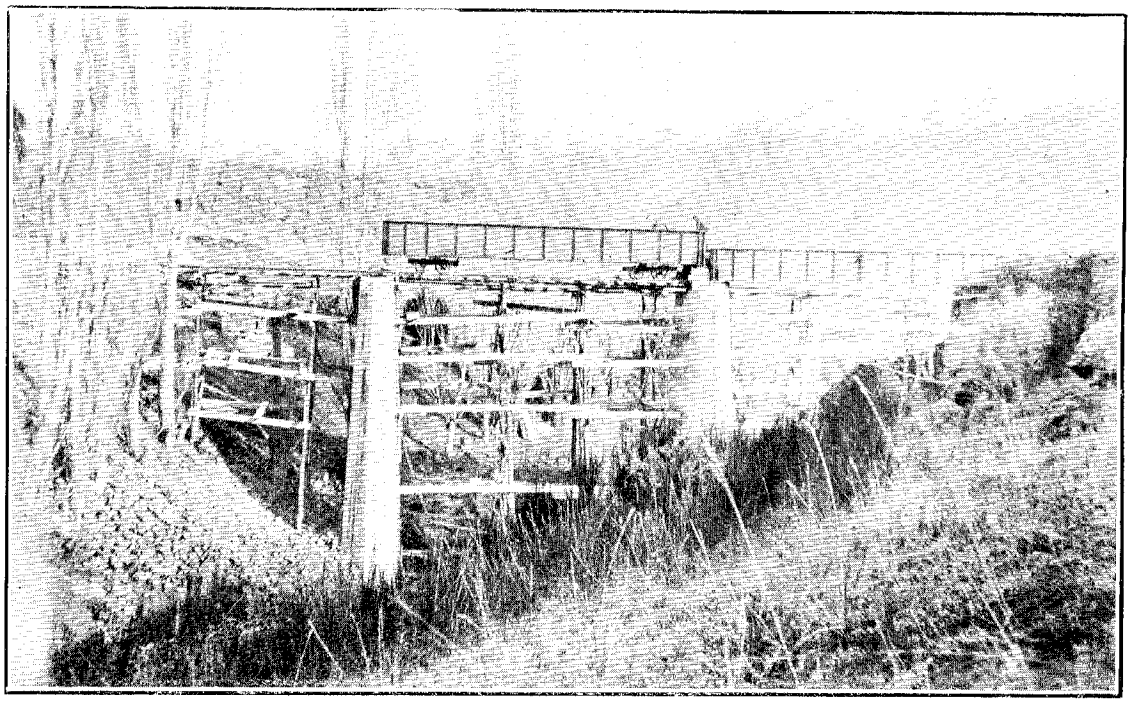
East Coast Main Trunk Railway.—Athenree Section: General View of Bridge at 6 M. 60 Ch.



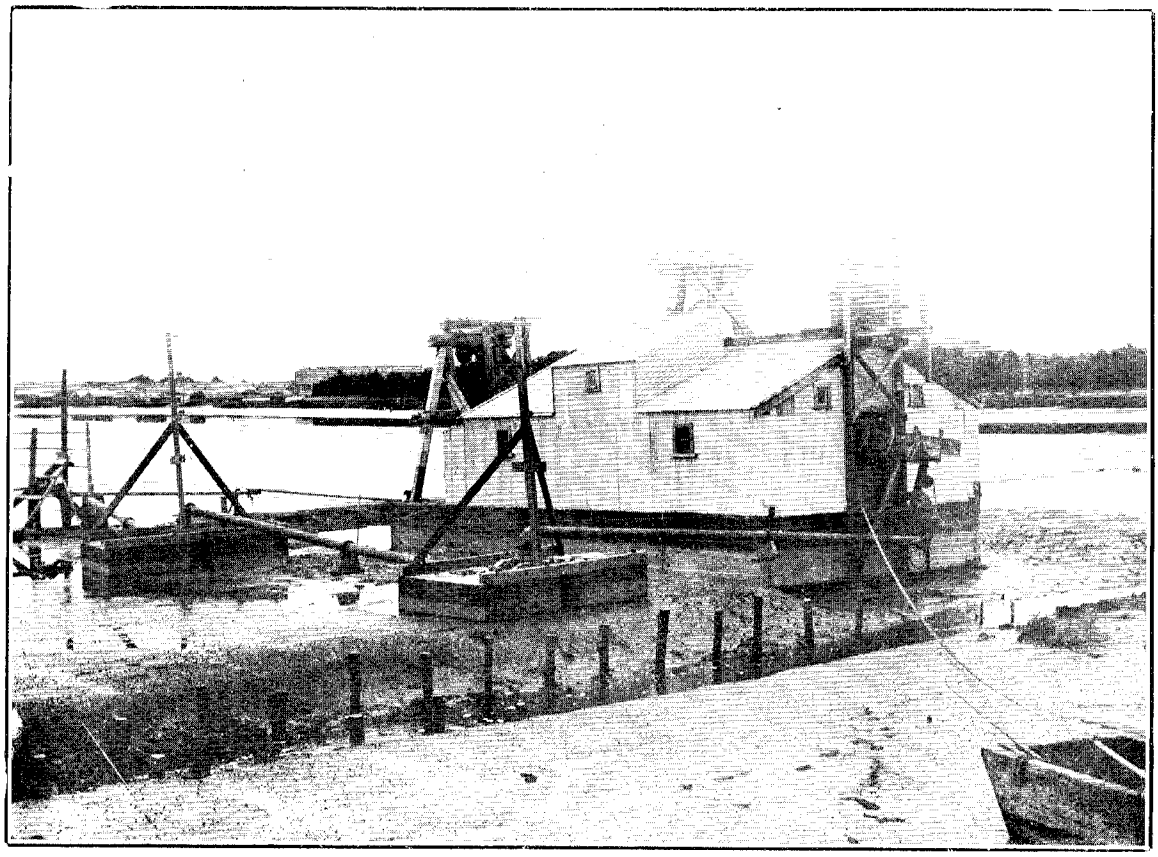
NAPIER-WAIROA RAILWAY: TUNNEL AT 17 M. 30 CH.



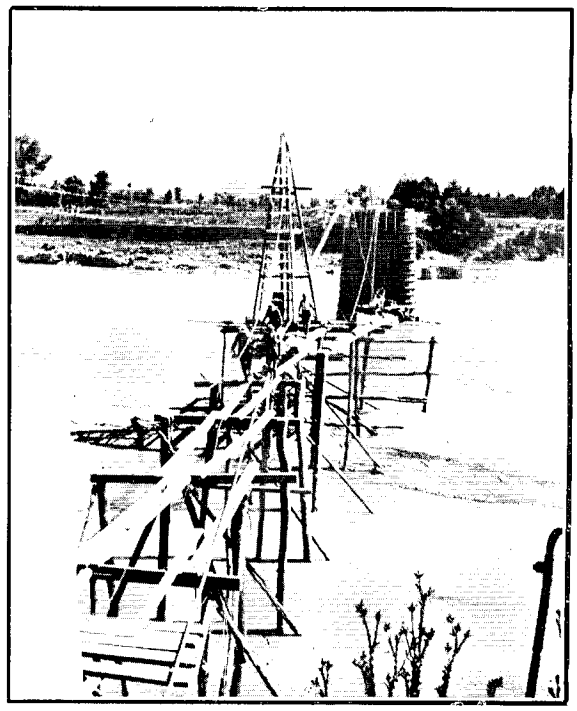
NAPIER-WAIROA RAILWAY.—EXCAVATING FOR WAIPUNGA STATION YARD: STEAM-SHOVEL IN FOREGROUND.



Lawrence-Roxburgh Railway: Minzion Burn Bridge under Construction.



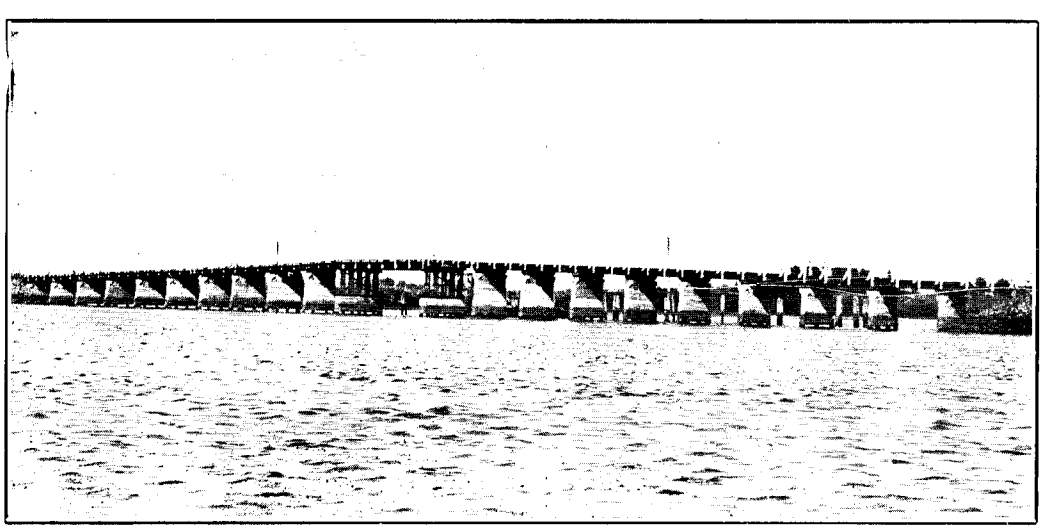
Invercargill Reclamation: View of Dredge.



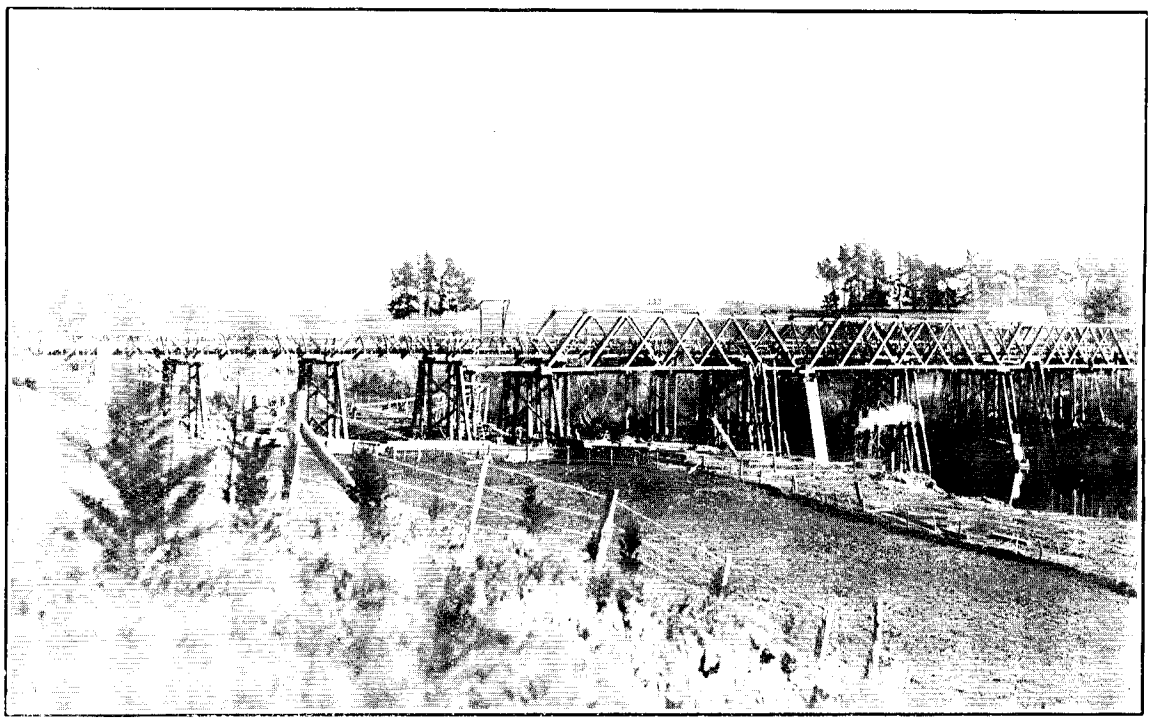
Rotokautuku Bridge: View showing Construction of Piers. (River normal.)



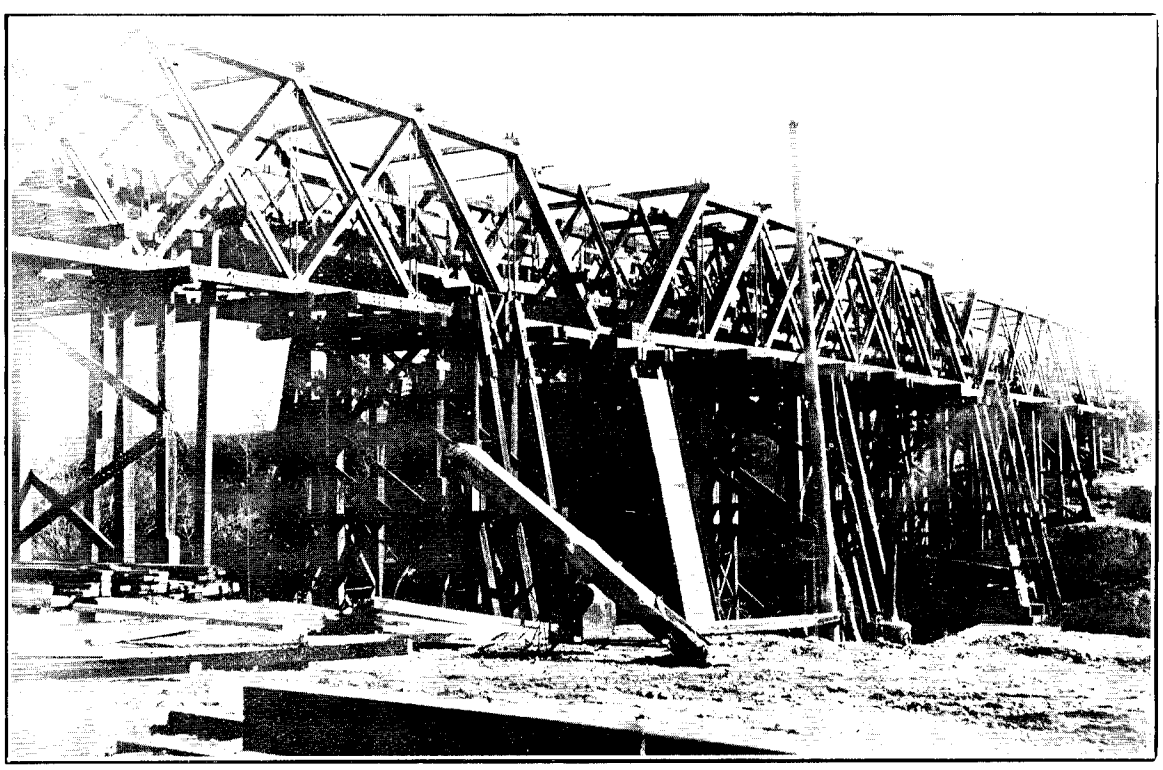
Rotokautuku Bridge.—River in Flood: False Work washed away.



Hairini River Road-bridge, near Tauranga.

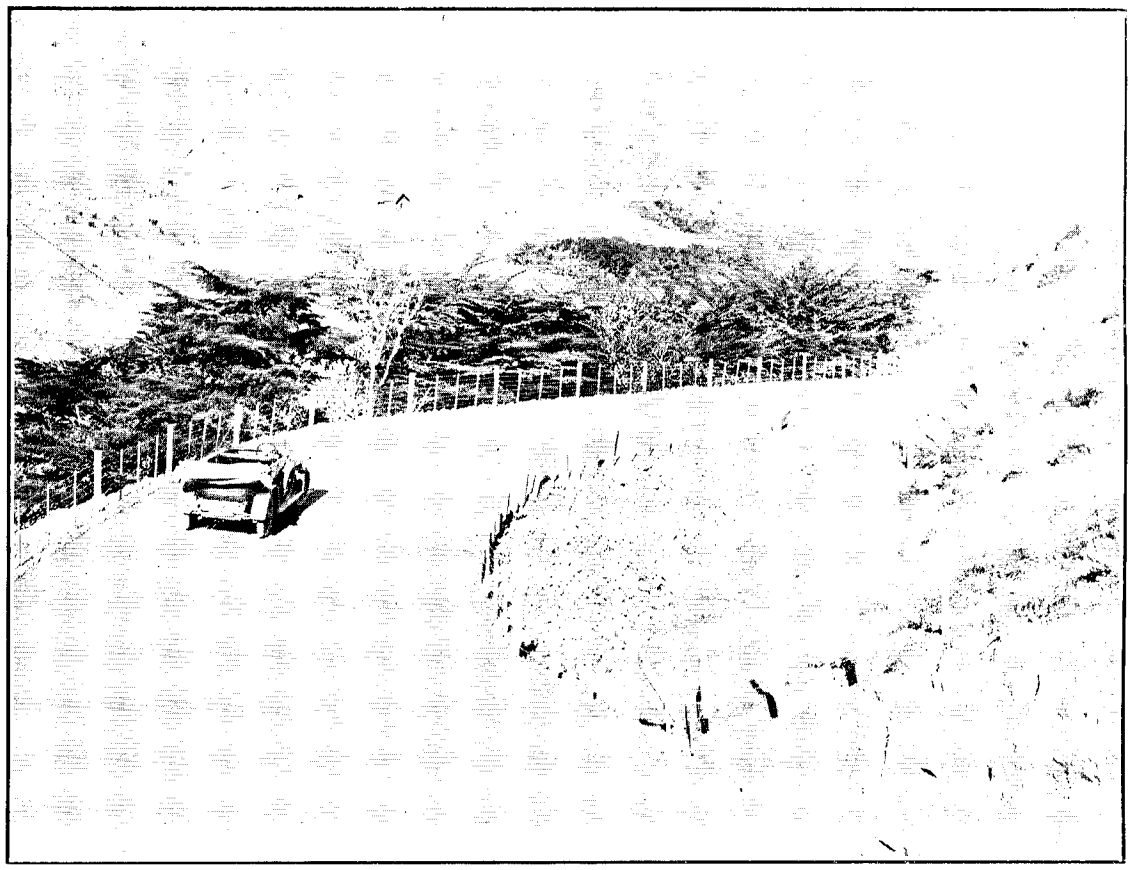


Waipa River Bridge, Whatawhata: View from Right Bank, looking up stream.

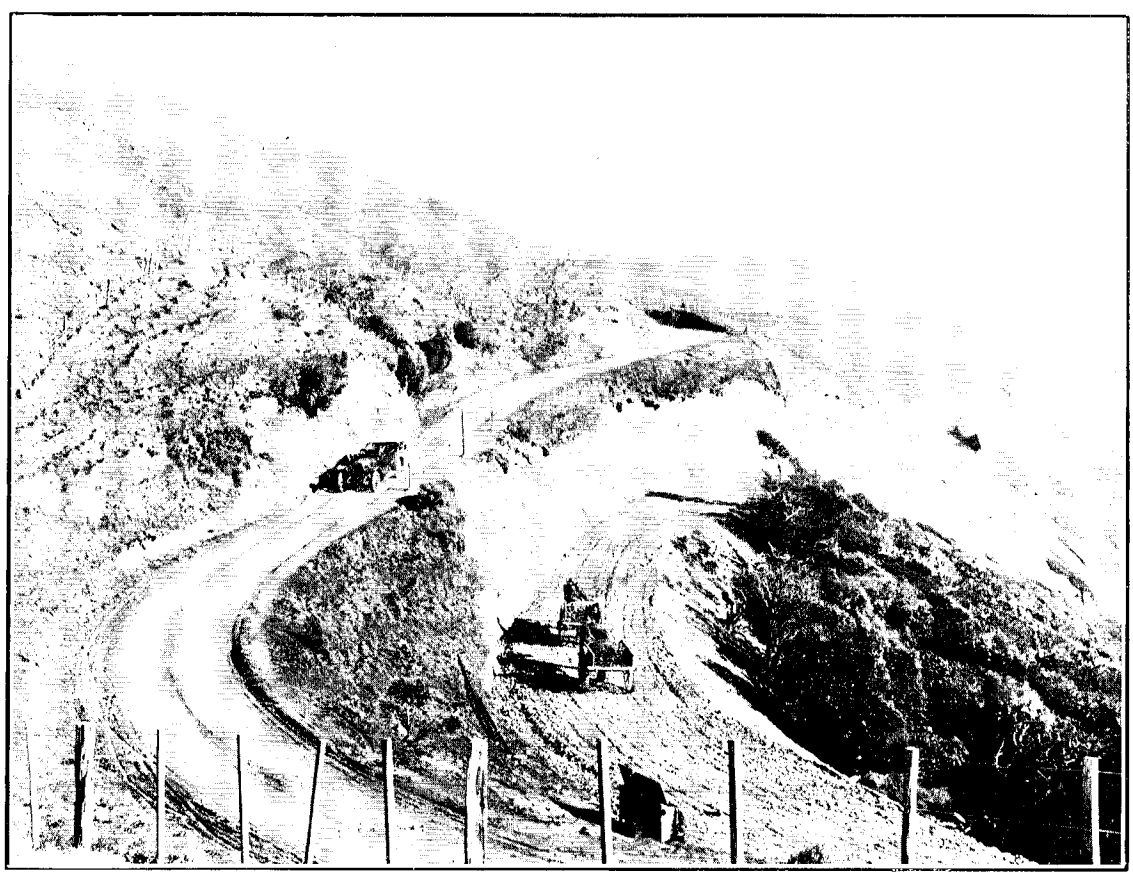


Waipa River Road-bridge, Whatawhata: Detail of Construction.

Bridge is being built around old bridge.

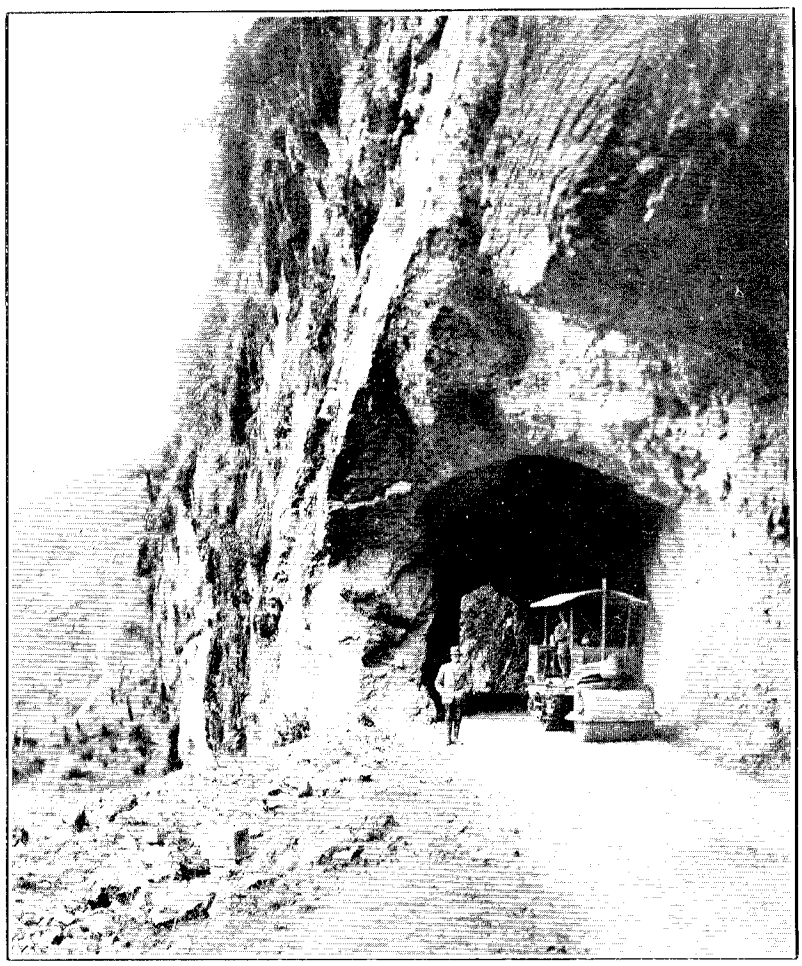


Paekakariki Hill Road Improvement: View of Road as constructed.

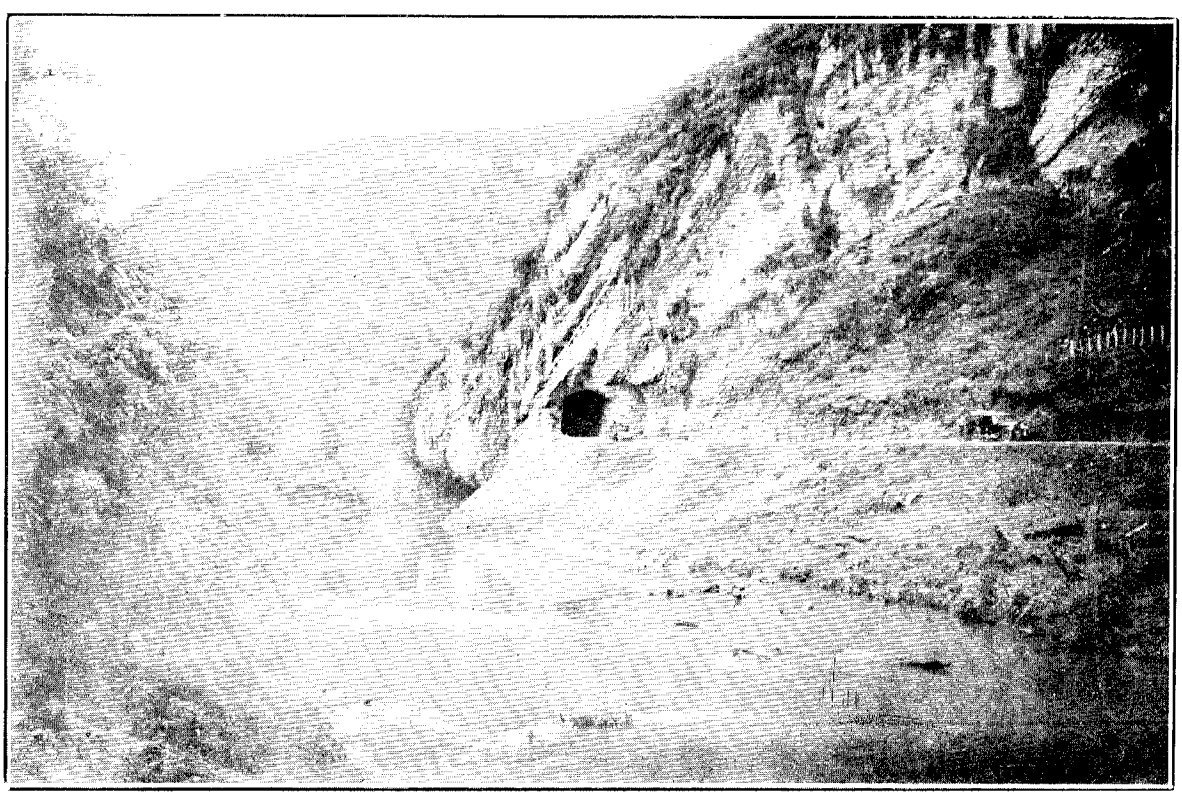


Paekakariki Hill Road Improvement: Deviation near Summit.

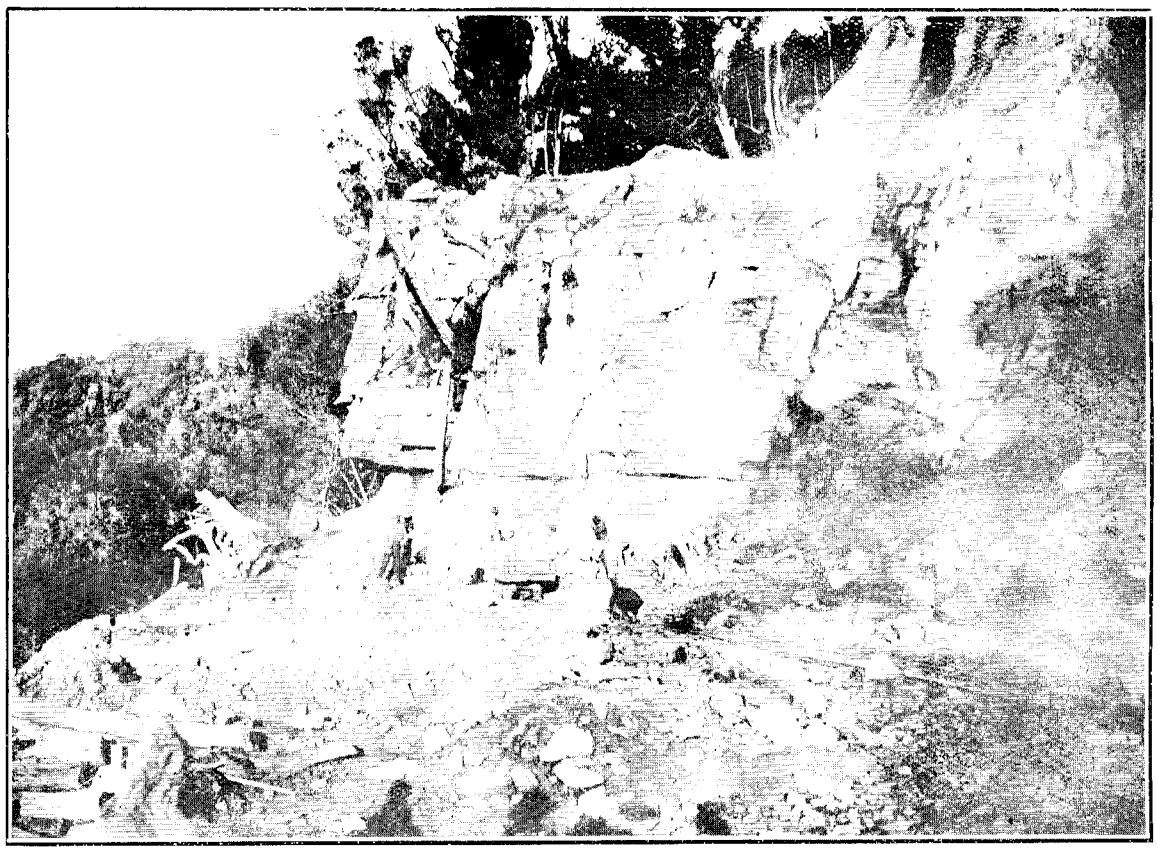
Grade reduced from 1 in 8 to 1 in 37.



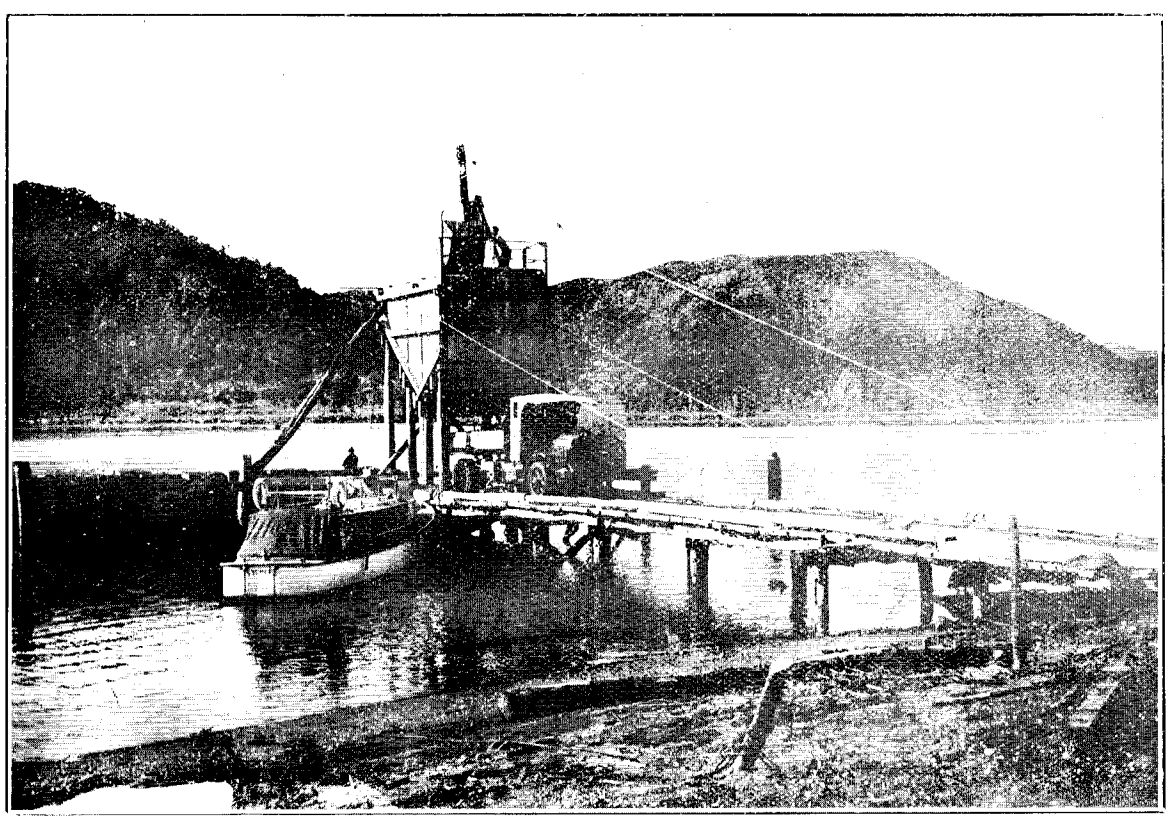
Awakino Valley Road: Rolling Newly laid Metal near Road tunnel.



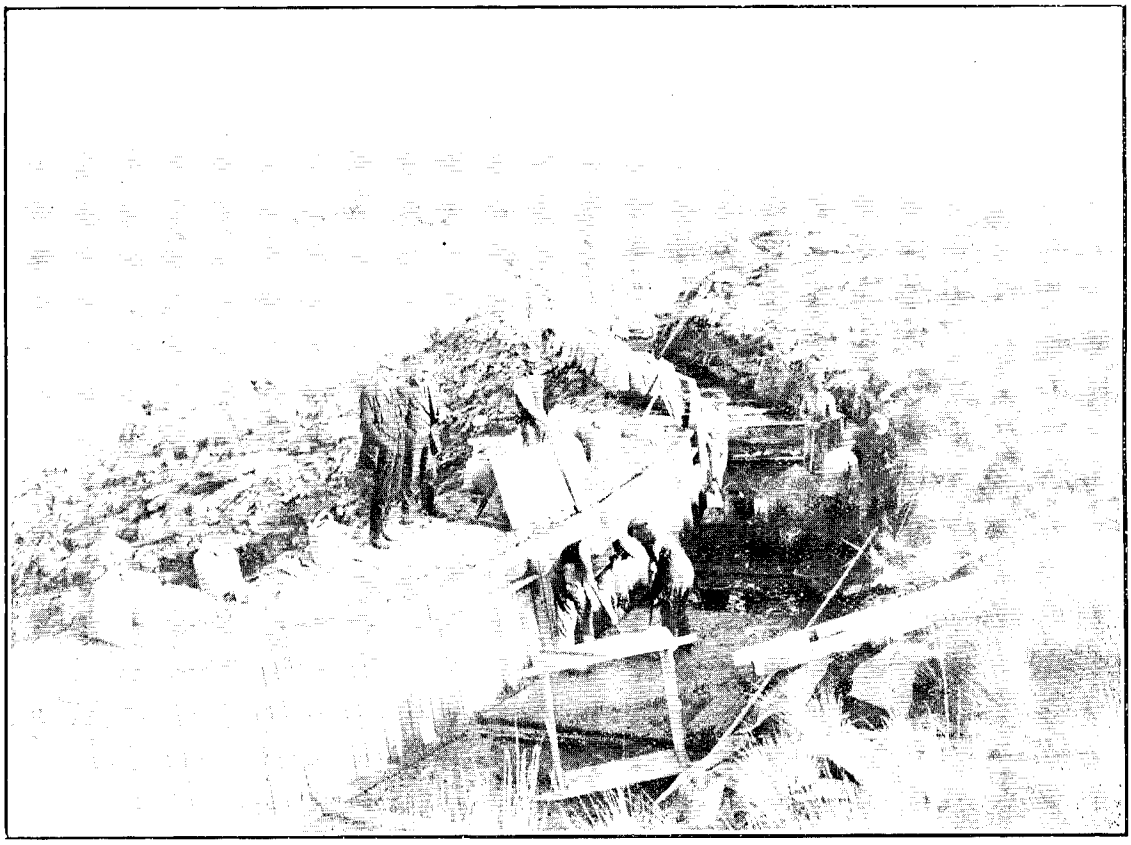
Awakino Valley Road: View of Road, showing Road tunnel.



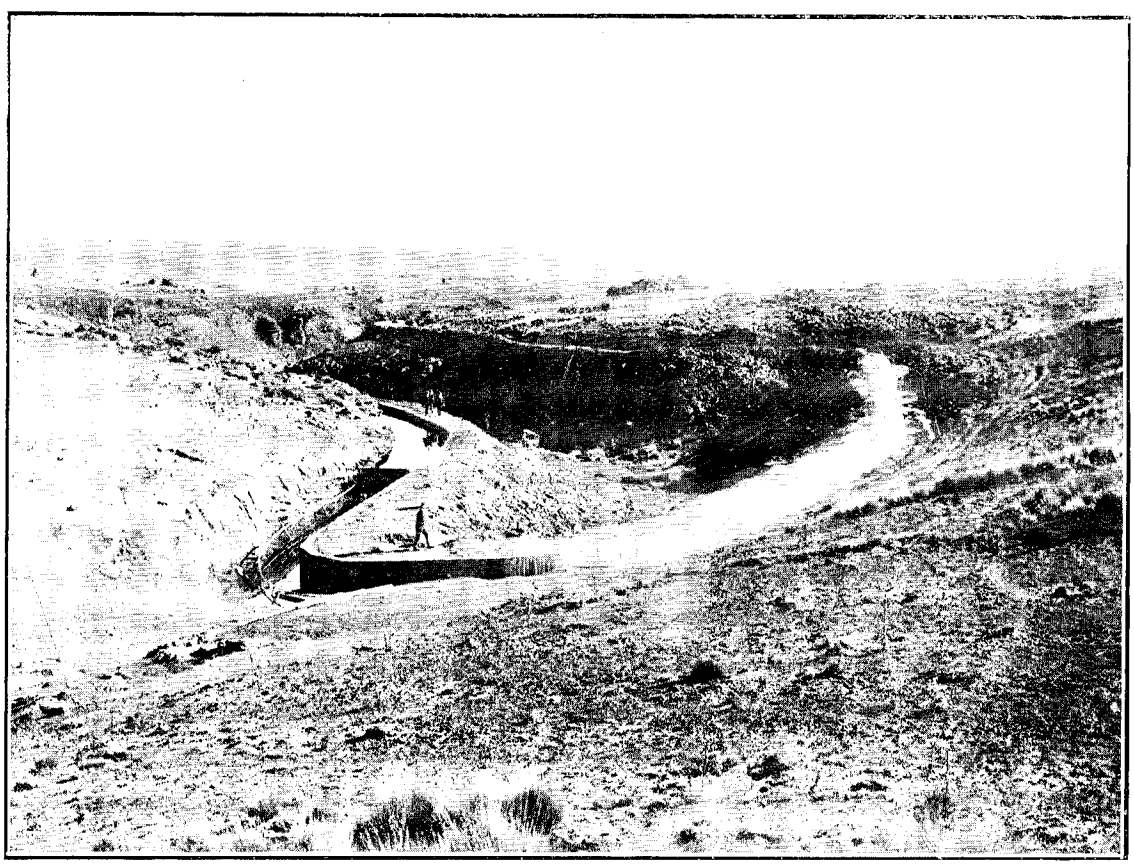
Mimi Mokau Road: Mokau Quarry.



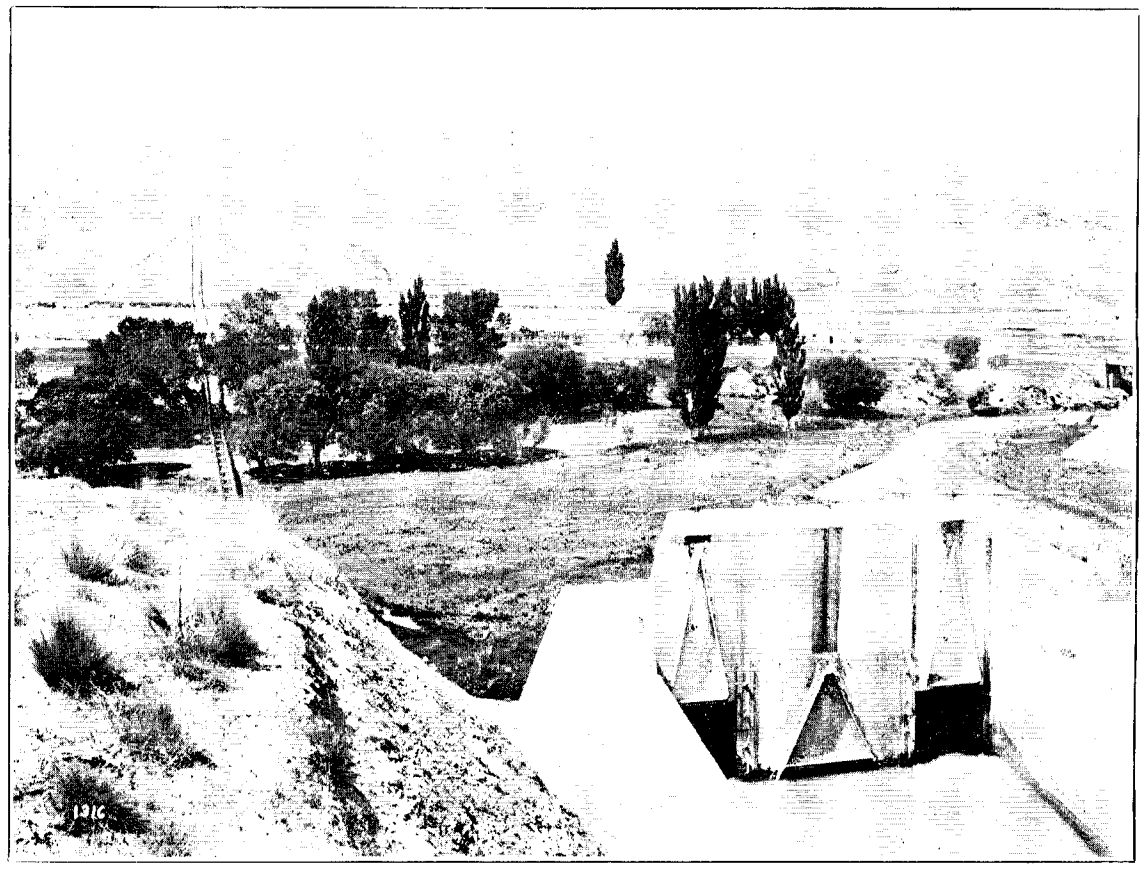
Mimi Mokau Road, Mokau Quarry: Unloading jetty.



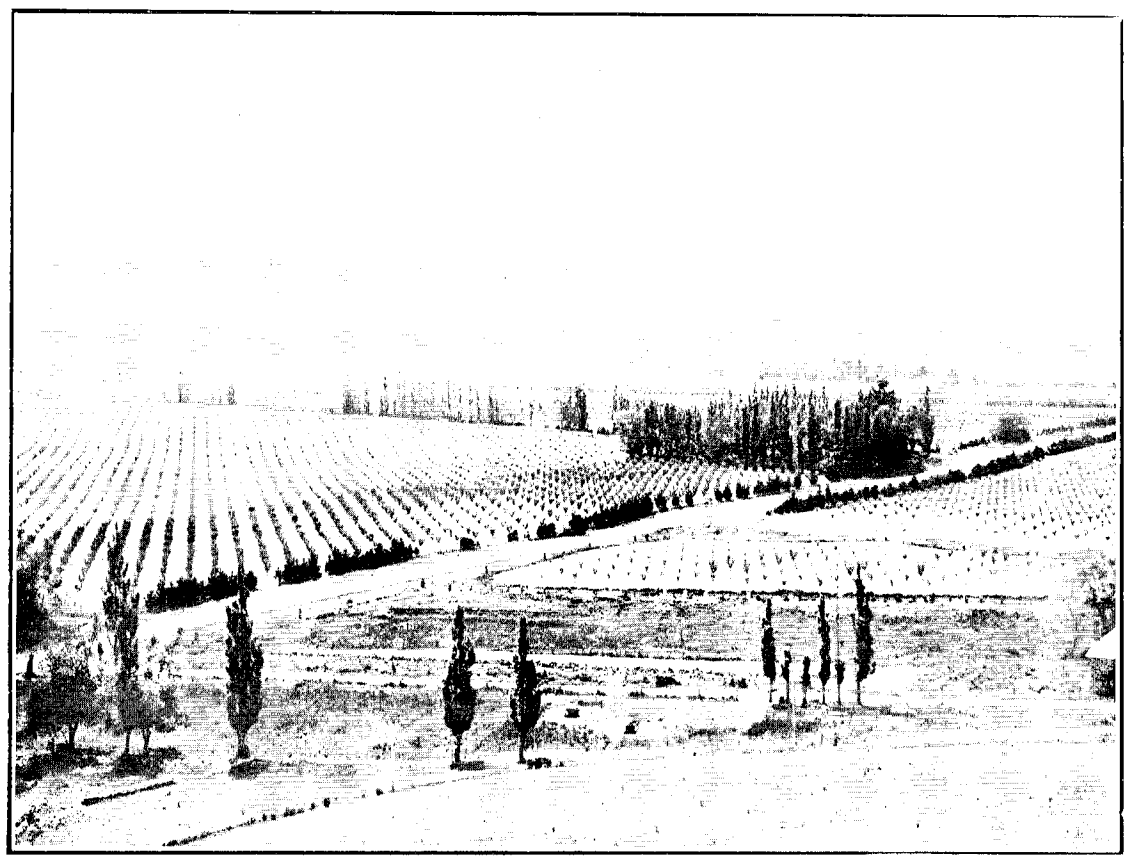
Ida Valley Irrigation. Main Water-race: View showing Concrete Lining under Construction.



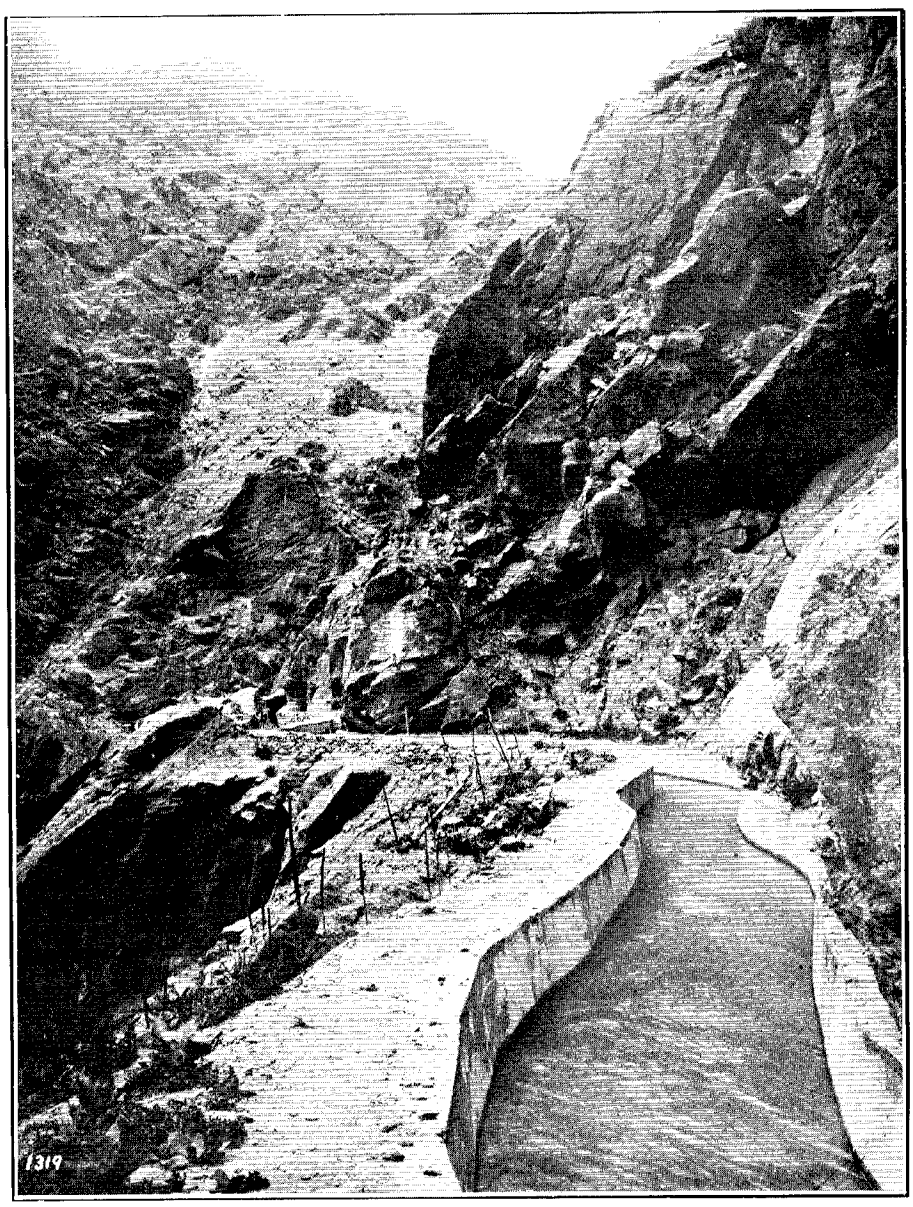
Ida Valley Irrigation. Main Water-race: View showing Completed Concrete Lining.



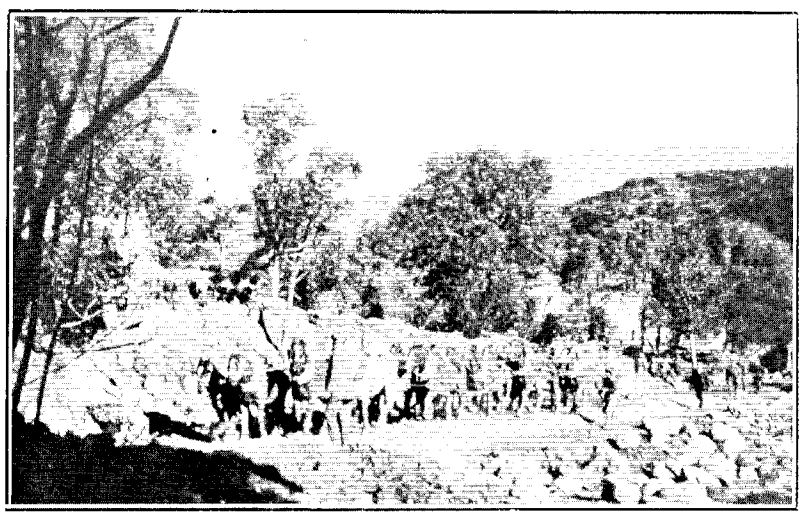
Otago Central Irrigation. Manuherikia Scheme: Chatto Creek Siphon.



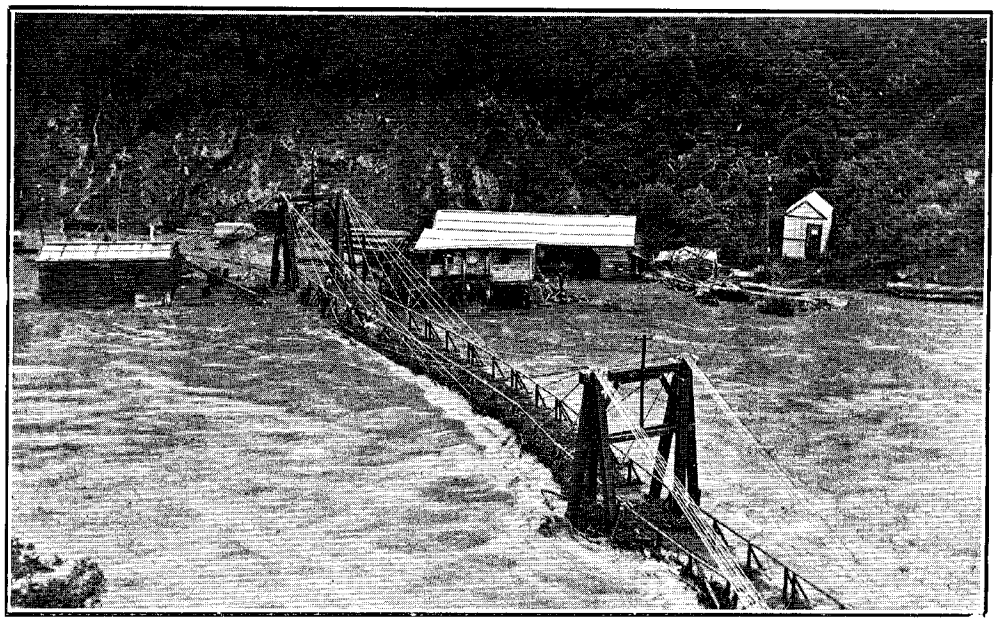
Otago Central Irrigation. Manuherikia Scheme: Fruit farms in Irrigated Area.



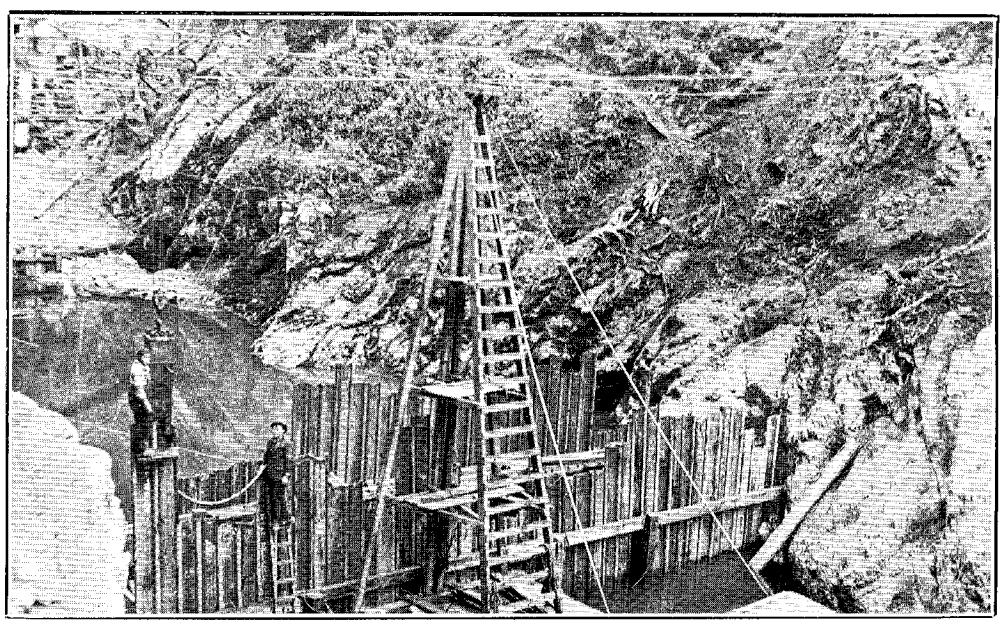
Otago Central Irrigation. Lower Manuherikia Scheme: Main Race in Manuherikia Gorge.



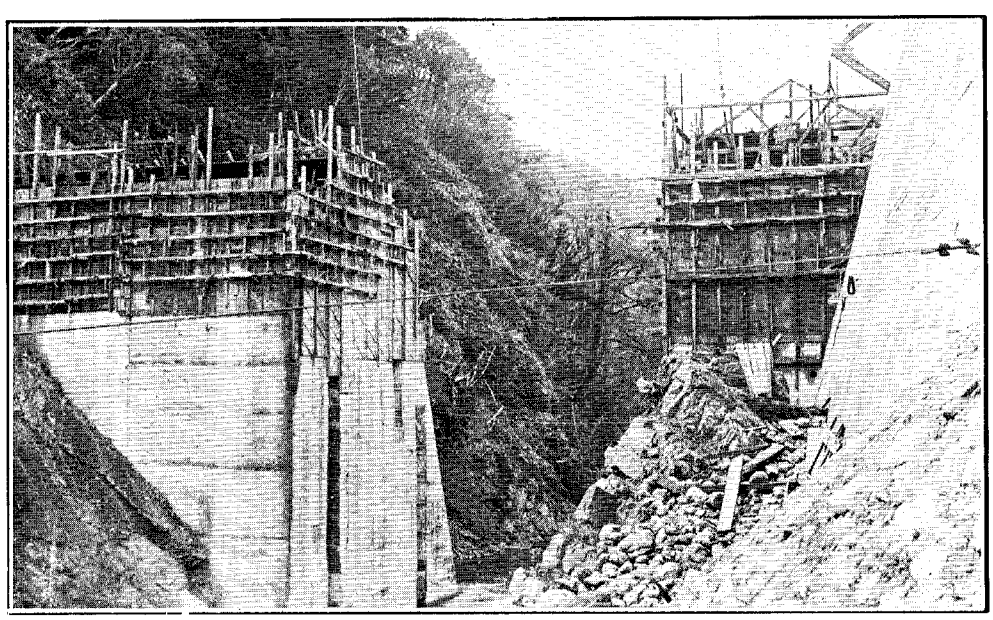
Waikaremoana Hydro-electric Scheme: Twenty-three-horse Team hauling Power-house Plant.



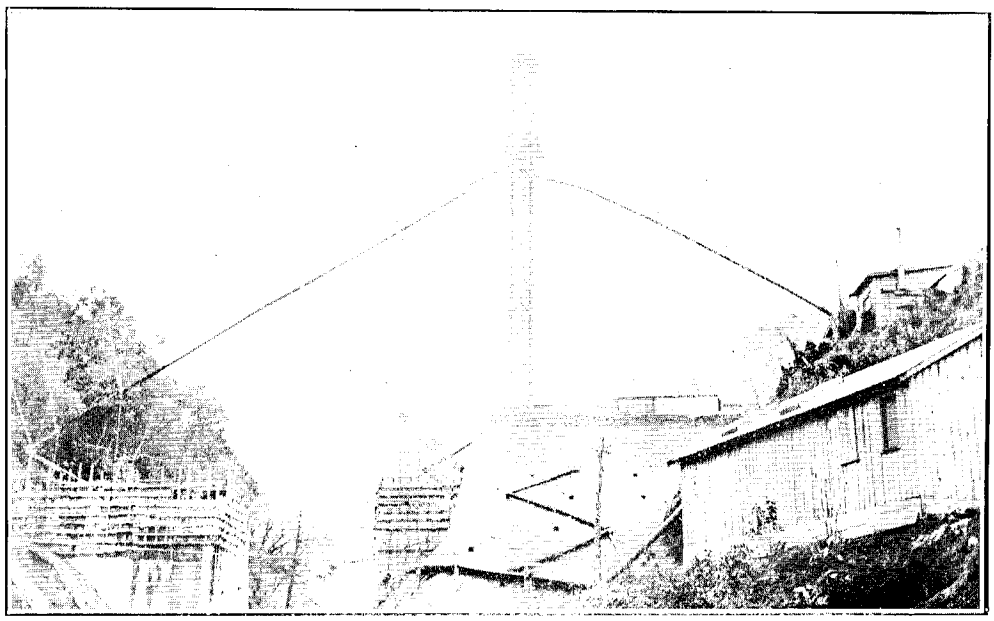
MANGAHAO HYDRO-ELECTRIC-POWER PLANT: MANGAHAO RIVER IN FLOOD.



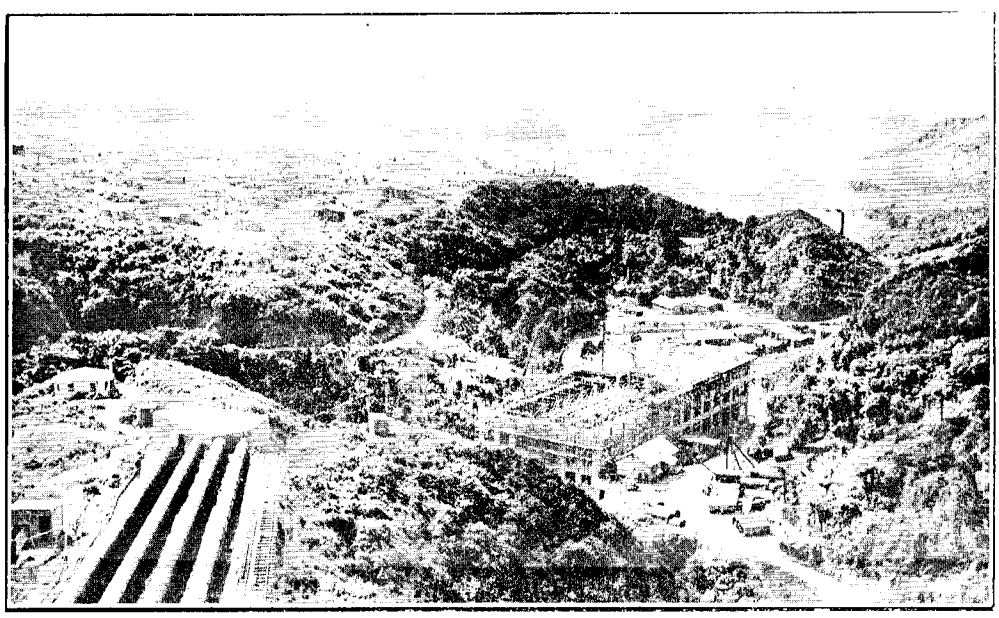
MANGAHAO HYDRO-ELECTRIC-POWER PLANT: STEEL-SHEET PILE COFFER-DAM FOR MANGAHAO DAM FOUNDATIONS.



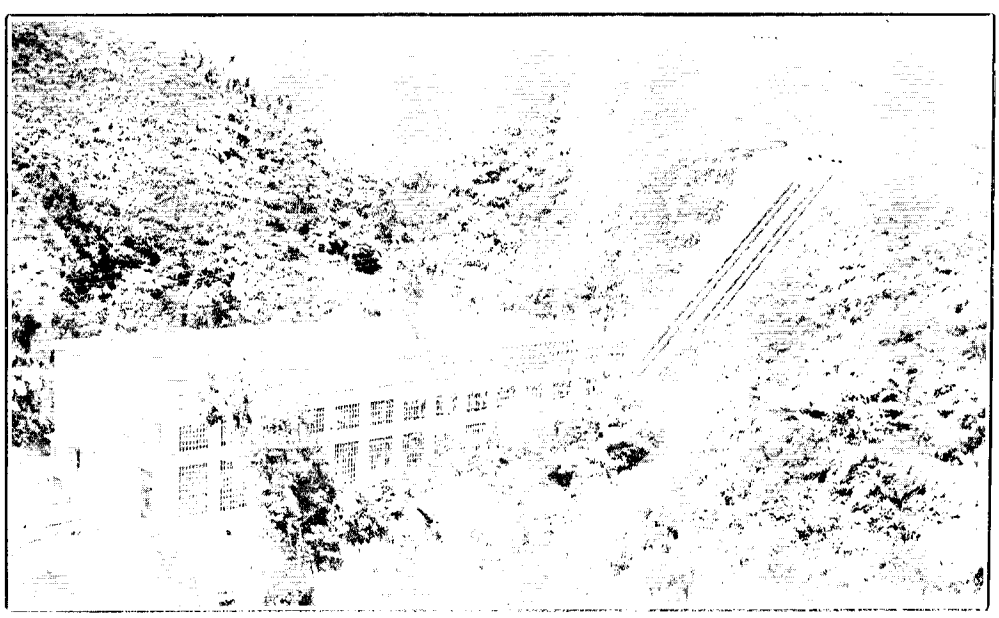
MANGAHAO HYDRO-ELECTRIC-POWER PLANT: MANGAHAO DAM UNDER CONSTRUCTION.



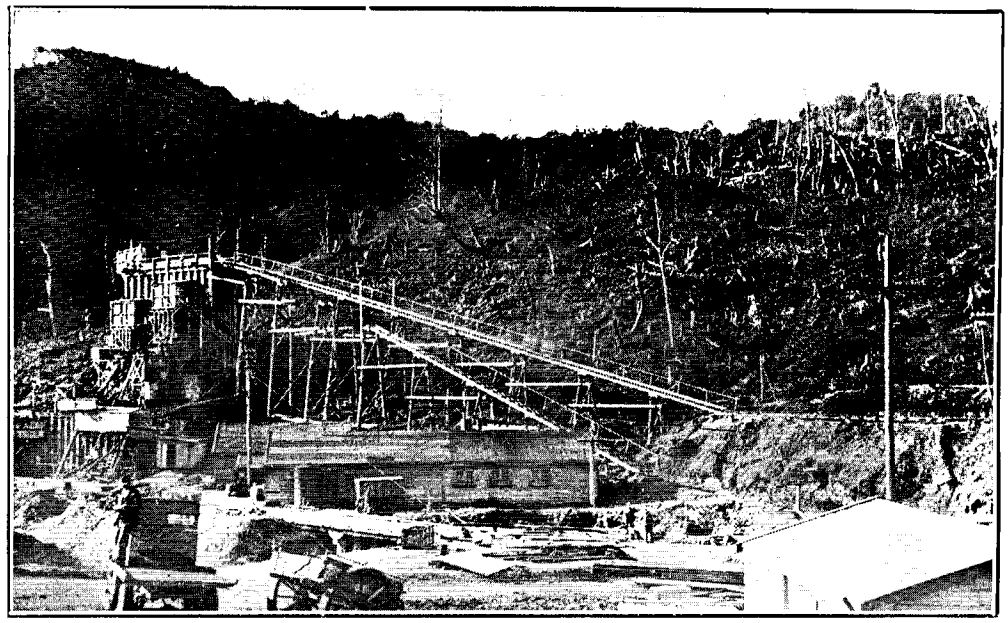
Mangahao Hydro-electric-power Plant. Mangahao Dam under Construction: View showing Method of distributing Concrete.



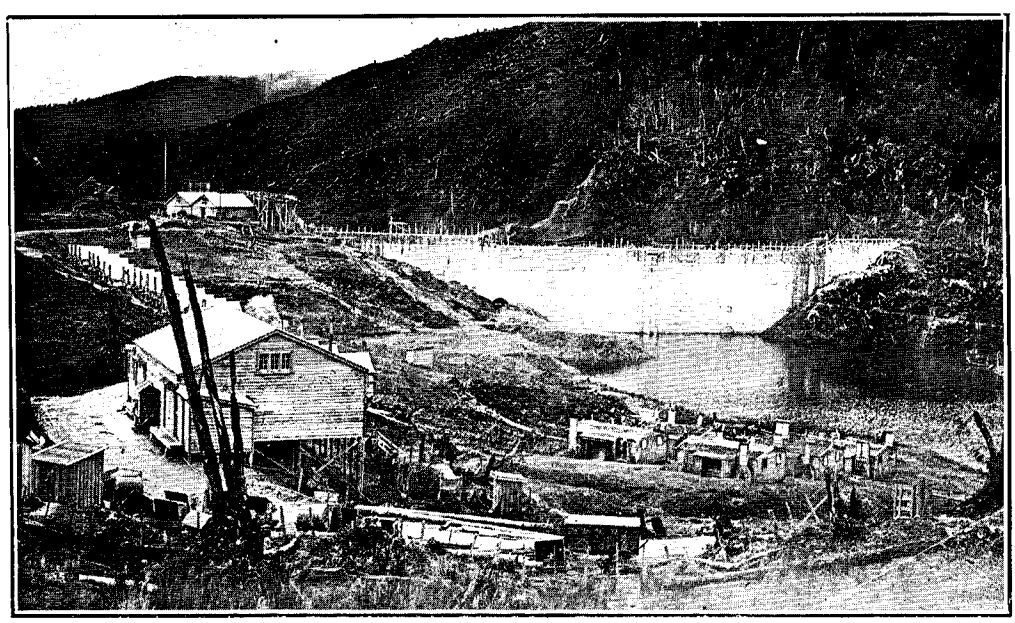
Mangahao Hydro-electric-power Plant: View from Pipe-line, showing Power-house under Construction.



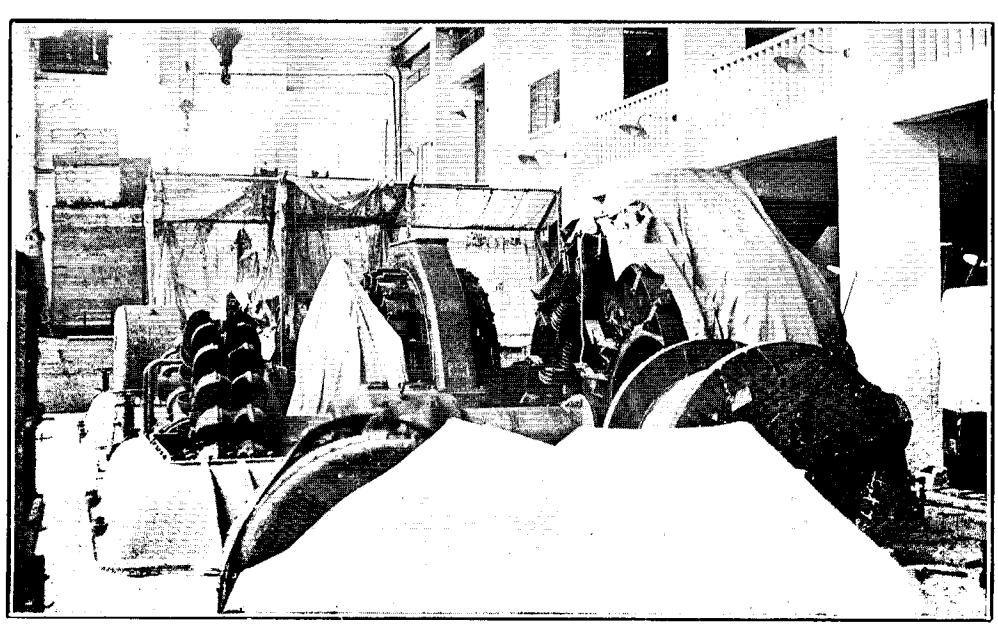
Mangahao Hydro-electric-power Plant. View looking up Pipe-line: Power-house in Foreground (almost complete).



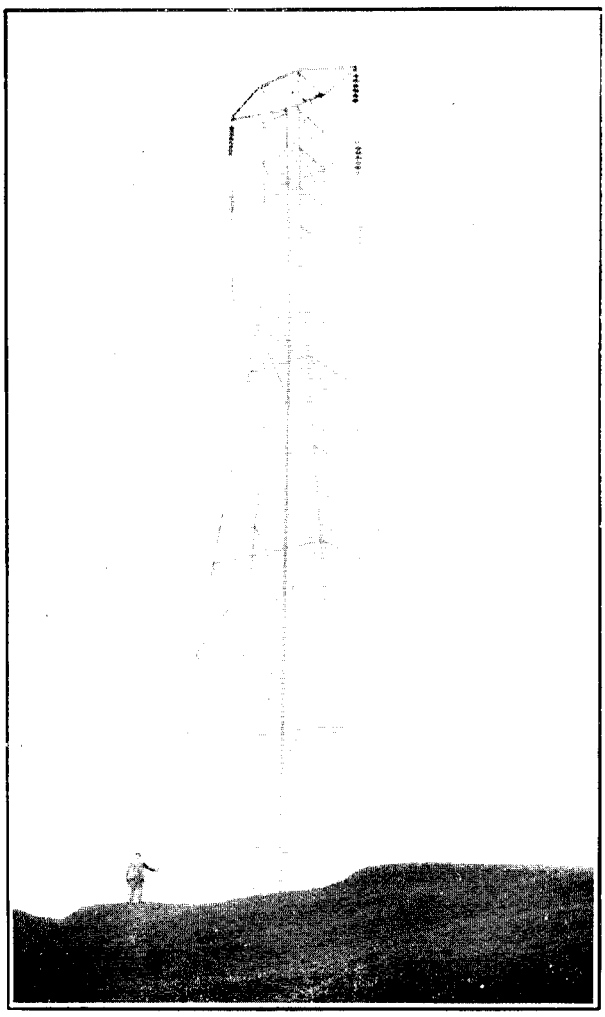
Mangahao Hydro-electric-power Plant. Crushing and Concreting Plant, Arapeti Dam.

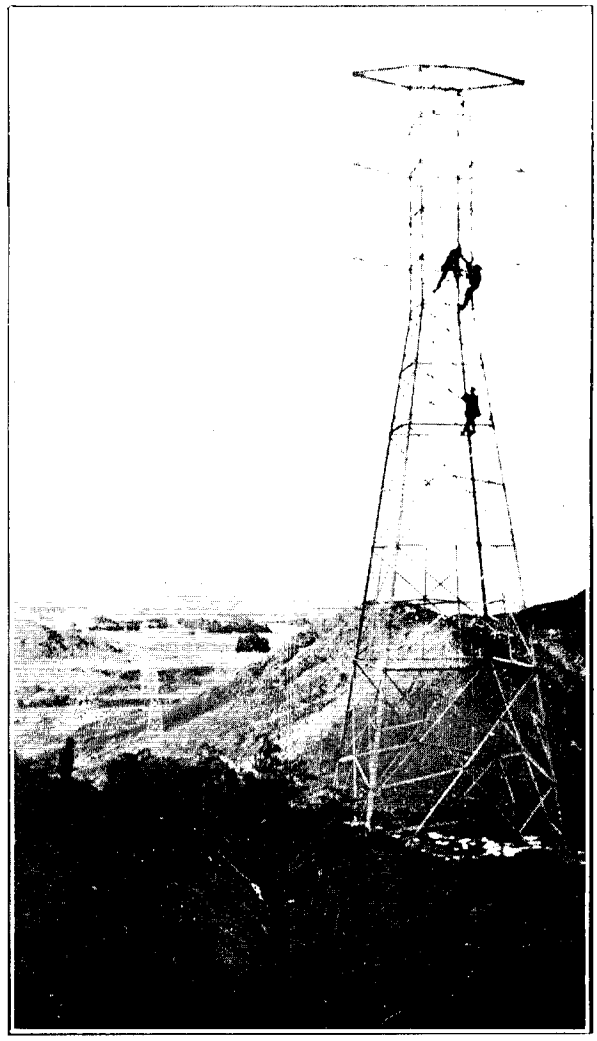


Mangahao Hydro-electric-power Plant. Water rising in Reservoir, Arapeti Dam.

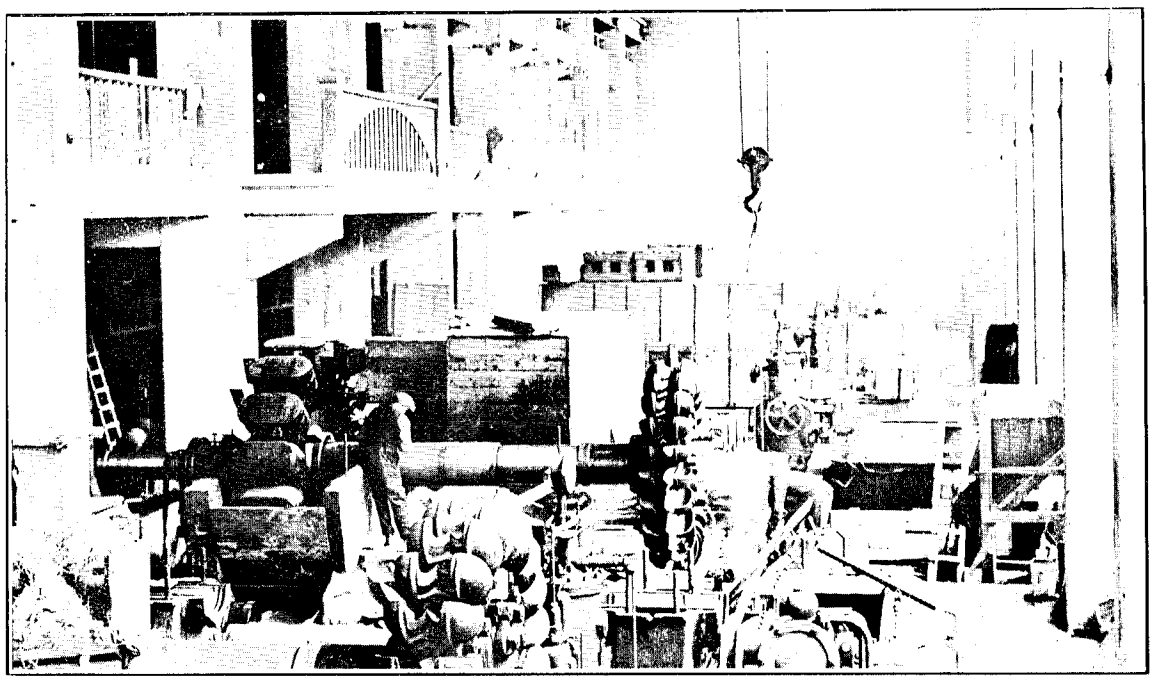


Mangahao Hydro-electric-power Plant. Mangahao Power-house: Machinery in Position in Power-house, covered to keep out Dust.

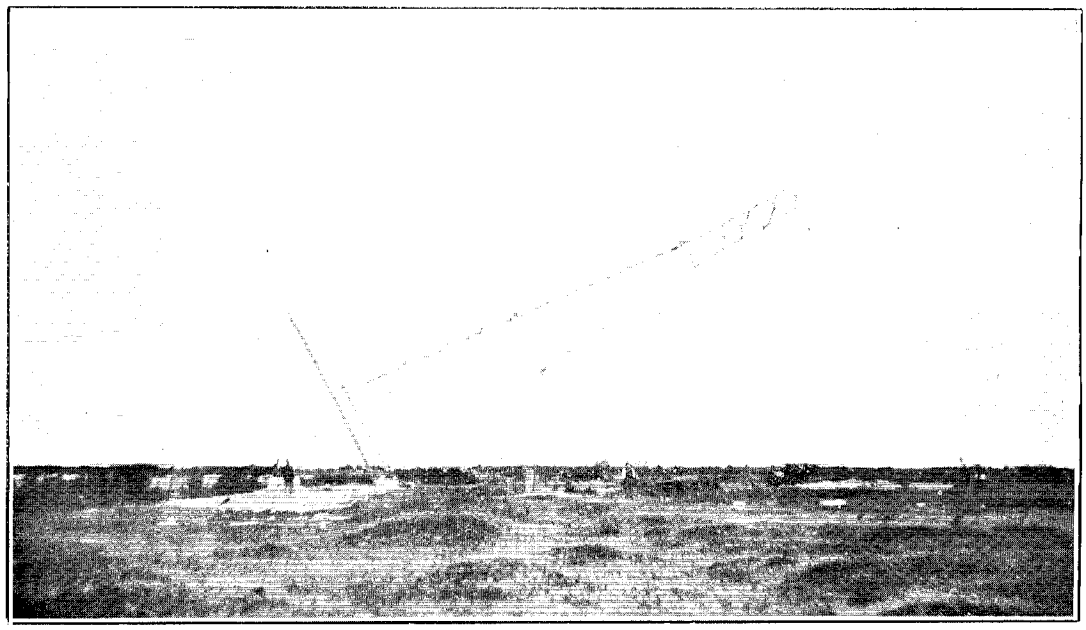




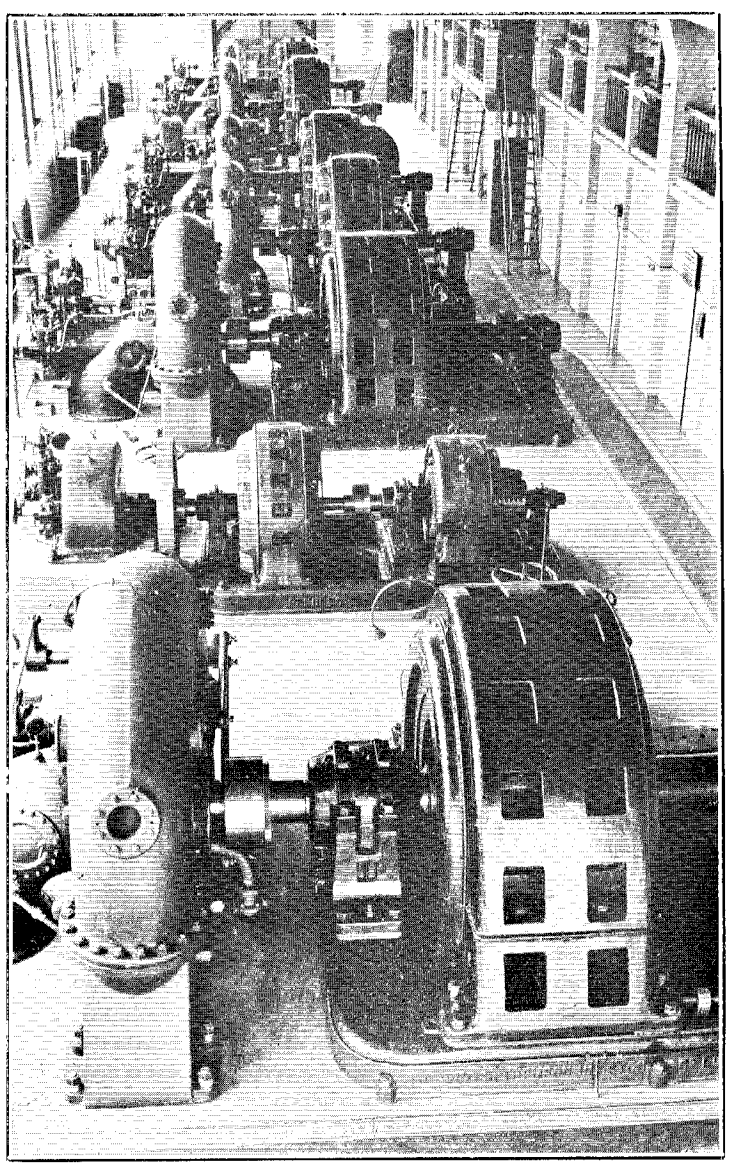
MANGAHAO HYDRO ELECTRIC POWER PLANT: 110,000 VOLT TRANSMISSION LINE TOWERS.



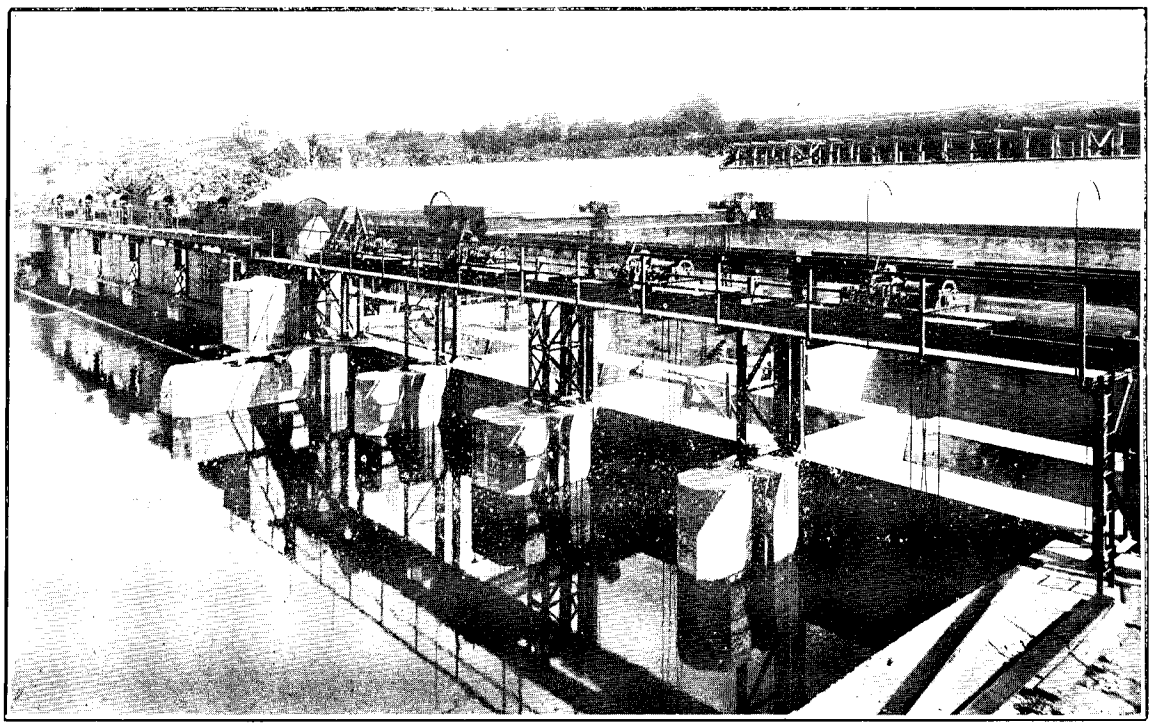
MANGAHAO HYDRO-ELECTRIC POWER PLANT: PLACING MACHINERY IN POSITION IN POWER HOUSE.



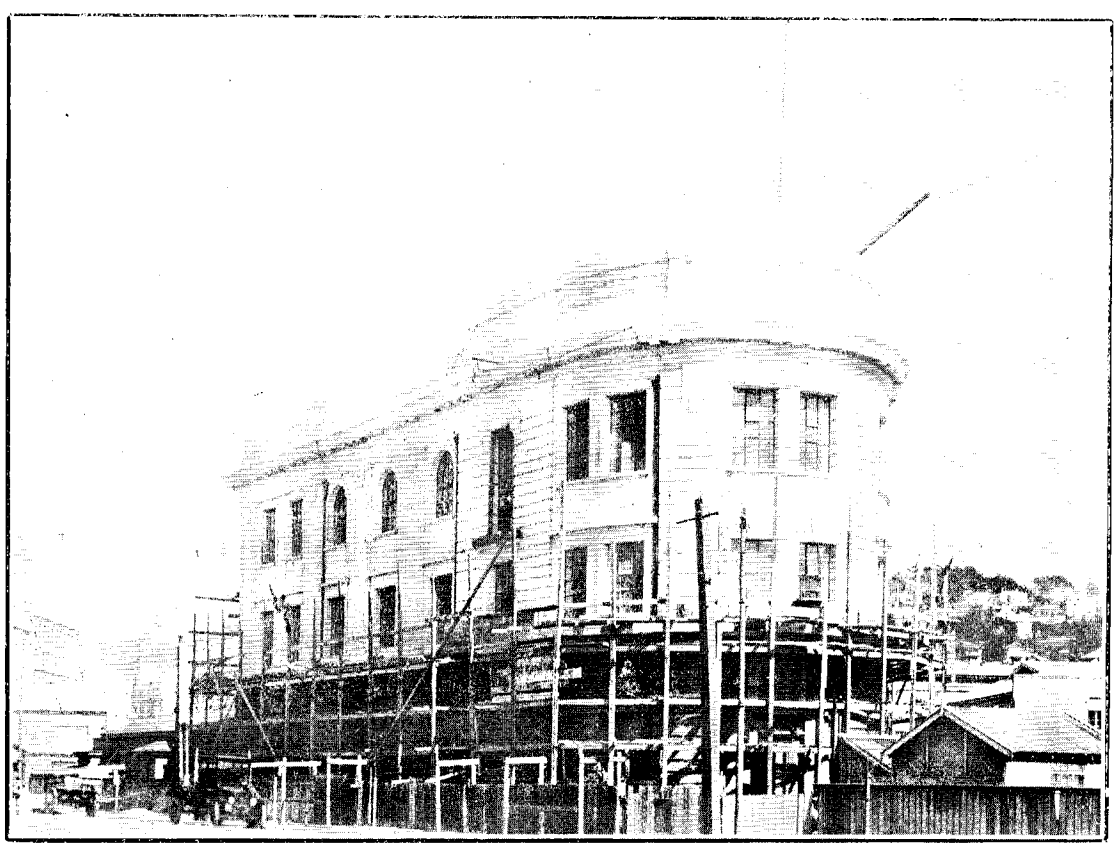
Lake Coleridge Hydro-electric-power Plant: Method of erecting Transmission-line Towers.



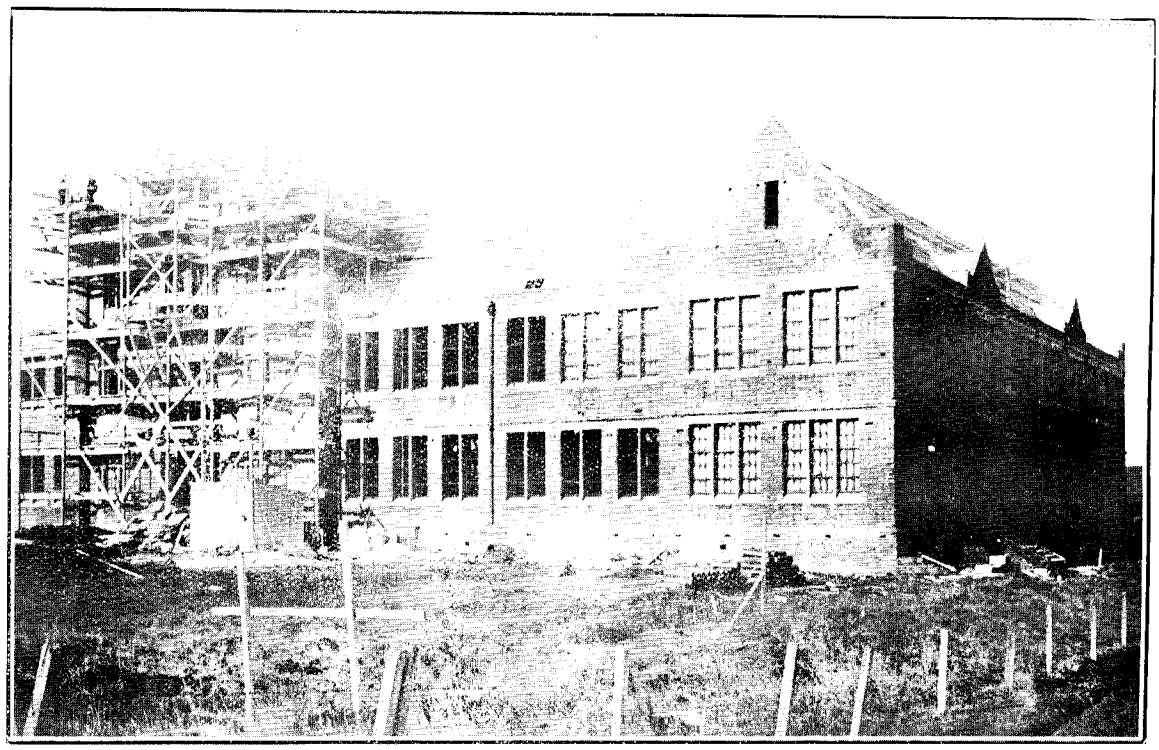
Lake Coleridge Hydro-electric-power Plant: Turbines and Generators in Power-house.



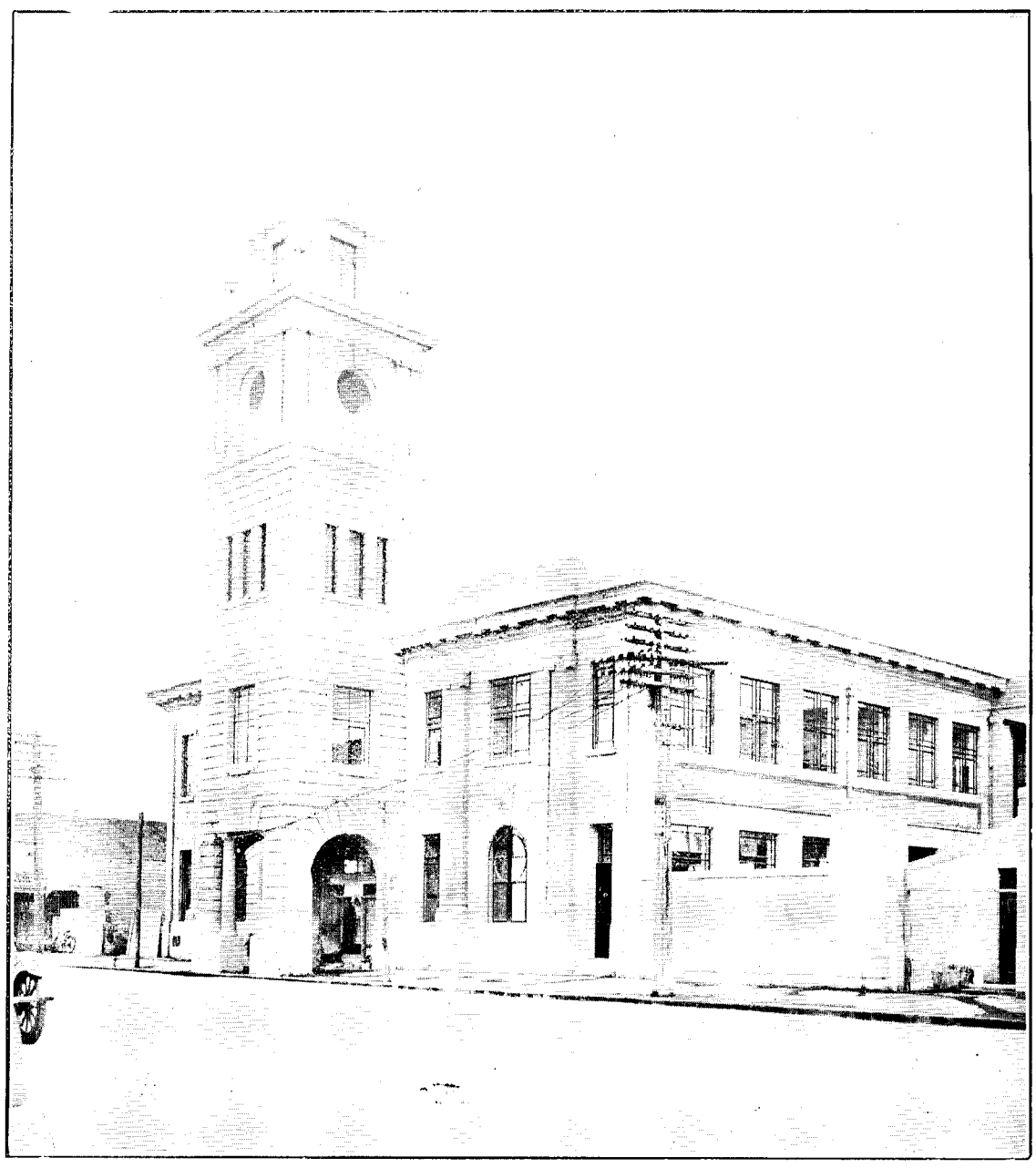
Waikato Hydro-electric-power Plant: Headworks at Horahora.



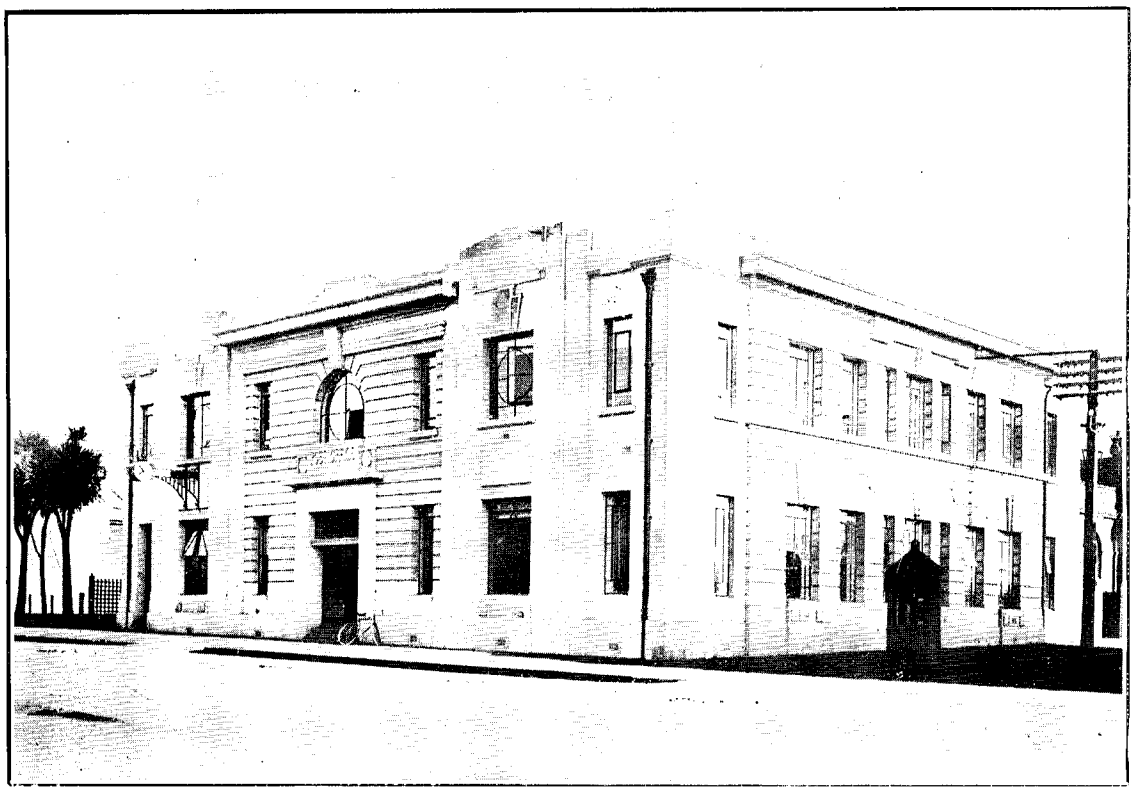
Wellington Automatic-telephone Exchange.



Southland Boys' High School.



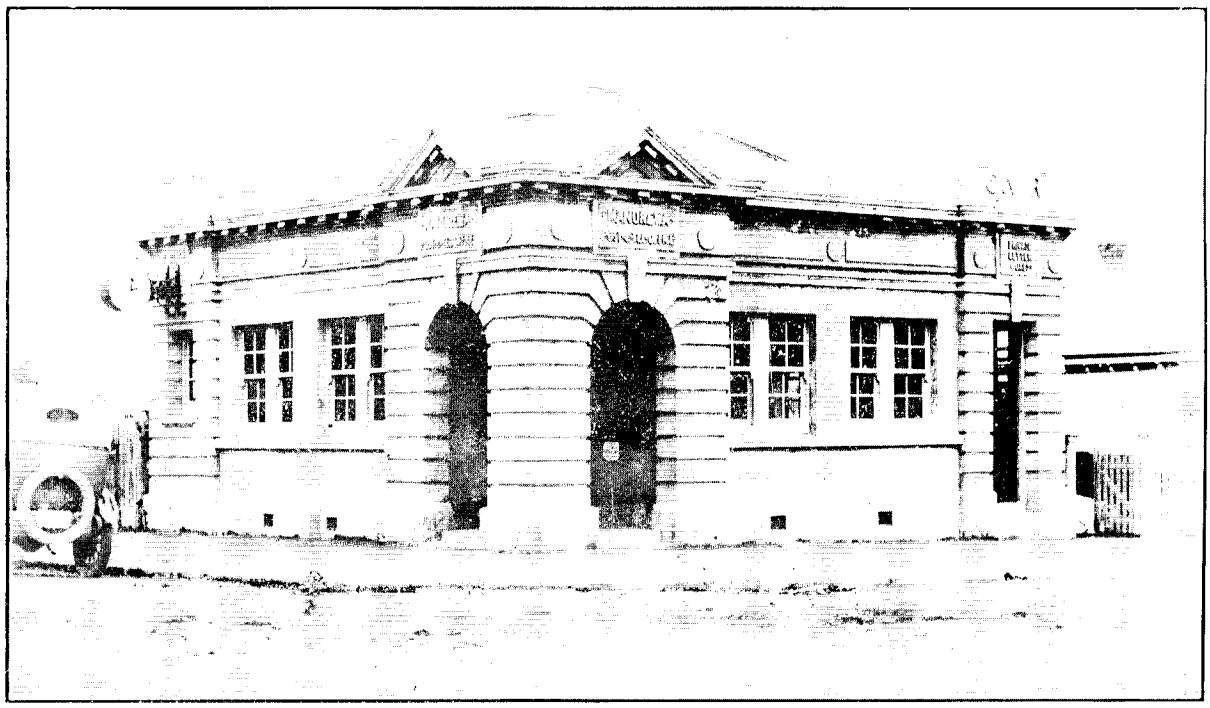
Stratford Post-office.



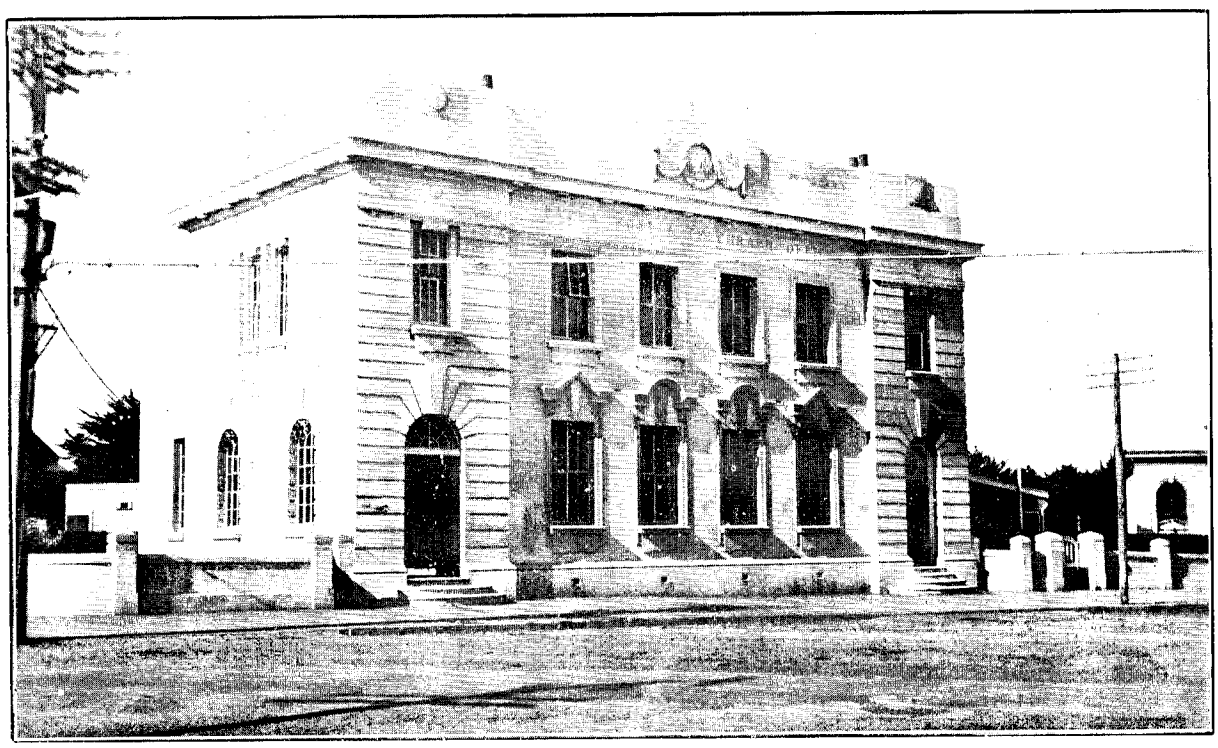
Dannevirke Post-office.



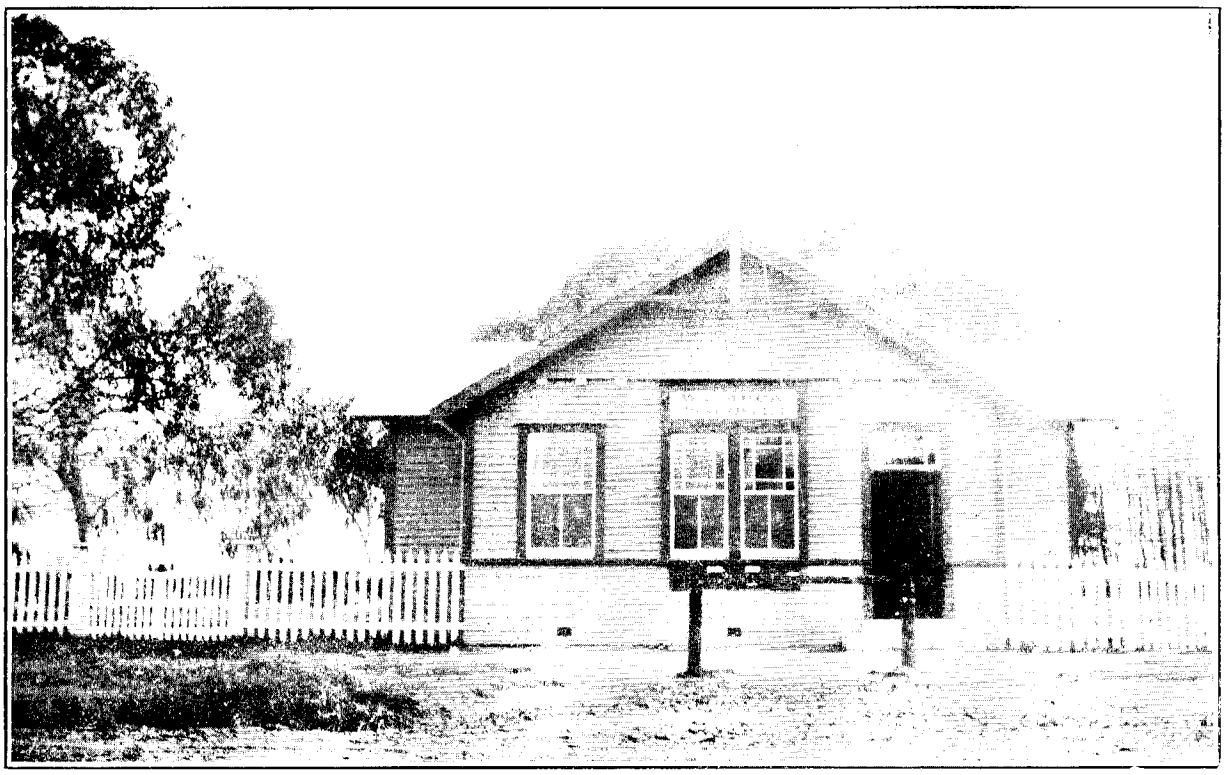
Automatic-telephone Exchange, Christchurch.



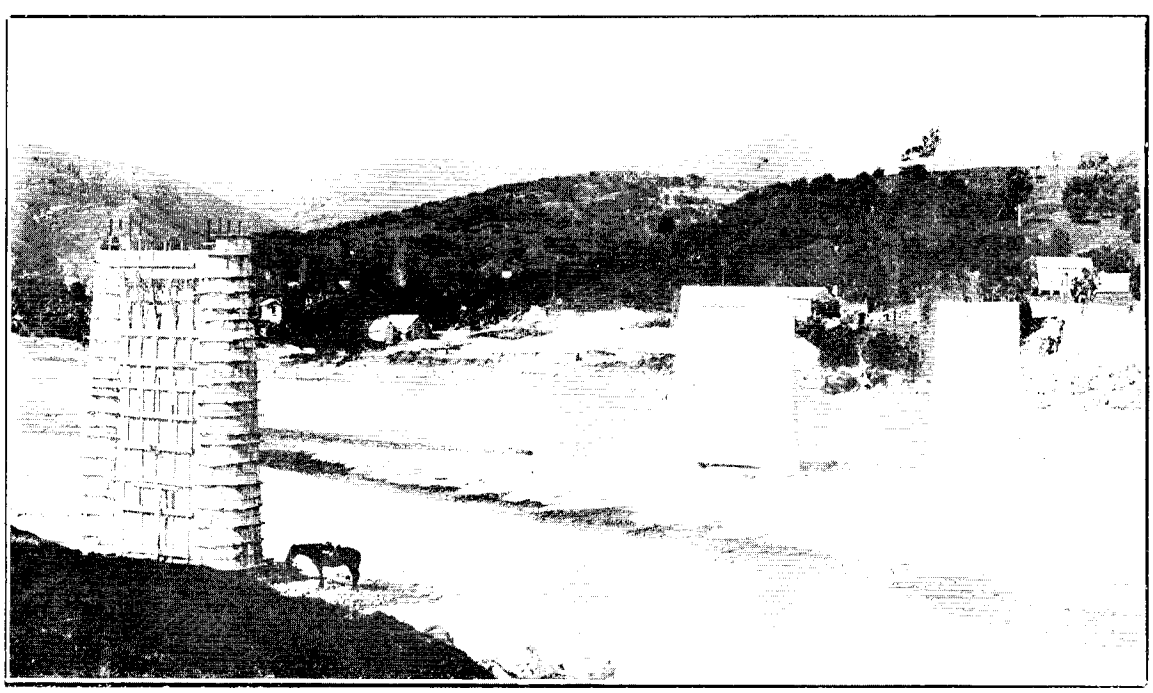
Manurewa Post and Telegraph Office.



Patea Post and Telegraph Office.



Waiaroa Post-office.



Rotokauciuki Bridge: Two Piers erected and another in Course of Construction.

PUBLIC WORKS STATEMENT, 1924.

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TABLE No. 1.

SUMMARY SHOWING THE TOTAL EXPENDITURE ON PUBLIC WORKS AND OTHER SERVICES OUT OF PUBLIC WORKS FUND TO 31ST MARCH, 1924, AND THE LIABILITIES ON THAT DATE.

Number of Table containing Details.	Works.	Total Net Expenditure to 31st March, 1923.	Expenditure during Twelve Months ended 31st March, 1924.	Recoveries on Account of Services of Previous Years.	Total Net Expenditure to 31st March, 1924.	Liabilities on 31st March, 1924.	Total Net Expenditure and Liabilities.	Works.
		£	£	£	£	£	£	
3	Railways*..	42,843,329	1,776,413	1,167	44,618,575	106,064	44,724,639	Railways.*
..	Roads†	13,759,722	754,237	188	14,513,771	142,565	14,656,336	Roads.†
..	Development of mining	833,922	1,363	2,310	832,975	..	832,975	Development of mining.
..	Telegraphs	5,502,002	717,409	..	6,219,411	..	6,219,411	Telegraphs.
..	Public buildings	8,891,421	192,739	3,829	9,080,331	18,752	9,099,083	Public buildings.
..	Lighthouses, harbour-works, and harbour-defences	1,184,102	10,807	16	1,194,893	91	1,194,984	Lighthouses, harbour-works, and harbour-defences.
..	Departmental	1,928,643	110,445	69	2,039,019	503	2,039,522	Departmental.
18 of 1878	Coal-exploration and mine-development	10,835	..	..	10,835	..	10,835	Coal-exploration and mine-development.
11 of 1877	Aiding works on Thames goldfields ..	50,000	..	..	50,000	..	50,000	Aiding works on Thames goldfields.
..	Immigration	2,597,742	92,600	1,267	2,689,075	..	2,689,075	Immigration.
..	Purchase of Native lands	2,061,739	..	..	2,061,739	..	2,061,739	Purchase of Native lands.
..	Defence	1,087,291	4,931	280	1,091,942	..	1,091,942	Defence.
..	Charges and expenses of raising loans ..	1,489,937	311,905	..	1,801,842	..	1,801,842	Charges and expenses of raising loans.
..	Interest and sinking fund	218,500	..	..	218,500	..	218,500	Interest and sinking fund.
..	Rates on Native lands	68,672	..	..	68,672	..	68,672	Rates on Native lands.
..	Thermal springs	14,600	..	..	14,600	..	14,600	Thermal springs.
..	Tourist and health resorts	309,616	27,264	..	336,880	776	337,656	Tourist and health resorts.
..	Lands improvement‡	177,323	18,182	..	195,505	1,166	196,671	Lands improvement.‡
..	Payment to Midland Railway bondholders	150,000	..	..	150,000	..	150,000	Payment to Midland Railway bondholders.
..	Irrigation and water-supply§ ..	397,750	95,467	..	493,217	11,257	504,474	Irrigation and water-supply.§
..	Plant, material, and stores	415,930	*Cr.* 52,772	16	363,142	5,638	368,780	Plant, material, and stores.
..	Timber-supply and sawmills for Public Works Department	31,094	3,613	..	34,707	865	35,572	Timber-supply and sawmills for Public Works Department.
..	Motor Transport Services	22,679	962	..	23,641	..	23,641	Motor Transport Services.
	Totals	84,046,849	4,065,565	9,142	88,103,272	287,677	88,390,949	Totals.

* Exclusive of expenditure on Hutt Railway and Road Improvement and Railways Improvement Accounts. † Includes £4,500 expended under section 16 (1) Native Land Amendment and Native Land Claims Adjustment Act, 1923. ‡ £6,727 previously expended on irrigation under this item, now transferred to Irrigation and Water-supply. § Includes £115,000 previously expended under Irrigation and Water-supply Account 1911–12 to 1915–16 and part 1917–18, now included in Public Works Fund; also £6,727 previously expended on irrigation under Lands Improvement, now transferred to Irrigation and Water-supply.

TABLE No. 2.

GENERAL SUMMARY.

Showing NET YEARLY EXPENDITURE out of PUBLIC WORKS FUND, 1902–1903 to 1923–24.

N.B.—The figures in italics, prefixed by "*Cr.*," are either recoveries on account of services of previous years or receipts-in-aid applied in reduction of expenditure.

Description of Services.	Total Net Expenditure to 31st March, 1902.	Expenditure.										
		1902–3.	1903–4.	1904–5.	1905–6.	1906–7.	1907–8.	1908–9.	1909–10.	1910–11.	1911–12.	1912–13.
	£	£	£	£	£	£	£	£	£	£	£	£
Immigration	1,247,858	142	*Cr.* 7	6,481	8,753	14,353	9,132	15,075	17,003	9,441	11,681	14,694
Public Works, Departmental	477,087	13,949	16,088	12,814	13,517	16,710	18,219	24,512	41,176	42,733	49,864	57,426
Irrigation and Water-supply	..	..	..	..	..	..	..	..	..	1,562	2,794	14,689
Railways	18,501,966	759,752	828,704	779,891	1,021,265	1,227,880	1,093,535	1,116,183	1,128,400	1,104,071	1,125,905	1,148,832
										Cr. 652	*Cr. 6,987*	*Cr.29,528*
Payment to Midland Railway Bondholders	..	..	150,000	..	..	..	..	..	..	..	..	..
Roads :—												
Miscellaneous Roads and Bridges	5,113,804	230,349	316,248	202,850	306,065	308,500	285,248	422,174	297,932	229,537	383,511	337,584
Roads on Goldfields	535,452	51,690	45,594	26,112	45,139	38,970	38,494	47,375	40,830	25,626	41,067	36,761
Development of Thermal Springs and Natural Scenery ..	16,023	..	..	..	..	..	..	..	..	..	..	..
Lands Improvement Account*	300,930	..	..	..	..	..	..	..	..	..	..	..
Total, Roads	5,966,209	282,039	361,842	228,962	351,204	347,470	323,742	469,549	338,762	255,163	424,578	374,345
Development of Mining	701,679	24,213	16,278	6,258	18,533	11,064	8,633	32,859	18,597	10,845	21,244	10,644
									Cr. 1,000	*Cr. 1,000*	*Cr. 30*	*Cr. 1,015*
Purchase of Native Lands	1,491,251	15,782	5,352	6,281	13,777	9,135	2,190	2,099	30,567	2,976	*Cr. 2,466*	*Cr. 917*
										Cr. 2,286		
Native Lands Purchase Account	491,980	..	..	..	..	..	..	..	..	..	..	..
Total, Land Purchases	1,983,231	15,782	5,352	6,281	13,777	9,135	2,190	2,099	30,567	690	*Cr. 2,467*	*Cr. 917*
Telegraph Extension	937,887	68,578	47,228	79,298	77,186	114,068	155,491	163,032	123,423	111,867	147,692	251,375

* Subsequent expenditure under separate class "Lands Improvement," see next page.

[*Continued on page 4.*

TABLE No. 2—*continued.*

GENERAL SUMMARY—*continued*

Showing Net Yearly Expenditure out of Public Works Fund, 1902–1903 to 1923–24—*continued.*

Description of Services.	Total Net Expenditure to 31st March, 1902.	Expenditure.										
		1902–3.	1903–4.	1904–5.	1905–6.	1906–7.	1907–8.	1908–9.	1909–10.	1910–11.	1911–12.	1912–13.
Public Buildings:—	£	£	£	£	£	£	£	£	£	£	£	£
General (including Miscellaneous)	256,436	9,031	10,964	9,021	2,231	14,216	16,260	39,635	41,964	44,044	34,721	44,719
Parliamentary	59,450	1,503	602	697	71	1,047	4,119	5,172	3,157	237	2,004	18,806
Judicial—Courthouses	438,855	16,627	8,799	2,174	6,509	9,580	5,788	14,473	11,119	5,759	14,556	20,097
Judicial—Prisons		4,964	6,876	4,127	1,537	3,146	4,164	5,008	4,231	7,506	9,760	6,911
Judicial—Police-stations		11,633	10,303	6,782	7,853	22,466	18,986	17,730	16,256	9,030	19,817	18,423
Post and Telegraph	257,686	74,686	53,918	16,008	38,419	43,918	43,724	62,262	68,574	117,815	130,815	122,999
Customs	9,968	6,630	8,719	13,018	7,903	414	47	2,507	233	..	..	..
Quarantine Stations	6,865	..	..	..	..	..	..	..	..	..	..	..
Mental Hospitals	475,595	10,167	15,812	15,949	16,235	8,049	7,987	15,296	19,839	12,707	8,809	46,181
Public Health	..	..	6,315	4,265	7,926	1,765	7,497	4,402	319	..	..	376
Hospitals and Charitable Institutions	55,684	3,540	4,291	1,204	4,786	10,259	15,576	11,153	7,259	1,484	12,745	8,750
School Buildings	1,087,967	57,790	87,089	42,721	69,223	109,459	100,197	102,340	98,103	124,926	90,535	105,000
Agricultural	6,744	883	2,504	1,362	2,618	2,707	1,690	5,543	6,103	1,160	3,684	6,475
Workers' Dwellings	..	..	..	..	..	..	..	..	..	..	22,644	46,455
Total, Public Buildings	2,655,250	197,454	216,192	117,328	165,311	227,026	226,035	285,521	277,157	324,668	350,090	445,192
Lighthouses, Harbour-works, and Harbour-defences:—												
Lighthouses	147,438	6,082	6,206	2,167	962	..	1,417	7,481	6,762	1,470	5,428	9,031
Harbour-works	323,155	1,373	1,773	1,308	2,684	2,963	2,867	4,439	4,548	4,092	6,004	7,415
Harbour-defences	507,179	6,126	2,885	2,515	1,300	1,541	2,579	7,297	5,372	2,865	1,144	339
Total, Lighthouses, &c.	977,772	13,581	10,864	5,990	4,946	4,504	6,863	19,217	16,682	8,427	12,576	16,785
Rates on Native Lands	64,797	471	666	631	548	695	837	27	..	..	..	..
Contingent Defence	696,835	37,005	38,723	46,588	35,569	14,874	18,574	10,766	4,977	6,071	10,437	23,790
Tourist and Health Resorts	11,260	10,949	15,643	17,508	15,888	42,271	45,048	24,286	14,507	5,912	13,361	12,906
Lands Improvement*	1,741	2,349	2,019	2,248	1,052	5,605	9,561	19,542	6,910	11,125	20,394	22,550
												Cr. 383
Charges and Expenses of raising Loans	1,062,875	88,180	87,249	10,764	236	*Cr. 5,175*	*Cr. 8,487*	575	17,715	66,367	67,470	72,950
									Cr. 12,000	*Cr. 66,392*	*Cr. 66,954*	*Cr. 71,681*
Interest and Sinking Funds	218,500	..	..	..	..	..	..	..	..	..	..	..
Coal-exploration and Mine-development	10,835	..	..	..	..	..	..	..	..	..	..	..
Thermal Springs	14,600	..	..	..	..	..	..	..	..	..	..	..
Total Ways and Means Credits	..	..	*7*	..	..	*5,175*	*8,487*	..	..	..	*10,530*	*103,524*
Grand Total—Net Expenditure	36,430,382	1,514,444	1,796,841	1,321,510	1,730,686	2,035,144	1,909,688	2,183,245	2,022,876	1,891,918	2,190,731	3,362,654

* For previous expenditure see Roads Class.

[*Continued on page 5.*

TABLE No. 2—*continued.*

GENERAL SUMMARY—*continued.*

Showing NET YEARLY EXPENDITURE out of PUBLIC WORKS FUND, 1902–1903 to 1923–24—*continued.*

Description of Services.	Expenditure.											Total Net Expenditure to 31st March, 1924.
	1913–14.	1914–15.	1915–16.	1916–17.	1917–18.	1918–19.	1919–20.	1920–21.	1921–22.	1922–23.	1923–24.	
	£	£	£	£	£	£	£	£	£	£	£	£
Immigration	33,914	33,219	10,010 *Cr. 10*	6,533	3,856	*Cr. 12,018*	*Cr. 62,561*	*Cr. 7,806*	247,528	90,611 *Cr. 140*	92,600 *Cr. 1,267*	2,689,075
Public Works, Departmental	66,650	100,719	111,489	131,701	127,962 *Cr. 2,662*	115,419 *Cr. 4,119*	121,677	143,280 *Cr. 6,281*	128,002 *Cr. 525*	111,367 *Cr.* 131	110,445 *Cr. 69*	2,039,019 ..
Irrigation and Water-supply*	40,329	32,090	29,874	20,794	11,650	13,665	34,115	55,344	82,713	58,131	95,467	493,217
Railways	1,104,897 *Cr. 5,485*	2,146,753† *Cr. 6,022*	1,065,171 *Cr. 4,633*	620,947 *Cr. 4,845*	495,771 *Cr.* 110	387,923 *Cr. 4,924*	748,649 *Cr. 105,196*	1,365,466 *Cr.* 388	3,133,200 *Cr.* 751	2,110,859 *Cr. 3,171*	1,776,413 *Cr. 1,167*	44,618,575 ..
Payment to Midland Railway Bondholders	..	..	..	..	..	..	..	..	..	..	..	150,000
Roads:—												
Miscellaneous Roads and Bridges	353,836 *Cr. 515*	484,365	400,062	203,746	128,730 *Cr. 600*	221,887 *Cr. 997*	376,097 *Cr. 603*	527,854 *Cr. 81*	552,895 *Cr. 197*	643,156 *Cr. 244*	751,370 *Cr. 188*	.. ..
Roads on Goldfields	24,143	30,065	24,432	17,099	6,912	4,186	12,465	11,050	11,264	4,850	2,867	..
Development of Thermal Springs and Natural Scenery	..	..	..	..	..	..	..	..	..	..	..	..
Lands Improvement Account	..	..	..	..	..	..	..	..	..	..	..	..
Total, Roads	377,464	514,430	424,494	220,845	135,042	225,076	387,959	538,823	563,962	647,762	754,049	14,513,771
Development of Mining	4,889	2,384 *Cr. 255*	6,602	4,592	27 *Cr. 6,545*	518 *Cr. 1,000*	1,173 *Cr. 7,008*	2,153 *Cr. 1,606*	2,130 *Cr.* 51	*Cr. 98* *Cr. 1,785*	1,363 *Cr. 2,310*	882,975 ..
Purchase of Native Lands	*Cr. 857*	*Cr. 1,060*	*Cr. 972*	*Cr. 868*	*Cr. 57*	..	*Cr. 57*	*Cr. 57*	*Cr. 52*	..	..	..
Native Lands Purchase Account	..	..	..	..	..	..	..	..	..	..	..	..
Total, Land Purchases	*Cr. 857*	*Cr. 1,060*	*Cr. 972*	*Cr. 868*	*Cr. 57*	..	*Cr. 57*	*Cr. 57*	*Cr. 52*	..	..	2,061,739
Telegraph Extension	392,648	288,395	249,554	203,311	213,955	198,611	249,379	336,468	590,981	512,657 *Cr. 11,082*	717,409	6,219,411

* £6,727 previously included under Lands Improvement, now transferred to Irrigation and Water-supply.

† Includes £1,000,000 expended 1908–9 and 1909–10 under Wellington–Manawatu Railway Purchase Account.

[*Continued on page 6.*

TABLE No. 2—*continued.*

GENERAL SUMMARY—*continued.*

Showing NET YEARLY EXPENDITURE out of PUBLIC WORKS FUND, 1902–1903 to 1923–24—*continued.*

Description of Services.	Expenditure.											Total Net Expenditure to 31st March, 1924.
	1913–14.	1914–15.	1915–16.	1916–17.	1917–18.	1918–19.	1919–20.	1920–21.	1921–22.	1922–23.	1923–24.	
Public Buildings :—	£	£	£	£	£	£	£	£	£	£	£	£
General (including Miscellaneous)	43,199	52,239	22,050	12,648	11,646 *Cr. 15,067*	43,168	64,207	39,504	87,057	113,553	8,160	..
Parliamentary	23,612	31,478	17,133	22,586	37,233	..	..	..	..	..	..	..
Judicial — Courthouses	9,423	5,171	4,902	299	21	..	868	1,400	4,358	2,018 *Cr. 13*	2,448	..
Judicial — Prisons	4,928	14,515	17,786	15,685	13,195	16,299	20,981	30,038 *Cr. 800*	41,740	23,313	26,484 *Cr. 2,568*	..
Judicial — Police-stations	14,094	19,122	25,484	21,147	18,814	6,157	24,944	36,843	22,544	6,298	12,838	..
Post and Telegraph	78,815	60,838	35,258	22,744	33,525	26,072	66,543	93,364 *Cr. 560*	112,906 *Cr. 675*	77,211 *Cr. 69*	108,395	..
Customs	..	..	..	..	..	..	..	..	..	..	..	..
Quarantine Stations	..	..	..	..	..	..	35,490	15,529	4,581	154	171	..
Mental Hospitals	26,001	53,996	54,898 *Cr. 15*	44,602	26,502	14,640	18,277	27,368	41,838	13,852	26,541	..
Public Health	..	..	..	..	..	..	..	..	..	..	..	..
Hospitals and Charitable Institutions	1,435	998	1,426	7,570	4,080	2,332	8,484	4,099	26,131	20,981 *Cr. 1,399*	7,420 ..	..
School Buildings	121,954	122,940	97,972	70,367	63,082	115,656	195,500	244,722	2,469 *Cr. 9,255*	*Cr. 367*	*Cr. 1,090*	
Agricultural	4,398	2,428 *Cr. 34*	2,972	3,046	5,685	4,229	7,227	9,345	1,115	514 *Cr. 27*	282 *Cr. 171*	..
Workers' Dwellings	41,741	68,275	55,893	35,437	15,505	7,293	26,674	..	..	..	..	..
Total, Public Buildings	369,600	431,966	335,759	256,131	214,221	235,846	469,195	500,851	334,809	255,818	188,910	9,080,331
Lighthouses, Harbour-works, and Harbour-defences :—												
Lighthouses	5,174	3,887	1,415	449	561	1,663	253	758	16,350	3,260	4,473	..
Harbour-works	3,346 *Cr. 1,462*	12,563	9,355	2,280	2,359	3,729	3,245	4,080	2,424	6,524	6,334	..
Harbour-defences	539 *Cr. 300*	681	2,903	1,038	56	..	..	..	..	.. *Cr. 1,235*	.. *Cr. 16*	..
Total, Lighthouses, &c.	7,297	17,131	13,673	3,767	2,976	5,392	3,498	4,838	18,774	8,549	10,791	1,194,892
Rates on Native Lands	..	..	..	..	..	..	..	..	..	..	..	68,672
Contingent Defence	30,186	15,221	37,619	9,742	6,714	8,809 *Cr. 922*	10,187	8,701	15,586	1,702 *Cr. 463*	4,931 *Cr. 280*	1,091,943
Tourist and Health Resorts	14,989	8,232 *Cr. 12*	5,167 *Cr. 500*	1,094	931	1,620	6,194	19,041	17,996 *Cr. 110*	5,435	27,264	336,880
Lands Improvement*	10,269 *Cr. 432*	13,810 *Cr. 522*	5,936	*Cr. 2,731*	1,838	*Cr. 4,268*	2,964	2,064	17,478	26,204	18,182	195,505
Charges and Expenses of raising Loans	105,449 *Cr. 96,741*	35,495 *Cr. 34,865*	5,037 *Cr. 5,030*	35	1	..	..	184	174,280	62,399	311,905	1,801,842
Interest and Sinking Funds	..	..	..	..	..	..	..	..	..	..	..	218,500
Coal-exploration and Mine-development	..	..	..	..	..	..	..	..	..	..	..	10,835
Thermal Springs	..	..	..	..	..	..	..	..	..	..	..	14,600
Plant, Material, and Stores	..	..	74,418	9,778	6,811	20,638 *Cr. 31*	47,682	169,910	106,432	*Cr. 19,708*	*Cr. 52,788*	363,142
Timber-supply and Sawmills for Public Works Department	..	..	..	..	..	..	..	..	16,369	14,725	3,613	34,707
Motor Transport Service	..	..	..	..	..	..	..	..	..	22,679	962	23,641
Total Ways and Means Credits	*105,792*	*43,400*	*11,160*	*5,713*	*43,492*	*11,993*	*112,864*	*19,627*	*11,616*	*20,127*	*61,914*	..
Grand Total—Net Expenditure	2,455,066	2,597,109	2,363,658	1,502,588	1,237,422	1,207,482	2,020,714	3,121,131	3,449,351	3,892,320	4,056,423	88,103,272

* Expenditure on Irrigation and Water-supply—1905–6, £22; 1906–7, £750; 1907–8, £1,554; 1908–9, £1,966; 1909–10 £2,435, now transferred to Irrigation and Water-supply.

TABLE No 3.

Expenditure on Railways to 31st March, 1924.

Lines of Railway.	Total Expenditure by General Government to 31st March, 1923.	Recoveries on Account of Expenditure of Previous Years.	Expenditure out of Public Works Fund during Year 1923–24.				Expenditure under Special Acts during Year 1923–24.*	Amounts previously charged to "Surveys of New Lines" now charged to Individual Lines.	Total Expenditure by General Government to 31st March, 1924.	Valuation of Works constructed by Provinces and Midland Railway Company.
			New Works.			Works on Open Lines.				
			Construction and Surveys.	Permanent-way.	Total New Works.					
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Kaihu Valley	175,110 0 0	..	3,749 8 1	..	3,749 8 1	..	..	..	178,859 8 1	..
Opua Wharf to Whangarei and Onerahi	535,512 0 0	..	..	..	..	25,183 15 3	43 0 5	..	560,738 15 8	..
Otiria to Ngapuhi	125,987 0 0	..	..	..	..	..	..	..	125,987 0 0	..
Whangarei (Kioreroa) to Waiotira	370,872 0 0	..	13,985 10 2	3,648 13 10	17,634 4 0	..	..	..	388,506 4 0	..
Waipu Branch	25,303 0 0	..	2,711 18 2	..	2,711 18 2	..	..	..	28,014 18 2	..
North Auckland Main Trunk—										
Ngapuhi Northwards	241,271 0 0	..	7,226 16 9	143 0 2	7,369 16 11	..	..	..	248,640 16 11	..
Helensville Northwards	1,629,660 16 1	..	299,677 13 3	3,360 18 5	303,038 11 8	5,250 0 2	..	..	1,937,949 7 11	..
North Auckland Main Trunk to Dargaville	474 0 0	..	..	..	..	..	..	..	474 0 0	..
Helensville to Te Awamutu	2,728,211 0 0	..	..	..	..	95,254 15 2	6,299 2 6	..	2,829,764 17 8	..
Waiuku Branch (Paerata to Waiuku)	207,032 0 0	41 11 3	431 6 1	..	431 6 1	252 4 0	..	..	207,673 18 10	..
Huntly to Awaroa	174,637 0 0	..	2,960 9 4	3,157 12 9	6,118 2 1	..	..	..	180,755 2 1	..
Waikokowai Branch	3,474 0 0	..	..	..	..	..	..	..	3,474 0 0	..
Waipa Gravel Access Branch	114 0 0	..	..	..	..	..	..	..	114 0 0	..
Frankton to Thames	375,612 0 0	..	..	..	..	1,104 11 2	582 17 2	..	377,299 8 4	..
Cambridge Branch (Ruakura Junction to Cambridge)	54,977 0 0	..	..	..	..	..	..	..	54,977 0 0	..
Morrinsville to Rotorua	382,080 0 0	..	..	..	..	2,618 5 1	582 17 2	..	385,281 2 3	..
Marton to Te Awamutu	2,870,983 11 4	25 0 0	..	..	..	5,154 4 4	554 6 2	..	2,876,667 1 10	..
Raetihi Branch	88,565 0 0	..	..	..	..	54 17 1	..	..	88,619 17 1	..
Paeroa to Waihi and Tauranga	330,907 0 0	..	59,677 9 4	3,933 1 5	63,610 10 9	..	..	..	394,517 10 9	..
Tauranga to Taneatua, including Te Maunga to Maunganui Branch	938,344 0 0	..	154,151 11 0	15,165 17 3	169,317 8 3	..	..	..	1,107,661 8 3	..
Gisborne to Motu	624,357 0 0	..	..	..	..	197 14 7	..	..	624,554 14 7	..
Gisborne to Ormond Tramway	4,975 1 7	..	..	..	..	..	..	..	4,975 1 7	..
Napier to Gisborne—										
Gisborne Southwards	249,785 0 0	..	17,702 12 4	923 19 2	18,626 11 6	..	..	..	268,411 11 6	..
Wairoa Northwards	19,473 0 0	..	1,289 16 6	..	1,289 16 6	..	..	..	20,762 16 6	..
Napier Northwards	263,666 0 0	..	107,168 18 1	7,596 5 2	114,765 3 3	..	..	..	378,431 3 3	..
Waikokopu Branch	354,505 0 0	..	68,566 15 2	1,868 0 10	70,434 16 0	..	..	..	424,939 16 0	..
Wellington to Napier—										
Napier to Woodville and Palmerston North	953,258 0 0	694 13 3	..	..	..	1,003 14 2	1,569 0 7	..	955,136 1 6	..
Wellington to Woodville, including Te Aro Extension	1,783,723 0 0	..	*Cr.* 56 8 9	..	*Cr.* 56 8 9	3,891 1 8	4,425 12 2	6,556 0 0	1,798,539 5 1	..
Featherston to Martinborough	399 0 0	..	..	..	..	..	..	..	399 0 0	..
Wellington to Waitara—										
Wellington to Longburn	1,046,517 0 0	..	1,097 4 9	..	1,097 4 9	6,799 0 9	4,709 3 3	944 0 0	1,060,066 8 9	..
Foxton to Waitara and Moturoa	1,594,978 0 0	225 0 0	..	..	..	2,105 14 11	1,335 1 7	..	1,598,193 16 6	..
Mount Egmont Branch	71,699 0 0	..	..	..	..	..	..	..	71,699 0 0	..
Moturoa to Opunake	759 0 0	..	..	..	..	..	..	..	759 0 0	..
Opunake Branch (Te Roti to Opunake)	174,385 0 0	..	58,433 2 5	13,393 17 6	71,826 19 11	..	..	..	246,211 19 11	..
Manaia Branch (Kapuni to Manaia)	19,253 0 0	..	390 19 4	..	390 19 4	..	..	..	19,643 19 4	..
Rangitikei River Quarry Line	206 0 0	..	..	..	..	..	..	..	206 0 0	..

* Railways Improvement Authorization Act 1914 Account.

TABLE No. 3—*continued.*

EXPENDITURE ON RAILWAYS TO 31ST MARCH, 1924—*continued.*

Lines of Railway.	Total Expenditure by General Government to 31st March, 1923.	Recoveries on Account of Expenditure of Previous Years.	Expenditure out of Public Works Fund during Year 1923–24.				Expenditure under Special Acts during Year 1923–24.*	Amounts previously charged to "Surveys of New Lines" now charged to Individual Lines.	Total Expenditure by General Government to 31st March, 1924.	Valuation of Works constructed by Provinces and Midland Railway Company.
			New Works.			Works on Open Lines.				
			Construction and Surveys.	Permanent-way.	Total New Works.					
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£	£ s. d.	£ s. d.
Stratford to Okahukura (East End) ..	390,738 0 0	..	45,614 9 3	6,125 7 3	51,739 16 6	..	..	..	442,477 16 6	..
Stratford to Okahukura (West End) ..	782,552 0 0	..	14,668 11 8	1 11 8	14,670 3 4	..	..	..	797,222 3 4	..
Nelson to Greymouth—										
Nelson to Inangahua	400,673 0 0	..	22,687 10 9	..	22,687 10 9	..	..	..	423,360 10 9	78,307 0 0
Stillwater to Inangahua	213,387 0 0	..	..	..	..	416 9 5	..	..	213,803 9 5	279,685 0 0
Ngahere to Blackball	147,532 0 0	..	..	..	..	..	..	..	147,532 0 0	..
Westport to Ngakawau	189,521 0 0	..	..	..	..	..	..	..	189,521 0 0	..
Westport to Inangahua	152,702 0 0	..	1,672 3 3	..	1,672 3 3	..	..	..	154,374 3 3	..
Greymouth to Rewanui	255,646 0 0	..	..	..	..	..	..	..	255,646 0 0	..
Point Elizabeth Branch	70,963 0 0	..	3,182 10 9	..	3,182 10 9	..	..	..	74,145 10 9	..
Greymouth to Ross and Mikonui	342,314 0 0	..	..	..	..	9,375 11 11	..	..	351,689 11 11	..
Picton to Waipara—										
Picton Southwards	656,086 0 0	126 10 1	45 14 5	..	45 14 5	122 2 2	..	..	656,127 6 6	..
Waipara Northwards	377,253 0 0	3 18 0	..	..	..	283 18 5	..	..	377,533 0 5	..
Christchurch to Greymouth—										
Rolleston to Bealey	889,555 0 0	..	..	..	..	95,827 16 2	..	..	985,382 16 2	61,579 0 0
Whitecliffs Branch	25,021 0 0	..	..	..	..	..	..	..	25,021 0 0	..
Greymouth to Bealey	1,842,047 0 0	..	89,349 4 10	1,238 19 9	90,588 4 7	57,515 8 7	8 10 11	..	1,990,159 4 1	263,889 0 0
Hurunui to Waitaki—										
Main Line (Waiau to Waitaki)	2,074,197 0 0	..	85 1 6	..	85 1 6	23,622 10 9	2,193 17 7	..	2,100,098 9 10	316,135 0 0
Oxford Branch (Rangiora to Oxford West)	52,952 0 0	..	..	..	..	..	..	..	52,952 0 0	..
Eyreton Branch (Kaiapoi to Bennett's) ..	44,277 0 0	..	..	..	..	..	..	..	44,277 0 0	..
Lyttelton Branch	80,908 0 0	..	..	..	..	..	..	..	80,908 0 0	340,500 0 0
Southbridge Branch (Hornby to Southbridge)	91,441 0 0	..	..	..	..	..	..	..	91,441 0 0	..
Little River Branch (Lincoln to Little River)	109,185 0 0	..	..	..	..	476 5 10	..	..	109,661 5 10	..
Rakaia to Methven	74,676 0 0	..	..	..	..	5 13 0	..	..	74,681 13 0	..
Ashburton to Springburn	61,814 0 0	..	..	..	..	1,204 16 0	..	..	63,018 16 0	..
Orari to Geraldine	321 0 0	..	..	..	..	..	..	..	321 0 0	..
Fairlie Branch (Washdyke Junction to Fairlie)	68,056 0 0	..	..	..	..	110 0 1	..	..	68,166 0 1	75,124 0 0
Waimate Branch	80,672 0 0	..	*Cr.* 231 7 9	..	*Cr.* 231 7 9	230 1 6	..	..	80,670 13 9	..
Canterbury Interior Main Line—										
Oxford to Malvern	54,248 0 0	..	..	..	..	..	..	..	54,248 0 0	..
Whitecliffs to Rakaia	542 0 0	..	..	..	..	..	..	..	542 0 0	..
Temuka to Rangitata	5,152 0 0	..	..	..	..	..	..	..	5,152 0 0	..
Waitaki to Bluff—										
Main Line, including Port Chalmers Branch	3,348,645 0 0	..	..	..	..	4,633 2 4	1,426 4 7	..	3,354,704 6 11	82,259 0 0
Duntroon Branch (Pukeuri to Kurow) ..	97,465 0 0	..	..	..	..	..	..	..	97,465 0 0	37,500 0 0
Ngapara Branch (Waiareka Junction to Ngapara)	26,090 0 0	..	..	..	..	..	..	..	26,090 0 0	58,009 0 0

* Railways Improvement Authorization Act 1914 Account.

TABLE No. 3—*continued.*

EXPENDITURE ON RAILWAYS TO 31ST MARCH, 1924—*continued.*

Lines of Railway.	Total Expenditure by General Government to 31st March, 1923.	Recoveries on Account of Expenditure of Previous Years.	Expenditure out of Public Works Fund during Year 1923-24.				Expenditure under Special Acts during Year 1923-24.*	Amounts previously charged to "Surveys of New Lines" now charged to Individual Lines.	Total Expenditure by General Government to 31st March, 1924.	Valuation of Works constructed by Provinces and Midland Railway Company.
			New Works.			Works on Open Lines.				
			Construction and Surveys.	Permanent-way.	Total New Works.					
Waitaki to Bluff—*continued.*	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Livingstone Branch (Windsor to Tokarahi)	82,785 0 0	..	..	..	..	..	..	..	82,785 0 0	..
Waihemo Branch (Palmerston to Dunback)	33,191 0 0	..	..	..	..	..	..	..	33,191 0 0	..
Fernhill Railway	1,415 0 0	..	..	..	..	..	..	..	1,415 0 0	..
Brighton Road Branch	6,474 0 0	..	..	..	..	..	..	..	6,474 0 0	12,829 0 0
Outram Branch (Mosgiel to Outram) ..	11,951 0 0	..	..	..	..	..	..	..	11,951 0 0	29,691 0 0
Lawrence Branch	398,777 0 0	..	59,900 8 10	19,422 2 5	79,322 11 3	..	..	..	478,099 11 3	..
Balclutha to Tuapeka Mouth	2,489 0 0	..	..	..	..	..	..	..	2,489 0 0	..
Catlin's River Branch (Balclutha to Tahakopa)	462,722 0 0	..	..	..	..	..	..	..	462,722 0 0	..
Heriotburn Branch (Waipahi to Edievale)	124,088 0 0	..	..	..	..	720 4 5	..	..	124,808 4 5	..
Waikaka Branch (McNab to Waikaka) ..	68,423 0 0	..	..	..	..	..	..	..	68,423 0 0	..
Gore to Lumsden	112,143 0 0	..	..	..	..	..	..	..	112,143 0 0	..
Edendale to Glenham	53,328 0 0	..	..	..	..	..	..	..	53,328 0 0	..
Riversdale to Switzers	82,304 0 0	..	..	..	..	..	..	..	82,304 0 0	..
Seaward Bush to Catlin's (Appleby to Tokanui)	185,360 0 0	..	..	..	..	..	..	..	185,360 0 0	..
Otago Central (Wingatui to Cromwell) ..	1,435,496 0 0	..	..	..	..	422 12 6	..	..	1,435,918 12 6	..
Invercargill to Kingston—										
Main Line	360,966 0 0	50 0 0	..	..	..	880 7 3	..	..	361,796 7 3	91,937 0 0
Mararoa Branch (Lumsden to Mossburn)	27,217 0 0	..	..	..	..	145 12 4	..	..	27,362 12 4	..
Winton to Heddon Bush	140 0 0	..	..	..	..	..	..	..	140 0 0	..
Makarewa to Orepuki and Waiau	282,101 0 0	..	21,113 7 6	17,643 0 0	38,756 7 6	577 13 9	..	..	321,435 1 3	37,097 0 0
Thornbury to Wairio	86,275 0 0	..	..	..	..	..	..	..	86,275 0 0	23,200 0 0
Forest Hill (Winton to Hedgehope) ..	23,337 0 0	..	..	..	..	..	..	..	23,337 0 0	..
Expenses of Railway Commissions and other Expenditure not chargeable to Individual Lines	10,337 0 0	..	..	..	..	..	..	..	10,337 0 0	..
Surveys of New Lines—										
North Island	41,172 0 0	..	1,431 8 11	..	1,431 8 11	..	..	*Cr.* 7,500 0 0	35,103 8 11	..
Middle Island	5,763 0 0	..	..	..	..	..	..	..	5,763 0 0	..
Rolling-stock	9,075,047 8 8	..	..	..	..	298,207 19 6	*Cr.* 3,209 10 9	..	9,370,045 17 5	..
Suspense Account, being proportion of cost of raising loan of £1,000,000 at 6 per cent. for Railways Authorization Improvement Act 1914 Account	..	..	..	..	..	..	61,725 17 8	..	61,725 17 8	..
Stock of Permanent-way Materials, 31st March, 1923 .. .. £224,122 0 0	224,122 0 0	..	..	..	..	..	..	..	..	..
	44,625,118 17 8									
Stock of Permanent-way decreased by .. £23,541 17 10	23,541 17 10	..	..	..	..	..	..	..	..	..
Stock of Permanent-way Materials, 31st March, 1924 .. .. £200,580 2 2		..	..	..	..	..	..	..	200,580 2 2	..
Total	44,601,576 19 10	1,166 12 7	1,058,684 5 11	97,622 7 7	1,156,306 13 6	643,648 4 3	82,246 1 0	..	46,482,611 6 0	1,787,741† 0 0

* Railways Improvement Authorization Act 1914 Account. † Includes value for £150,000 paid to debenture-holders under the Midland Railway Petitions Settlement Act Amendment Act, 1903.

TABLE No. 4.

EXPENDITURE OUT OF SEPARATE ACCOUNTS ON WORKS UNDER THE CONTROL OF THE PUBLIC WORKS DEPARTMENT.

Year.	Loans to Local Bodies Account. Roads to open up Crown Lands.	Opening up Crown Lands for Settlement Account. Roads to open up Crown Lands.	Land for Settlements Account. Opening up Crown Lands for Settlement Account. Roads to open up Crown Lands.	National Endowment Account. Roads to open up National-endowment Lands.	Land for Settlements Account. Roads to open up Land for Settlements.	Waihou and Ohinemuri Rivers Improvement Account. Waihou and Ohinemuri Rivers Improvement.
	£	£	£	£	£	£
1890-91	25,000					
1891-92	64,000					
1892-93	800					
	89,800*					
1891-92	8,000†					
1892-93	29,833†					
1893-94	30,000†					
1894-95	6,114†					
1894-95	42,971‡					
1895-96	30,057‡					
1896-97	31,017					
1897-98	18,770					
1898-99	16,972					
1899-1900	31,363					
1900-1	37,390					
1901-2	31,979					
1902-3	18,578					
1903-4	25,753					
1904-5	28,895					
1905-6	38,801					
1906-7	47,371					
1907-8	38,524					
1908-9	54,713					
1909-10	40,507	..	..	4,975	..	..
	607,608§					
1910-11	..	45,691	..	5,619	..	..
1911-12	..	49,739	..	6,554	..	3,769
1912-13	..	47,951	..	2,689	..	9,555
1913-14	..	63,245	..	4,282	..	9,633
1914-15	..	..	92,975	9,151	..	10,004
1915-16	..	..	47,974	13,344	..	9,225
1916-17	..	..	24,730	6,787	..	10,407
1917-18	..	..	..	..	43,996	12,025
1918-19	..	..	..	..	51,355	27,402
1919-20	..	..	..	..	61,692	34,806
1920-21	..	..	..	..	28,920	62,249
1921-22	..	..	..	..	51,471	54,379
1922-23	..	..	..	..	78,350	66,708
1923-24	..	..	..	..	49,186	70,533
	697,408	206,626	165,679	53,401	364,970	380,695

* Payment to the Public Works Fund under section 31 of the Government Loans to Local Bodies Act, 1886, in reduction of expenditure under Class "Roads."
† Paid into the Public Works Fund, reducing the expenditure under Class "Roads."
‡ Paid into the Lands Improvement Account (now included in Public Works Fund under Class "Roads"), reducing the expenditure on roads.
§ Expenditure under the Government Loans to Local Bodies Act Amendment Act, 1891.

TABLE No. 5.

EXPENDITURE ON PUBLIC BUILDINGS OUT OF PUBLIC WORKS FUND TO THE 31ST MARCH, 1924, AND THE LIABILITIES ON THAT DATE.

—	Total Expenditure to 31st March, 1923.	Expenditure for Year ended 31st March, 1924.	Total Expenditure to 31st March, 1924.	Liabilities on Authorities, Contracts, &c., 31st March, 1924.	Total Expenditure and Liabilities.
	£	£	£	£	£
Judicial*	1,193,219	39,202	1,232,421	3,225	1,235,646
Postal and telegraph	1,651,794	108 395	1,760,189	5,673	1,765,862
Customs	49,441	..	49,441	..	49,441
Offices for public Departments	589,291	4,607	593,898	..	593,898
Mental hospitals	974,583	26,541	1,001,124	3,023	1,004,147
Alexandra Depot, Wellington†	8,084	..	8,084	..	8,084
School buildings	3,100,392	*Cr.* 1,090	3,099,302	..	3,099,302
Hospitals‡	245,886	7,591	253,477	2,088	255,565
Quarantine-stations	62,464	..	62,464	..	62,464
Parliament Buildings (old buildings) ..	76,553	..	76,553	..	76,553
Parliament Buildings (new buildings) ..	388,976	3,366	392,342	..	392,342
Parliament Buildings (alterations to streets, surrounding grounds, and purchase of land)	14,187	..	14,187	..	14,187
Government House, Wellington (land and new building)	72,645	..	72,645	..	72,645
Agricultural	82,371	111	82,482	78	82,560
Workers' dwellings	319,916	..	319,916	..	319,916
Miscellaneous	61,619	187	61,806	4,665	66,471
Totals	8,891,421	188,910	9,080,331	18,752	9,099,083

* Includes Courthouses, prisons, and police-stations. † Expenditure *re* Defence requirements only. Other expenditure included in "Judicial" class. ‡ Includes £32,754 previously shown under "Public Health."

TABLE No. 6.

DEVELOPMENT OF WATER-POWER.

STATEMENT OF ACCOUNTS AT THE 31st MARCH, 1924.

GENERAL BALANCE-SHEET AT 31ST MARCH, 1924, COMPARED WITH POSITION AT 31ST MARCH, 1923.

1922-23.	*Liabilities.*	1923-24.		1922-23.	*Assets.*	1923-24.	
£ s. d.		£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.
	Aid to Water-power Works and Electric Supply Accounts—			906,921 12 2	Lake Coleridge scheme—		
	Debentures issued—				Assets as per separate balance-sheet ..	954,529 8 10	
350,000 0 0	At 4 per cent. interest .. .	125,000 0 0		23,875 16 11	Profit and Loss Account—Accumulated loss to date	23,172 9 7	
119,000 0 0	At 4½ per cent. interest	344,000 0 0					977,701 18 5
4,000 0 0	At 5½ per cent. interest	4,000 0 0		930,797 9 1			
56,150 0 0	At 5 per cent. interest	55,750 0 0			Lake Waikaremoana scheme—		
	N.Z. inscribed stock—			76,650 17 8	Assets as per separate balance-sheet ..	77,147 19 0	
1,331,360 0 0	At 5 per cent. interest (due 1930) ..	800,360 0 0		390 5 0	Profit and Loss Account—Loss to date ..	3,864 4 0	
	N.Z. Consolidated Stock—						81,012 3 0
10,469 13 9	At 5 per cent. (due 1935–45) ..	510,991 13 4		77,041 2 8			
1,076,938 9 3	At 6 per cent. interest (due 1936–51) ..	1,076,938 9 3			Waikato River schemes—		
807,703 17 0	At 6 per cent. interest (due 1936–51) ..	807,703 17 0			Horahora—		
			3,724,743 19 7	436,755 0 4	Assets as per separate balance-sheet ..	512,201 19 0	
3,755,622 0 0							
				..	Arapuni—	£ s. d.	
				..	Land and fencing ..	176 0 0	
	Waihi Gold-mining Company (Limited)—				Roads and bridges ..	10,598 13 3	
	Purchase of Horahora works—Deed of				Electric lines and		
212,500 0 0	security at 5 per cent. interest ..	..	212,500 0 0	..	telephone service ..	822 18 4	
3,968,122 0 0				56 11 9	Houses	4,715 15 8	
				4,267 0 6	50,000-volt lines—		
				..	Horahora–Arapuni	4,832 13 1	
					Arapuni–Ngongotaha	155 9 5	
					110,000-volt lines—		
	Consolidated Fund—			625 5 3	Ruakura–Penrose	10,743 1 3	
	Interest accrued on loans to 31st March,			148 6 0	Arapuni–TeKuiti ..	148 6 0	
41,363 12 5	1923	..	42,036 14 11		110,000-volt sub-station—		
70 15 11	Sundry creditors for interest unclaimed ..	..	..		Penrose	515 7 2	
				500 0 0	Headworks and surveys	9,421 1 0	
					Engineering, office and general expenses on preliminary surveys and investigations at Arapuni and during		
	Amount set aside as reserve to cover difference between interest payable on loans raised and interest earned from their			17,565 18 10	construction ..	16,333 8 9	
36,433 1 1	temporary investment pending use ..	..	29,452 4 11		Motor-vehicles ..	198 16 11	
					Loose tools, plant, and equipment ..	2,814 19 4	
				..	Stocks of material on hand	62,510 16 6	
				49,158 1 8	Interest during construction ..	12,548 13 9	
	Lake Coleridge scheme—						
61,275 8 7	Depreciation reserve	72,593 19 8		6,508 2 9		136,536 0 5	
2,741 7 11	Sundry creditors	5,392 12 1					
			77,986 11 9	78,829 6 9	Sundry debtors ..	707 10 10	
64,016 16 6				9 14 2			
				78,839 0 11		137,243 11 3	
							649,445 10 3
4,110,006 5 11	Carried forward	..	4,086,719 11 2	1,523,432 13 0	Carried forward	..	1,708,159 11 8

TABLE No. 6—*continued.*

General Balance-sheet at 31st March, 1924, compared with Position at 31st March, 1923—*continued.*

1922–23.	*Liabilities.*	1923–24.		1922–23.	*Assets.*	1923–24.	
£ s. d.		£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.
4,110,006 5 11	Brought forward	..	4,086,719 11 2	1,523,432 13 0	Brought forward		1,708,159 11 8
	Horahora scheme—				Mangahao River scheme—		
16,605 7 10	Depreciation reserve	24,831 14 8		12,221 11 0	Land and easements	12,686 18 8	
..	Sinking fund	12,718 0 0		144,856 10 4	Headworks, dams, tunnels, &c. ..	298,451 3 7	
1,028 15 5	Sundry creditors	8,673 10 9		41,375 6 8	Roads, trams, &c.	41,123 7 8	
386 8 0	Net profit to date	3,493 19 3		36,410 10 1	Pipe-lines, &c.	82,588 0 9	
			49,717 4 8	53,714 17 11	Buildings	90,127 13 6	
18,020 11 3				..	Substations	36,547 17 8	
				13,968 0 1	Power plant and machinery	119,923 7 8	
				91,446 15 2	Construction plant, tools, &c.	99,196 3 11	
	Arapuni scheme—			23,212 4 11	Transmission-lines	201,855 1 6	
209 16 6	Sundry creditors	..	2,968 9 7	30,088 9 2	Workers' accommodation	32,278 7 4	
				33,535 9 3	Surveys, engineering, &c.	59,909 8 4	
				108,231 11 11	Construction material on hand ..	140,859 13 0	
	Mangahao scheme—			..	Canteen stocks on hand	3,427 19 1	
12,039 8 10	Sundry creditors	..	21,231 6 9	43,000 19 3	Interest during construction	95,397 11 3	
				632,062 5 9		1,314,372 13 11	
	Waikaremoana scheme—			901 12 8	Sundry debtors	2,736 19 3	
..	Depreciation reserve	1,408 11 0					1,317,109 13 2
4,146 6 11	Sundry creditors	20 5 3		632,963 18 5	Other schemes, surveys, &c.—		
			1,428 16 3		North Island—		
				376 13 11	Aratiatia (Waikato River)	376 13 11	
				433 9 6	Huka Falls (Waikato River) ..	443 9 6	
				2,750 17 3	Hutt River (including dam site) ..	2,746 17 3	
				38 9 0	Makuri River	38 9 0	
				1,355 4 4	Rotoiti-Kaituna	1,355 4 4	
				879 16 8	Tauherenikau River	879 16 8	
				236 6 8	Wairua River	236 6 8	
							6,076 17 4
				6,070 17 4			
					South Island—		
				803 1 9	Clarence River	803 1 9	
				5 0 0	Lake Kanieri	5 0 0	
				749 8 2	Nelson–Marlborough	749 8 2	
				96 1 0	Timaru–Oamaru	96 1 0	
				519 12 7	Opihi River	519 12 7	
				17 7 0	Toaroha River	17 7 0	
				543 0 5	Teviot River	543 0 5	
				11 19 0	Upper Taieri River	11 19 0	
				475 5 8	Lake Hawea	475 5 8	
							3,220 15 7
				3,220 15 7			
4,144,422 9 5	Carried forward	..	4,162,065 8 5	2,165,688 4 4	Carried forward	..	3,034,566 17 9

TABLE No. 6—*continued.*

GENERAL BALANCE-SHEET AT 31ST MARCH, 1924, COMPARED WITH POSITION AT 31ST MARCH, 1923—*continued.*

1922–23.	*Liabilities.*	1923–24.	1922–23.	*Assets.*	1923–24.
£ s. d.		£ s. d.	£ s. d.		£ s. d. £ s. d.
4,144,422 9 5	Brought forward	4,162,065 8 5	2,165,688 4 4	Brought forward	.. 3,034,566 17 9
			4,413 10 11	General expenditure not chargeable to any individual scheme	.. 4,427 16 10
				Balance in Electric Supply Account at the end of the year—	
			98,702 4 1	Cash in Public Account	23,413 2 11
			732 18 9	In hands of Government officers in New Zealand	..
			49,725 3 7	In hands of Government officers in London	29,752 10 10
			149,160 6 5		53,165 13 9
			1,803,758 6 10	Investment Account (funds invested until actually required for use)	.. 1,053,008 6 3
				Stamp Duty Deposit Account	.. 233 19 3
			4,123,020 8 6		4,145,402 13 10
			21,402 0 11	Interest accrued on investments to 31st March, 1924	16,653 14 7
			..	Sundry debtors for interest due but unpaid	9 0 0
					16,662 14 7
4,144,422 9 5	Total	£4,162,065 8 5	4,144,422 9 5	Total	.. £4,162,065 8 5

J. J. GIBSON,
Accountant, Public Works Department.

I hereby certify that the balance-sheet has been duly examined and compared with the relative books and documents submitted for audit, and correctly states the position as disclosed thereby.

G. F. C. CAMPBELL,
Controller and Auditor-General.

TABLE No. 6—*continued.*

WAIKAREMOANA ELECTRIC-POWER SUPPLY.

Profit and Loss Account for Year ended 31st March, 1924.

1922–23.		1923–24.	1922–23.		1923–24.
£ s. d.		£ s. d.	£ s. d.		£ s. d.
915 5 0	To Interest on capital	4,165 8 0	525 0 0	By Rental of plant leased to Wairoa Power Board	2,100 0 0
..	Depreciation on plant (2 per cent. on value of assets in operation)	1,408 11 0	..	Loss for year	3,473 19 0
915 5 0		5,573 19 0	525 0 0		5,573 19 0
..	Loss for year, as above	3,473 19 0	..		
..	Loss carried forward at 1st April, 1923	390 5 0		Accumulated loss to date carried to balance-sheet	3,864 4 0
..		£3,864 4 0	..		£3,864 4 0

Depreciation Reserve.

	£ s. d.		£ s. d.
Balance carried to balance-sheet	1,408 11 0	By Amount set aside as per Profit and Loss Account	1,408 11 0
	£1,408 11 0		£1,408 11 0

Balance-sheet at 31st March, 1924.

1922–23.	*Liabilities.*	1923–24.	1922–23.	*Assets.*	1923–24.
£ s. d.		£ s. d.	£ s. d.		£ s. d.
72,894 15 9	Balance carried to general balance-sheet	79,583 6 9	11,920 11 4	Access roads and bridges	11,431 10 10
4,146 6 11	Sundry creditors	20 5 3	18,550 17 3	Pipe-lines	18,474 8 0
..	Depreciation reserve	1,408 11 0	27,564 5 10	Power-house building and machinery	25,443 0 0
			6,334 10 7	Compensation for land	6,625 1 11
			227 0 6	Headworks	278 17 3
			1,714 16 10	Staff cottages	2,950 15 9
			..	Workmen's huts	1,260 1 5
			..	Workshop	407 18 5
			335 10 0	Loose plant	..
			1,000 0 0	Telephone-line to Wairoa	1,000 0 0
			2,780 10 11	Survey, engineering, and office expenses	3,053 11 0
			5,697 14 5	Interest during construction	5,697 14 5
			76,125 17 8		76,622 19 0
			525 0 0	Sundry debtors	525 0 0
			390 5 0	Balance from Profit and Loss Account: Accumulated loss to date	3,864 4 0
£77,041 2 8		£81,012 3 0	£77,041 2 8		£81,012 3 0

TABLE No. 6—*continued.*

WAIKATO ELECTRIC-POWER SUPPLY.—HORAHORA SCHEME.

PROFIT AND LOSS ACCOUNT FOR YEAR ENDED 31ST MARCH, 1924, COMPARED WITH YEAR ENDED 31ST MARCH, 1923.

Gross Revenue Account.

1922–23.	——	1923–24.		1922–23.	——	1923–24.	
£ s. d.	To Generating expenses, headworks, and power-house—	£ s. d.	£ s. d.	£ s. d.	By Sales of electrical energy to wholesale consumers	£ s. d.	£ s. d.
2,478 3 3	Salaries	2,711 19 2		40,467 15 8		58,630 16 5	
127 7 4	Wages	102 0 7		86 5 0	Less discounts and rebates	86 11 11	
324 19 11	Supplies	132 10 10		40,381 10 8			58,544 4 6
141 19 3	Transport	72 18 1					
	Maintenance and repairs—						
305 12 10	Headworks and buildings	810 19 8		37 14 6	Hire of plant	5 10 0	
375 0 2	Power-house machinery	671 10 6		461 4 1	Rent of lines	579 17 0	
106 5 8	Staff village	143 19 3		506 17 5	Miscellaneous rents	607 2 2	
..	Erection of temporary weir	937 6 7		14 16 9	Discounts forfeited	..	
			5,583 4 8				1,192 9 2
3,859 8 5	Main transmission-lines (50,000-volt)—			1,020 12 9			
	Horahora to Waikino—						
628 16 0	Wages	531 1 5			Testing, oil-drying, and repairs for consumers	..	165 1 8
331 18 2	Repairs and supplies	1,013 4 11		368 3 2	Fees for inspection of lines and testing of instruments, &c.	..	22 1 0
137 15 10	Transport	181 9 9		48 6 0			
			1,725 16 1				
1,098 10 0							
	Horahora to Hamilton—						
123 18 9	Wages	133 5 7					
120 8 9	Repairs and supplies	25 11 3					
46 2 7	Transport	58 6 0					
			217 2 10				
290 10 1							
	Mystery Creek to Te Awamutu—						
60 18 2	Wages	86 9 10					
8 3 5	Repairs and supplies	15 10 9					
21 9 0	Transport	19 7 3					
			121 7 10				
90 10 7							
	Wairongomai to Waihou—						
..	Wages	18 16 9					
..	Repairs and supplies	8 17 2					
			27 13 11				
	Main substations (50,000-volt)—						
	Waikino—						
503 13 3	Operating wages (half)	590 3 10					
132 6 1	Repairs to buildings, machinery, &c.	92 10 11					
			682 14 9				
635 19 4							
	Hamilton—						
151 11 9	Operating wages	178 19 5					
33 3 1	Repairs and supplies to buildings, machinery, &c.	27 4 6					
89 16 4	Maintenance yards, workshops, &c.	35 1 7					
45 1 0	Repairs, tools, and instruments	19 13 2					
			260 18 8				
319 12 2							
6,294 10 7	Carried forward	..	8,618 18 9	41,818 12 7	Carried forward	..	59,923 16 4

TABLE No. 6—*continued.*

WAIKATO ELECTRIC-POWER SUPPLY.—HORAHORA SCHEME—*continued.*

PROFIT AND LOSS ACCOUNT FOR YEAR ENDED 31ST MARCH, 1924, COMPARED WITH YEAR ENDED 31ST MARCH, 1923—*continued.*

Gross Revenue Account—continued.

1922–23.	——	1923–24.		1922–23.	——	1923–24.
£ s. d.		£ s. d.	£ s. d.	£ s. d.		£ s. d.
6,294 10 7	Brought forward	..	8,618 18 9	41,818 12 7	Brought forward	59,923 16 4
	Main substations (50,000 volt)—*contd.*—					
	Te Awamutu—					
58 9 3	Operating wages	258 17 6				
	Repairs and supplies to building					
1 13 11	and machinery	15 5 5				
			274 2 11			
	Waihou—					
..	Operating wages	148 18 0				
	Repairs and supplies to buildings					
..	and machinery	35 19 4				
			184 17 4			
60 3 2						
	Distribution substations (11,000 volt)—					
33 13 11	Wages, repairs, and supplies ..	..	37 18 11			
	Distribution lines, (11,000 volt)—					
	Horahora–Hamilton–Frankton—					
109 16 1	Wages	132 16 10				
61 9 0	Repairs and supplies	31 1 8				
34 18 11	Transport	60 12 3				
5 11 10	Waikino–Waihi	2 0 0				
			226 10 9			
211 15 10						
	Transmission and distribution general in Horahora–Hamilton area—					
..	Salaries	687 10 6				
..	Expenses	2 0 0				
	Transport	115 6 10				
			804 17 4			
	Management and general—					
1,497 19 6	Salaries, wages, and audit fees ..	960 2 1				
	Accident insurance, sick and holiday					
339 8 6	pay	220 15 8				
430 1 8	Travelling-expenses and motor-cars ..	305 12 9				
103 12 1	Postages, telegrams, and telephones ..	149 1 0				
26 5 6	Fire insurance	28 7 6				
1 11 6	Legal expenses	10 10 0				
74 5 7	Printing, stationery, and advertising..	112 3 10				
179 9 0	Office rent, cleaning, and lighting ..	233 14 0				
56 7 11	Experimental testing	53 16 11				
15 5 5	Miscellaneous expenses	23 14 5				
..	Fire damage, Hamilton office ..	29 10 3				
			2,127 8 5			
2,724 6 2						
9,324 9 8	Carried forward		12,274 14 5	41,818 12 7		59,923 16 4

TABLE No. 6—*continued.*

WAIKATO ELECTRIC-POWER SUPPLY.—HORAHORA SCHEME—*continued.*

PROFIT AND LOSS ACCOUNT FOR YEAR ENDED 31ST MARCH, 1924, COMPARED WITH YEAR ENDED 31ST MARCH, 1923—*continued.*

Gross Revenue Account—continued.

1922–23.		1923–24.	1922–23.		1923–24.
£ s. d.	——	£ s. d.	£ s. d.	——	£ s. d.
9,324 9 8	Brought forward	12,274 14 5	41,818 12 7	Brought forward	59,923 16 4
	Management and general—*continued.*				
90 4 2	Purchase of current	88 6 8			
306 13 11	Testing, oil-drying, repairs, &c., for consumers	111 0 5			
9,721 7 9		12,474 1 6			
32,097 4 10		47,449 14 10			
£41,818 12 7	Balance to Net Revenue Account	£59,923 16 4	£41,818 12 7		£59,923 16 4

Net Revenue Account.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
19,208 7 8	To Interest on purchase-money for plant purchased from Waihi Gold-mining Company, and on advances from Treasury ..	21,230 14 7	32,097 4 10	By Balance from Gross Revenue Account	47,449 14 10
6,236 9 3	Depreciation on completed works (2 per cent.) and on stocks	10,393 9 0			
383 4 2	Special depreciation provision to cover cost of replacing temporary work				
6,269 3 9	Balance to Profit and Loss Appropriation Account ..	15,825 11 3			
£32,097 4 10		£47,449 14 10	£32,097 4 10		47,449 14 10

PROFIT AND LOSS APPROPRIATION ACCOUNT.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
5,882 15 9	To Balance from previous year	..	6,269 3 9	By Balance from previous year	386 8 0
..	Sinking Fund contributions to date, as required by section 12 of the State Supply of Electrical Energy Act, 1917 ..	12,718 0 0		Balance from Net Revenue Account	15,825 11 3
386 8 0	Balance to balance-sheet	3,493 19 3			
£6,269 3 9		£16,211 19 3	£6,269 3 9		£16,211 19 3

DEPRECIATION RESERVE ACCOUNT.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
633 4 2	To Amount written off for temporary works	..	10,210 10 7	By Balance at close of previous year	16,605 7 10
..	Amount written off for depreciation of stocks	2,831 6 2	408 8 0	Interest for year	664 4 0
16,605 7 10	Balance to balance-sheet	24,831 14 8	6,619 13 5	Amount set aside as per Net Revenue Account	10,393 9 0
£17,238 12 0		27,663 0 10	£17,238 12 0		£27,663 0 10

TABLE No. 6—*continued.*

WAIKATO ELECTRIC-POWER SUPPLY.—HORAHORA SCHEME—*continued.*

Sinking Fund Account.

1923–24.	——	1923–24.	1922–23.	——	1923–24.
£ s. d.		£ s. d.	£ s. d.		£ s. d.
..	To Balance to balance-sheet	12,718 0 0	..	By Amount set aside as per Profit and Loss Appropriation Account	12,718 0 0
		£12,718 0 0			£12,718 0 0

Balance-sheet at March 31st, 1924.

1922–23.	*Liabilities.*	1923–24.		1922–23.	*Assets.*	1923–24.	
£ s. d.	Electric-supply Account—	£ s. d.	£ s. d.	£ s. d.	Works, &c., at Horahora—	£ s. d.	£ s. d.
418,734 9 1	Balance carried to general balance-sheet	..	462,484 14 4	2,168 5 9	Roads and bridges	2,168 5 9	
1,028 15 5	Sundry creditors	..	8,673 10 9	956 14 9	Land and fencing	1,039 15 3	
16,605 7 10	Depreciation reserve	..	24,831 14 8	10,320 3 7	Accommodation for staff and workmen ..	11,053 17 2	
..	Sinking Fund	..	12,718 0 0	88,666 5 1	Headworks	134,797 0 1	
				41,414 9 0	Generating-station	64,483 10 3	
	Balance from Profit and Loss Appropriation Account—			30,894 13 7	Transformer building and machinery ..	32,244 6 6	
				81 6 5	Tools and equipment	905 15 3	
386 8 0	Net profit	..	3,493 19 3	174,501 18 2			246,692 10 3
					Transmission-lines (50,000 volts)—		
				44,573 13 9	Horahora–Waihi	38,460 1 3	
				22,122 5 0	Horahora–Hamilton	22,190 10 10	
				7,485 0 0	Mystery Creek – Te Awamutu	7,556 9 9	
				4,524 7 4	Waiorongomai–Waihou	4,561 6 6	
				138 19 2	Waihou–Hamilton	138 19 2	
				857 13 6	Linesmen's cottages	1,003 17 6	
				79,701 18 9			73,911 5 0
436,755 0 4	Carried forward	..	512,201 19 0	254,203 16 11	Carried forward	..	320,603 15 3

TABLE No. 6—*continued.*

WAIKATO ELECTRIC-POWER SUPPLY.—HORAHORA SCHEME—*continued.*

BALANCE-SHEET AT 31ST MARCH, 1924—*continued.*

1922–23.	*Liabilities.*	1923–24.	1922–23.	*Assets.*	1923–24.
£ s. d.		£ s. d.	£ s. d.		£ s. d.
436,755 0 4	Brought forward	512,201 19 0	254,203 16 11	Brought forward	.. 320,603 15 3
				Main substations (50,000-volt)—	
			20,352 15 2	Waikino	20,612 13 8
			7,754 2 7	Hamilton	7,826 2 5
			5,455 14 4	Te Awamutu	5,453 16 2
			6,626 10 10	Waihou	7,230 16 3
			40,189 2 11		41,123 8 6
				Distribution-lines (11,000-volt)—	
			32,556 3 8	Horahora–Frankton	33,333 19 7
			704 11 11	Waihi Grand Junction Company line ..	704 11 11
			..	Waikino–Waihi	6,000 0 0
			33,260 15 7		40,038 11 6
			7,394 11 2	Distribution substations (11,000-volt) ..	.. 7,413 16 8
			3,975 11 9	Land at Ruakura	3,975 11 9
				Stores buildings and fittings and railway-siding,	
			7,365 7 2	Ruakura	7,365 7 2
			3,521 5 1	Staff residences, Ruakura	3,521 5 1
			3,540 19 9	Loose tools and equipment	3,723 15 0
			4,317 17 6	Motor lorries, cars, and cycles	4,694 5 0
			440 6 1	Office furniture, Hamilton	494 2 5
				Engineering, office, and general expenses on	
			6,656 4 1	surveys and on construction	6,898 2 4
				Salaries of officers on surveys and on con-	
			8,947 18 6	struction	10,740 11 9
			21,207 15 4	Interest during construction	24,224 9 2
			67,367 16 5		65,637 9 8
			395,021 11 10		474,817 1 7
			31,620 4 7	General stocks of material on hand	.. 24,571 14 11
				Debtors—	
			10,039 8 1	For electricity and sales of material ..	12,596 4 7
			73 15 10	For payments in advance	216 17 11
			10,113 3 11		12,813 2 6
			436,755 0 4		
£436,755 0 4		£512,201 19 0	£436,755 0 4		.. £512,201 19 0

The balance-sheet has been duly compared with the various supporting books, vouchers, and documents, and found to correspond therewith.

G. F. C. CAMPBELL,
Controller and Auditor-General.

TABLE No. 6—*continued.*

LAKE COLERIDGE HYDRO-ELECTRIC-POWER SUPPLY.

Profit and Loss Account for Year ended 31st March, 1924, compared with Year ended 31st March, 1923.

Gross Revenue Account.

1922–23.		1923–24.		1922–23.		1923–24.	
£ s. d.	To Generating expenses, headworks, and power-house—	£ s. d.	£ s. d.	£ s. d.	By Sale of energy—	£ s. d.	£ s. d.
2,437 18 5	Salaries	2,601 6 6		64,893 19 8	Wholesale	74,524 11 11	
851 16 0	Wages	884 1 7		2,100 11 1	Retail	2,271 0 10	
142 10 3	Supplies	74 2 8		66,994 10 9			76,795 12 9
614 8 3	Transport of stores, &c.	350 14 8					
	Maintenance and repairs—						
568 6 1	Maintenance, Harper diversion	682 17 1		16 19 7	Discounts forfeited		18 11 7
159 10 9	Headworks	244 3 2					
69 12 6	Power-house building	124 14 3					
831 2 7	Power-house machinery	894 0 0			Rents—		
454 16 4	Roads and fences	164 2 5		777 0 10	Land and buildings	750 18 6	
234 5 2	Staff residences, &c.	437 9 6		281 2 1	Electric lines	245 3 8	
			6,457 11 10	41 16 11	„ plant	102 17 0	
6,364 6 4				1,099 19 10			1,098 19 2
	Transmission-lines—						
484 19 9	Salaries	468 4 6					
357 12 1	Transport, including upkeep of horses, traps, cars, and cycles	284 6 1					
400 12 7	Repairs to power-lines	770 13 8			Fees for testing and repairing electrical appliances		393 19 4
			1,523 4 3	726 15 11			
1,243 4 5							
	Substation, Addington—						
1,127 18 2	Salaries	1,121 17 9		80 0 0	Stand-by provision: Fees from wholesale consumers		80 0 0
519 17 9	Wages	523 17 11					
106 0 0	Supplies	74 17 7		9 6 7	Interest from local bodies in respect of reticulations sold on deferred payment		7 9 4
	Maintenance and repairs—						
335 15 8	Buildings and yards	249 6 7		224 17 6	Earnings motor-vehicles		113 12 10
74 9 3	Machinery	135 19 4					
			2,105 19 2				
2,164 0 10							
	Distribution—						
211 2 3	Salaries	208 3 3					
147 19 1	Transport, including upkeep of motor lorry and car	154 6 6					
	Maintenance of feeder cables, transformer stations, and tools						
1,807 1 5		2,437 9 1					
1,252 7 6	Maintenance of secondary distribution	1,612 3 0					
205 9 9	Maintenance of and testing meters	367 6 10					
138 5 6	Earth-testing	98 12 7					
			4,878 1 3				
3,762 5 6							
13,533 17 1	Carried forward		14,964 16 6	69,152 10 2	Carried forward		78,508 5 0

TABLE No. 6—*continued.*

LAKE COLERIDGE HYDRO-ELECTRIC-POWER SUPPLY—*continued.*

PROFIT AND LOSS ACCOUNT FOR YEAR ENDED 31ST MARCH, 1924, COMPARED WITH YEAR ENDED 31ST MARCH, 1923—*continued.*

Gross Revenue Account—continued.

1922–23.	——	1923–24.		1922–23.	——	1923–24.	
£ s. d.		£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.
..	Brought forward	..	14,964 16 6	69,152 10 2	Brought forward	..	78,508 5 0
	To Stand-by provision—						
	Payment to Christchurch Tramway						
1,350 0 0	Board for rental	1,350 0 0					
	Payment to Christchurch Tramway						
17 5 0	Board, for energy supplied ..	70 18 10					
			1,420 18 10				
1,367 5 0							
	Management and general expenses—						
1,889 13 1	Salaries	1,846 11 8					
167 11 2	Sick and holiday pay to workmen ..	308 16 7					
171 3 7	Travelling-expenses	114 14 3					
200 0 0	Office-rent	379 0 0					
65 10 0	Rent of other buildings	65 10 0					
191 14 2	Postages and telegrams	159 1 0					
92 10 3	Telephone subscriptions	121 8 6					
144 1 2	Printing and stationery	137 8 1					
51 6 3	Advertising	32 14 0					
206 6 10	Accident pay	383 7 8					
89 12 2	Fire insurance	93 9 1					
66 0 0	Audit fees	112 0 0					
338 1 0	Meter-reading and line-inspection ..	248 9 8					
74 2 1	Commission on collection of accounts	101 13 11					
615 14 5	Electrical testing	283 18 0					
6 10 4	Miscellaneous trade expenses ..	3 10 5					
			4,391 12 10				
4,369 16 6							
			20,777 8 2				
19,270 18 7							
49,881 11 7	Balance to Net Revenue Account ..	..	57,730 16 10				
69,152 10 2			78,508 5 0	£69,152 10 2			£78,508 5 0

Net Revenue Account.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
9,307 0 0	To Depreciation at 2 per cent. per annum on completed work ..	12,584 0 0	49,881 11 7	By Balance from Gross Revenue Account	57,730 16 10
35,274 19 1	Interest for year ended 31st March	44,443 9 6			
5,299 12 6	Balance to Profit and Loss Appropriation Account ..	703 7 4			
£49,881 11 7		£57,730 16 10	£49,881 11 7		£57,730 16 10

TABLE No. 6—*continued.*

LAKE COLERIDGE HYDRO-ELECTRIC-POWER SUPPLY—*continued.*

Profit and Loss Appropriation Account.

1922–23.	——	1923–24.	1922–23.	——	1923–24.
£ s. d.		£ s. d.	£ s. d.		£ s. d.
29,175 9 5	To Balance from previous year's statement	23,875 16 11	5,299 12 6	By Balance from Net Revenue Account	703 7 4
			23,875 16 11	Balance to balance-sheet—Accumulated loss	23,172 9 7
£29,175 9 5		£23,875 16 11	£29,175 9 5		£23,875 16 11

Depreciation Reserve Account.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
	To amounts written off—		54,536 19 0	By Balance from previous year's statement	61,275 8 7
..	Motor vehicles and tools	2,409 8 11	2,181 9 7	Interest at 4 per cent. per annum	2,451 0 0
4,750 0 0	Transmission-line reconstruction	..	9,307 0 0	Amount set aside as per Net Revenue Account	12,584 0 0
..	Powerhouse turbines (renewals)	307 0 0			
..	Feeder mains (renewals)	1,000 0 0			
61,275 8 7	Balance to balance-sheet	72,593 19 8			
£66,025 8 7		£76,310 8 7	£66,025 8 7		£76,310 8 7

Note.—The State Supply of Electric Energy Act provides for the establishment of a sinking fund of 1 per cent. per annum when profits are available for the purpose, and for the payment of arrears of sinking-fund contributions out of any future profits. The arrears of sinking fund (at 4 per cent. interest) since commencement of operations in 1915 total **£47,756.**

TABLE No. 6—*continued.*

LAKE COLERIDGE HYDRO-ELECTRIC-POWER SUPPLY—*continued.*

BALANCE-SHEET AT 31ST MARCH, 1924.

1922–23.	*Liabilities.*	1923–24.		1922–23.	*Assets.*	1923–24.	
£ s. d.		£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.
61,275 8 7	Depreciation Reserve Account	..	72,593 19 8	4,229 16 4	Works at Lake Coleridge—		
				5,317 4 6	Land, including fencing and planting ..	4,343 8 7	
				7,566 3 8	Coalgate Gorge Road	5,317 4 6	
	Sundry creditors—			279 12 8	Service roads	7,566 3 8	
1,526 2 4	On open accounts	1,659 14 0			Service telephones	310 8 5	
906 9 11	On contracts	3,424 11 5		17,392 17 2			17,537 5 2
308 15 8	Payment for current in advance ..	308 6 8					
			5,392 12 1	79,868 7 1	Headworks—		
2,741 7 11					First tunnel, including inlet and outlet works	80,148 6 6	
	Balance carried to general balance-sheet—			..	Second tunnel	10,333 5 8	
930,797 9 1	Total assets as *per contra*	977,701 18 5		68,842 4 6	Pipe-lines	68,871 1 1	
64,016 16 6	*Less* total liabilities as above	77,986 11 9		1,996 16 2	Tram-line	1,996 16 2	
			899,715 6 8	3,357 0 5	Weir at lake-outlet, gauges, and fencing	3,469 15 5	
866,780 12 7				21,413 8 11	Harper River diversion works ..	21,431 18 11	
				175,477 17 1			186,251 3 9
					Power-house—		
				25,215 17 1	Buildings, &c.	25,446 16 2	
				100,149 5 9	Machinery, &c.	95,297 4 4	
				231 2 1	Office furniture, fittings, &c. ..	231 2 1	
				125,596 4 11			120,975 2 7
					Accommodation for staff and workmen—		
				14,560 5 5	Buildings, fencing, &c.	..	14,708 15 1
					Transmission-lines—		
				4,051 11 8	Land	4,599 8 2	
				176,964 2 1	Power-lines to Christchurch	177,552 5 11	
				55,299 3 1	Power-lines to South Canterbury ..	56,280 19 3	
				2,403 18 2	Telephone-system	2,408 19 8	
				3,165 5 5	Linemen's cottages, depots, tools, and equipment	3,244 17 3	
				6,588 12 4	Alterations to public telegraph-lines ..	6,588 12 4	
				4,017 7 10	Point Swithcing Station	9,018 7 3	
				251,790 0 7			259,693 9 10
					Addington Substation—		
				3,483 0 5	Land, including cottages	3,483 0 5	
				3,875 6 0	Substation buildings	3,935 17 1	
				28,190 10 2	Machinery, &c.	31,365 7 10	
				5,856 4 3	Store buildings and workshops ..	5,856 4 3	
				41,405 9 10			44,640 9 7
930,797 9 1	Carried forward	..	977,701 18 5	626,222 15 0	Carried forward	..	643,806 6 0

TABLE No. 6—*continued.*

LAKE COLERIDGE HYDRO-ELECTRIC-POWER SUPPLY—*continued.*

BALANCE-SHEET AT 31ST MARCH, 1924—*continued.*

1922–23.	*Liabilities.*	1923–24.		1922–23.	*Assets.*	1923–24.	
£ s. d.		£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.
930,797 9 1	Brought forward	..	977,701 18 5	626,222 15 0	Brought forward	..	643,806 6 0
					Primary distribution—		
				6,963 9 0	Supply cables—Christchurch City ..	7,021 16 1	
				4,889 19 10	Christchurch Tramways	4,889 19 10	
				7,013 3 9	Lyttelton	7,015 3 8	
				18,893 9 8	Northern	18,997 4 11	
				10,876 10 2	Southern	11,886 15 6	
				3,994 11 1	Motukarara	4,045 9 5	
				1,019 0 2	Hororata–Darfield ..	1,613 19 10	
				..	Substations—Hororata	4,712 10 9	
				..	Ashburton	8,265 8 9	
				..	Timaru	9,984 1 6	
				622 9 9	Lightning-arresters	622 9 9	
				300 4 5	Tools and equipment	300 4 5	
				1,516 12 8	Alterations to public telegraph-lines ..	1,516 12 8	
				56,089 10 6			80,871 17 1
					Secondary distribution—		
				21,543 18 4	Supply cables and reticulation ..	22,807 15 9	
				26,409 19 9	Local substations	26,689 19 7	
				47,953 18 1			49,497 15 4
				16,683 1 3	Service transformers and meters	..	9,329 2 10
				6,646 18 2	Motor-cars, lorries, and cycles, &c. ..	..	6,865 16 4
				88 14 6	Test-room equipment	..	102 9 4
				11,957 15 10	Loose tools, plant, and equipment	..	11,415 9 4
				1,729 3 9	Public telephones to the lake	..	1,729 3 9
				173 19 1	Telephones to Christchurch City Council and Tramway Board and local officers ..	..	173 19 1
				249 6 5	Christchurch office—Furniture and fittings ..	..	250 3 10
				26,749 13 9	Engineering, office, and general expenses on preliminary surveys and during construction	..	28,288 0 11
				23,692 9 10	Salaries of Engineers and others on preliminary surveys and during construction	..	27,646 16 10
				29,795 19 10	Interest during construction	..	32,823 19 1
				848,033 6 0			892,800 19 9
				41,095 0 1	Stocks of material, &c., on hand at date ..	..	41,471 10 0
				186 15 4	Telephone subscriptions, fire insurance, &c., paid in advance	..	141 13 1
				17,606 19 9	Sundry debtors—For current, rent, work carried out, &c.	..	20,115 6 0
				906,921 12 2			954,529 8 10
				23,875 16 11	Balance from Profit and Loss Appropriation Account	..	23,172 9 7
£930,797 9 1			£977,701 18 5	£930,797 9 1			£977,701 18 5

The balance-sheet has been compared with the various supporting books, vouchers, and documents, and found to correspond therewith.

G. F. C. CAMPBELL,
Controller and Auditor-General.

TABLE No. 7.

IRRIGATION AND WATER-SUPPLY.

SCHEDULE OF SCHEMES COMPLETED OR UNDER CONSTRUCTION.

Scheme.	Source of Supply.	River Discharge (Minimum).	Main Canal Discharge (Maximum).		Average Rainfall from Records available.	Rainfall, 1923.	Area commanded (Gross).	Area irrigated at Present.	Works authorized.		Works completed.		Expenditure to 31st March, 1924.	Estimate to complete.	Remarks.
			As per Design.	During 1923-24.					Main Canals.	Distributaries.	Main Canals.	Distributaries.			
		Cusecs.	Cusecs.	Cusecs.	Inches.	Inches.	Acres.	Acres.	M. ch.	M. ch.	M. ch.	M. ch.	£	£	
Steward Settlement	Waitaki River ..	..	110	..	21·20 (Steward Settlement)	18·38	18,000	..	14 60	50 31	14 60	50 31	12,115	..	Completed.
Otekaike ..	Otekaike River ..	9	15	..	21·31 (Duntroon)	19·77	1,500	800	14 37	3 47	14 37	3 47	3,631	..	Completed. Used only on west side of river.
Ida Valley ..	Manorburn, Poolburn, and Moa Creek. (Storage Manorburn Dam)	..	110	88	15·62 (Moa Ck.)	14·19	28,918	7,200	73 0	54 0	73 0	22 20	157,424	9,623	About 20,000 acres can now receive partial irrigation equal to one-third complete irrigation, the balance being land that either does not require irrigation or benefits indirectly through irrigation of the balance. To provide further water for its complete irrigation further conservation-works would be necessary. These have been investigated, and as they appear to be excessive in cost, nothing further is now proposed in that direction.
Galloway ..	Manorburn Dam ..	..	15	15	13·49 (Galloway)	13·21	2,250	1,650	10 50	4 0	10 50	4 0	21,122	666	Almost completed. Olrig Terrace scheme now reduced in area and amalgamated with Galloway.
Manuherikia – Alexandra–Clyde No. 1	Manuherikia River	77	100	40	15·48 (Alexandra, Ophir, and Clyde)	15·15	11,000	2,050	23 0	41 0	23 0	37 6	189,651	22,045	Sufficiently completed to supply water to any part of area, but some earthwork enlargement of parts of main race will soon be necessary, as originally anticipated, to provide full irrigation.
Ardgour	Lindis River ..	40	20	20	16·90 (Tarras)	16·90	2,000	1,426	13 0	2 40	13 0	2 40	32,199	459	Almost completed.

TABLE No. 7—*continued.*

IRRIGATION AND WATER-SUPPLY—*continued.*

SCHEDULE OF SCHEMES COMPLETED OR UNDER CONSTRUCTION—*continued.*

Scheme.	Source of Supply.	River Discharge (Minimum).	Main Canal Discharge (Maximum).		Average Rainfall from Records available.	Rainfall, 1923.	Area commanded (Gross).	Area irrigated at Present.	Works authorized.		Works completed.		Expenditure to 31st March, 1924.	Estimate to complete.	Remarks.
			As per Design.	During 1923-24.					Main Canals.	Distributaries.	Main Canals.	Distributaries.			
		Cusecs.	Cusecs.	Cusecs.	Inches.	Inches.	Acres.	Acres.	M. ch.	M. ch.	M. ch.	M. ch.	£	£	
Fraser River (Earnscleugh)	Fraser River ..	10	20	20	13·70 (Earnscleugh)	13·46	2,743	1,110	4 30	12 10	4 30	12 10	3,318	7,805	Half of scheme completed and working. Now about to be extended to command 2,400 acres with 1 cusec to 300 acres at driest times. Two cusecs of water is allocated free to original settlement of 343 acres. If better irrigation required a storage dam or hydro-electric pumping will have to be resorted to.
Last Chance (Fruitlands and Earnscleugh Tops)	Shingle, Gorge, and Coal Creeks	14	20	10	13·75 (Earnscleugh and Roxburgh East)	14·53	4,300	696	22 0	1 0	15 60	1 0	16,010	6,495	All of Fruitlands district now commanded with water, and extension towards Earnscleugh Tops proceeding. Water available will irrigate 1,100 acres south of Butcher's Creek, and partially irrigate 2,400 acres of land available for settlement north of Butcher s Creek.
Tarras	Lindis River ..	40	70	4	16·90 (Tarras)	16·90 (Tarras)	7,000	320	13 16	15 60	10 00	0 75	37,745	43,801	Under construction. Estimated to be ready for large proportion of area next season.
Bengerburn ..	Bengerburn ..	1	4	4	..	..	1,000	..	2 06	..	2 06	..	353	507	Partly completed. Supplying domestic water and partial irrigation.
Teviot River ..	Teviot River and Lake Onslow dam	40 (estim.)	80	5	13·80 (Roxburgh East)	15·59	3,300	215	16 51	10 00	16 51	4 35	20,966	12,798	Works well in hand, and full water-supply estimated for next season. Has been slightly extended to include some lands south of Teviot River.

TABLE No. 7—*continued.*

IRRIGATION AND WATER-SUPPLY—*continued.*

SCHEDULE OF SCHEMES UNDER INVESTIGATION.

Scheme.	Source of Supply.	River Discharge (Minimum).	Main Canals Discharge (Maximum), as per Design.	Average Rainfall from Records available.	Rainfall, 1923.	Area commanded (Gross).	Length of Main Canal.	Length of Distributaries.	Expenditure to 31st March, 1924.	Estimate to complete.	Remarks.
		Cusecs.	Cusecs.	Inches.	Inches.	Acres.	Miles.	Miles.	£	£	
Maniototo (Upper Taieri)	Taieri River and storage dam	25	500	17·35 (Waipiata)	13·89	100,000	60	..	142	..	Modified scheme for complete irrigation of 5,000 acres is possible without storage, or for reasonable partial irrigation of 15,000 acres.
Cromwell Flat and Lowburn (Roaring Meg)	Roaring Meg Stream (gravity), Kawarau River (pumping)	29 3,000	40	21·13 (Luggate)	20·73	15,000	10	30	1,186	39,700	Roaring Meg Scheme: This will irrigate 3,750 acres, and may be reduced in cost by charging £11,350 to possible hydro-electric-power development. Kawarau River: A private company is developing this portion of scheme. A survey party is engaged investigating alternative proposals for taking part of Roaring Meg water to Mount Pisa Settlement lands. This may alter estimate.
Upper Manuherikia ..	Manuherikia and Dunstan Rivers, and storage dam in Manuherikia River at Falls	77	355	18·39 (Clyde, Ophir, and Blackstone Hill)	21·72	96,000	130	..	3,307	866,360	Survey has been proceeding for several years, and general report just completed. Of the gross area of 96,000 acres, 64,000 acres are estimated to be actually suitable for irrigation. The full development of this scheme involves the construction of a storage dam, estimated to cost £250,000, but some of this cost would be borne by the Mount Ida and Scandinavian schemes.
Mount Ida	Tributaries of Manuherikia River and Eweburn Reservoir	..	50	23·93 (Eweburn, Naseby)	31·59	10,000	..	..	..	50,000	For lands in Upper Idaburn to Naseby. Includes £19,000 towards cost of Falls dam, Upper Manuherikia scheme, and £11,000 for value of present works.
Arrow River	Arrow River	55	48	25·51 (Frankton)	26·44	6,536	17	24	16	93,598	To irrigate Arrow Flats, Miller's Flat, Speargrass Flat, and Frankton. Formation of an irrigation district under the Public Works Act is under close consideration by settlers and Department.
Hawea Flats (first alternative	Timaru Creek (gravity)	20	30	21·97 (Hawea Flat)	21·80	4,000	11	20	21	41,470	To irrigate lower flat only.

TABLE No. 7—*continued.*

IRRIGATION AND WATER-SUPPLY—*continued.*

SCHEDULE OF SCHEMES UNDER INVESTIGATION—*continued.*

Scheme.	Source of Supply.	River Discharge (Minimum).	Main Canals Discharge (Maximum), as per Design.	Average Rainfall from Records available.	Rainfall, 1923	Area commanded (Gross).	Length of Main Canal.	Length of Distributaries.	Expenditure to 31st March, 1924.	Estimate to complete.	Remarks.
		Cusecs.	Cusecs.	Inches.	Inches.	Acres.	Miles.	Miles.	£	£	
Hawea Flats (later alternative	Hawea River (pumping)	..	..	2·97 (Hawea Flat)	21·80	17,600	..	..	..	71,720	Latest tentative proposal. Electric power not necessary, but water to be pumped by direct application of power generated by low-pressure turbines at outlet of Lake Hawea. This appears preferable to alternative No. 1, and appears to be a promising scheme. Further closer survey and estimates are necessary.
Chapman's Gully ..	Butcher's Creek, Conroy's Creek, and storage dam	..	..	14·78 (Alexandra)	12·76	100	..	..	..	1,165	May yet be amalgamated with Last Chance scheme or possible scheme from Conroy's Gully.
Bendigo Flat	Lindis River and storage dam	40	30	16·90 (Tarras)	16·90	3,000	7	..	..	..	..
Teviot River Extension	Teviot River and Lake Onslow dam	40	80	13·80 (Roxburgh East)	15·59	13,400	..	..	..	..	To irrigate Teviot and Ettrick. Involves enlargement of Lake Onslow dam. Some further investigations made, and survey expected to be commenced shortly.
Miller's Flat	Minzionburn	6	..	..	..	2,000	..	..	..	..	Proposed to utilize abandoned race of Island Block Extended Gold-mining Company. A new and promising proposal, which is about to be placed under survey.
Luggate Burn	Luggate Burn ..	6 (after existing rights)	12	21·13 (Luggate)	20·73	1,200	..	..	..	..	To supply water to part of Mount Pisa Settlement lands. Survey about to proceed.
Scandinavian	Tributaries of Manuherikia River and Eweburn Reservoir	..	20	27·83 (St. Bathan's)	26·19	4,000	..	..	..	50,000	For lands about St. Bathan s. Includes £12,000 towards cost of Falls dam, Upper Manuherikia scheme.

TABLE No. 8.

IRRIGATION AND WATER-SUPPLY: SCHEMES IN OPERATION.

IDA VALLEY AND GALLOWAY SCHEMES.

PROFIT AND LOSS ACCOUNT.

Gross Revenue Account.

—	1921–22.	1922–23.	1923–24.	—	1921–22.	1922–23.	1923–24.
To Management and operation—							
Ida Valley section—	£ s. d.	£ s. d.	£ s. d.	By Sales of water—	£ s. d.	£ s. d.	£ s. d.
Salaries	57 7 4	90 11 11	89 0 0	Ida Valley section	1,905 3 4	2,207 7 4	3,130 18 9
Wages, horse allowances, and other costs of maintenance	995 0 3	1,077 3 10	1,789 5 6	Galloway section	126 9 11	271 4 7	
Galloway section—							
Salaries	15 5 2	21 5 0	..				
Wages, horse allowances, and other costs of maintenance	217 11 6	252 13 7	268 16 8				
Office rent	10 0 0	10 0 0	10 0 0				
Maintenance staff cottages	..	45 0 0	..				
Gross profit on working	736 9 0	981 17 7	973 16 7				
	2,031 13 3	2,478 11 11	3,130 18 9		2,031 13 3	2,478 11 11	3,130 18 9

Net Revenue Account.

	1921–22.	1922–23.	1923–24.	—	1921–22.	1922–23.	1923–24.	Total.
To Interest on capital outlay at 4½ per cent. per annum (one-half charged against revenue and one-half against capital)—	£ s. d.	£ s. d.	£ s. d.	By Gross profit on working, as per Gross Revenue Account	£ s. d. 736 9 0	£ s. d. 981 17 7	£ s. d. 973 16 7	£ s. d. 2,692 3 2
At 31st March, 1921, capital outlay was £137,426 12s. 2d.	3,092 1 11	..	..	Net loss	2,429 6 3	2,437 15 4	2,886 18 6	7,754 0 1
At 31st March, 1922, capital outlay was £148,579 2s. 7d.	..	3,343 0 8	..					
At 31st March, 1923, capital outlay was £168,047 15s. 7d.	..	..	3,781 1 6					
Interest on depreciation reserve	..	2 18 11	6 0 3					
Depreciation Reserve Account	73 13 4	73 13 4	73 13 4					
	£3,165 15 3	£3,419 12 11	£3,860 15 1		£3,165 15 3	£3,419 12 11	£3,860 15 1	£10,446 3 3

TABLE No. 8—*continued.*

Depreciation Reserve Account.

	1923–24. £ s. d.		1923–24. £ s. d.
To Balance to balance-sheet	229 19 2	By Balance at 31st March, 1923	150 5 7
		Interest at 4 per cent. per annum	6 0 3
		Amount set aside as per Net Revenue Account (1·05235 per cent. on £7,000)	73 13 4
	£229 19 2		£229 19 2

General Balance-sheet at 31st March, 1924.

Liabilities.	£ s. d.	*Assets.*	£ s. d.	£ s. d.
Public Works Fund—Capital expenditure to 31st March, 1924	178,545 7 10	Dams, weirs, water-races, &c.—		
Consolidated Fund—Excess of maintenance and interest charges over receipts	20,967 13 8	Ida Valley section—		
Depreciation Reserve Account	229 19 2	Proportion Manorburn dam and headraces	49,070 0 0	
Sundry creditors—		Main water-races	96,615 11 0	
Ida Valley	368 7 1	Distribution water-races	12,246 11 4	
Galloway	2 0 0			157,932 2 4
		Galloway section—		
		Proportion Manorburn dam and headraces	10,408 0 0	
		Dip Creek diverting-weir	1,090 4 7	
		Main water-races	7,295 8 0	
				18,793 12 7
				176,725 14 11
		Staff accommodation		1,140 0 0
		Telephone system		800 0 0
		Stocks of material on hand		250 0 0
		Interest during construction		10,216 4 2
		Sundry debtors (sale of water)		3,227 8 7
		Profit and loss—Accumulated loss to date		7,754 0 1
	£200,113 7 9			£200,113 7 9

N.B.—The above accounts take the place of any previously published.

J. J. Gibson,
Accountant, Public Works Department.

APPENDICES TO THE PUBLIC WORKS STATEMENT, 1924.

APPENDIX A.

AUDITED STATEMENT OF EXPENDITURE ON PUBLIC WORKS OUT OF THE PUBLIC WORKS FUND FOR THE YEAR 1923–24.

Prepared in compliance with Section 8 of the Public Works Act, 1908.

SIR,— Public Works Department, Wellington, 15th July, 1924.

In compliance with the 8th section of the Public Works Act, 1908, I enclose a statement of the expenditure during the preceding financial year on all works and services chargeable to the Public Works Fund.

I have, &c.,
J. G. COATES,
Minister of Public Works.

The Controller and Auditor-General, Wellington.

STATEMENT OF NET EXPENDITURE ON ALL WORKS AND SERVICES CHARGEABLE TO THE PUBLIC WORKS FUND FOR THE YEAR 1923–24.

Vote.	Summary.	Appropriation.	Expenditure.	Credits.	Net Expenditure.
	General Purposes Account—	£	£ s. d.	£ s. d.	£ s. d.
44	Public Works, Departmental	130,203	168,161 12 0	57,802 7 8	110,359 4 4
45, 46	Railways	2,270,000	1,902,002 19 9	125,589 19 10	1,776,412 19 11
47–54	Public Buildings..	262,850	196,361 5 6	3,630 2 0	192,731 3 6
55	Timber-supply and Sawmills for Public Works Department	17,000	33,023 4 7	29,410 13 1	3,612 11 6
56, 57	Lighthouses and Harbour-works	28,500	10,938 4 4	133 12 8	10,804 11 8
58	Tourist and Health Resorts	37,250	29,941 10 11	2,677 3 9	27,264 7 2
59	Immigration	150,050	233,244 0 11	140,643 12 4	92,600 8 7
60, 61	Roads, Bridges, and other Public Works ..	989,860	784,073 7 7	34,336 2 11	749,737 4 8
62	Development of Mining	1,500	442 2 9	..	442 2 9
63	Telegraph Extension	750,000	829,213 16 7	111,804 5 4	717,409 11 3
64	Motor Transport Service	5,000	1,302 0 0	340 5 0	961 15 0
65	Contingent Defence	25,500	5,307 0 9	375 10 0	4,931 10 9
66	Lands, Miscellaneous	55,600	18,456 9 2	274 14 1	18,181 15 1
67	Irrigation and Water-supply	108,000	97,154 6 6	1,687 15 8	95,466 10 10
68	Plant, Material, and Stores	15,000	59,996 8 3	112,768 10 0	*Cr.* 52,772 1 9
..	Unauthorized	..	1,015 17 9	..	1,015 17 9
	Totals, General Purposes Account ..	4,846,313	4,370,634 7 4	621,474 14 4	3,749,159 13 0
69	*Electric Supply Account*	1,175,000	835,569 15 6	22,597 11 11	812,972 3 7
..	*Unauthorized—Services not provided for* ..	..	2 10 10	..	2 10 10
..	*Waihou and Ohinemuri Rivers Improvement Account*	..	71,973 2 11	1,440 0 3	70,533 2 8
	Totals, Public Works Fund	6,021,313	5,278,179 16 7	645,512 6 6	4,632,667 10 1

This statement includes only the expenditure on works, and does not include expenditure such as interest, sinking funds, and charges and expenses of loans.

J. J. GIBSON,
Accountant.

F. W. FURKERT,
Engineer-in-Chief and Under-Secretary.

Examined and found correct.

G. F. C. CAMPBELL,
Controller and Auditor-General.

APPENDIX A—*continued.*

	Name of Vote.	Appropriation.	Expenditure.	Credits.	Net Expenditure.
	PUBLIC WORKS FUND.	£	£ s. d.	£ s. d.	£ s. d.
	General Purposes Account—				
44	Public Works, Departmental	130,203	168,161 12 0	57,802 7 8	110,359 4 4
	Railways—				
45	Railway-construction	1,420,000	1,253,750 0 6	120,985 4 10	1,132,764 15 8
46	Additions to Open Lines	850,000	648,252 19 3	4,604 15 0	643,648 4 3
	Public Buildings—				
47	General	23,000	9,026 15 8	875 2 9	8,151 12 11
48	Courthouses	7,000	2,447 10 10	..	2,447 10 10
49	Prisons	30,000	27,259 8 2	774 19 4	26,484 8 10
50	Police-stations	20,000	13,486 0 9	648 4 2	12,837 16 7
51	Postal and Telegraph	100,250	109,585 1 10	1,189 14 1	108,395 7 9
52	Agricultural	2,600	285 10 3	3 10 0	282 0 3
53	Mental Hospitals	40,000	26,555 2 11	14 3 6	26,540 19 5
54	Hospitals and Charitable Institutions	40,000	7,715 15 1	124 8 2	7,591 6 11
55	Timber-supply and Sawmills for Public Works Department	17,000	33,023 4 7	29,410 13 1	3,612 11 6
	Lighthouses, Harbour-works, and Harbour-defences—				
56	Lighthouses	19,000	4,526 1 6	55 9 10	4,470 11 8
57	Harbour-works	9,500	6,412 2 10	78 2 10	6,334 0 0
58	Tourist and Health Resorts	37,250	29,941 10 11	2,677 3 9	27,264 7 2
59	Immigration	150,050	233,244 0 11	140,643 12 4	92,600 8 7
	Construction and Maintenance of Roads, Bridges, and other Public Works—				
60	Roads, &c.	984,860	781,173 1 7	34,303 2 11	746,869 18 8
61	Road and other Works on Goldfields and Mineral Lands	5,000	2,900 6 0	33 0 0	2,867 6 0
62	Development of Mining	1,500	442 2 9	..	442 2 9
63	Telegraph Extension	750,000	829,213 16 7	111,804 5 4	717,409 11 3
64	Motor Transport Service	5,000	1,302 0 0	340 5 0	961 15 0
65	Contingent Defence	25,500	5,307 0 9	375 10 0	4,931 10 9
66	Lands, Miscellaneous	55,600	18,456 9 2	274 14 1	18,181 15 1
67	Irrigation and Water-supply	108,000	97,154 6 6	1,687 15 8	95,466 10 10
68	Plant, Material, and Stores	15,000	59,996 8 3	112,768 10 0	*Cr.*52,772 1 9
..	Unauthorized—Services not provided for ..	..	1,015 17 9	..	1,015 17 9
	Totals, General Purposes Account ..	4,846,313	4,370,634 7 4	621,474 14 4	3,749,159 13 0
69	*Electric Supply Account*	1,175,000	835,569 15 6	22,597 11 11	812,972 3 7
..	*Unauthorized—Services not provided for*	..	2 10 10	..	2 10 10
..	*Waihou and Ohinemuri Rivers Improvement Account* ..	..	71,973 2 11	1,440 0 3	70,533 2 8
	Totals, Public Works Fund	6,021,313	5,278,179 16 7	645,512 6 6	4,632,667 10 1

APPENDIX B.

ANNUAL REPORT ON PUBLIC WORKS BY THE ENGINEER-IN-CHIEF.

The Engineer-in-Chief to the Hon. Minister of Public Works.

Sir,—

I have the honour to submit the following report upon the various works under my control completed and in progress throughout the Dominion during the period from the 1st July, 1923, to the 30th June, 1924.

RAILWAYS.

Abstract.

The following table shows the expenditure on Government railways in New Zealand up to the 31st March, 1924:—

Name of Railway.	Total Length of Railway or Section.	Open for Traffic.	Expenditure to 31st March, 1924.
	M. ch.	M. ch.	£
Kaihu Valley	24 32	24 32	178,859
Otiria–Ngapuhi	13 45	13 45	125,987
Opua Wharf – Onerahi	58 6	58 6	560,739
Kioreroa–Waiotira	19 79	5 23	416,521
North Auckland Main Trunk Railway (from Helensville)	153 75	65 27	2,187,065
Helensville – Te Awamutu, with Branches	163 48	159 08	3,221,668
Frankton Junction – Thames, with Branches	127 35	87 20	826,794
Thames Valley – Rotorua	69 33	69 33	385,281
Tauranga–Opotiki, with Branches	145 32	..	1,107,661
Gisborne–Opotiki	93 44	49 32	624,555
Napier–Gisborne (including Waikokopu Branch)	231 44	11 73	1,092,545
Wellington – Napier and Palmerston North (including Te Aro Extension and Greytown and Martinborough Branches)	249 44	233 12	2,754,074
Wellington–Waitara, with Branches	350 11	285 59	2,996,780
Stratford–Okahukura	112 47	42 26	1,239,700
North Island Main Trunk (Marton – Te Awamutu), including Raetihi Branch and Waipa Gravel-access Branch	225 79	218 39	2,965,401
Picton–Waipara (South Island Main Trunk Railway)—			
Picton southwards	92 38	56 6	656,127
Waipara northwards	90 45	44 14	377,533
Nelson–Greymouth	177 51	125 57	637,164
Stillwater – Arthur's Pass	51 41	42 27	1,990,159
Rolleston – Arthur's Pass (including Whitecliffs Branch)	92 59	84 45	1,010,404
Westport–Ngakawau	19 56	19 56	189,521
Westport – Ngakawau Extension to Mokihinui*	7 12	7 12	..
Mokihinui Colliery Line†	3 69	3 69	..
Westport–Inangahua	26 0	5 74	154,374
Ngahere–Blackball	3 40	3 40	147,532
Greymouth–Rewanui and Branches	11 34	11 34	329,792
Greymouth–Waitaha	50 32	38 68	351,690
Waipara–Waitaki, with Branches	459 34	413 70	2,766,197
Canterbury Interior Main Line—Oxford–Temuka	83 0	11 44	59,942
Waitaki–Bluff, with Branches	600 21	546 12	5,183,751
Otago Central	182 51	147 27	1,435,919
Invercargill–Kingston, with Mararoa Branch	117 4	97 44	389,299
Forest Hill Railway—Winton–Hedgehope‡	12 40	12 40	23,337
Western Railways	94 8	70 31	407,710
Preliminary surveys	..	..	40,866
Miscellaneous	..	..	10,337
Stock of permanent-way on hand	..	..	200,580
Rolling-stock	..	..	9,370,046
Suspense Account, being proportion of cost of raising loan of £1,000,000 at 6 per cent. for Railways Improvement Authorization Act 1914 Account	..	..	61,726
Total	4,215 9	3,066 5	§46,477,636
Provincial Government Lines, etc.			
Canterbury (lengths included above)	..	..	731,759
Otago and Southland	..	..	372,522
Gisborne to Ormond Tramway	..	..	4,975
Midland Railway, valuation of works constructed by company	..	..	‖683,460
Grand total	4,215 9	3,066 5	48,270,352

* The funds for this extension—namely, £35,501 2s. 11d.—were provided by the Westport Harbour Board.
† The funds for purchase of this line, £15,745, were provided by the Westport Harbour Board.
‡ The expenditure on this line as a tramway was made by the Lands Department.
§ Includes expenditure on railways under Hutt Road and Railway Improvement, Railway Improvement Authorization Act, and Railway Improvement Authorization Act 1914 Accounts.
‖ Includes value for £150,000 paid to debenture-holders under the Midland Railway Petitions Settlement Act Amendment Act, 1903.

Kaihu Valley Railway Extension.

(19 m. 17 ch. to 23 m. 71 ch.; length, 4 miles 54 chains.)

No construction work has been carried out on this section, but a considerable amount of tree-planting was carried out on the railway reserve during the winter months, this work being executed by officers of the Forestry Department.

North Auckland Main Trunk Railway.

Huarau Northwards.

Okaihau Section (16 m. 25 ch. to 24 m. 25 ch.; length, 8 miles 20 chains).—The ballasting of this section, erection of stone walls, stone drains, &c., have been completed. A contract was let for the erection of station-buildings at Okaihau and completed; the whole section being handed over to the Railway Department in October last. (See photo.)

Paparewa Section (90 m. 30 ch. to 92 m. 6 ch.; length, 1 mile 56 chains).—The principal work carried out on this section during the period has consisted of maintenance. Several of the larger cuttings, chiefly the north approach to the Huarau Tunnel, has given considerable trouble, necessitating the provision of large water-table drains. The completion of the Paparewa station-yard formation and the erection of the station-buildings is well advanced, all the timber and materials being on the ground. The goods-shed has been erected and also the stockyards and tank-stand foundations. A co-operative contract is being let for the erection of the remaining buildings. The ballasting of the Paparewa yard and the metalling of the Paparoa–Paparewa Railway-station Road are being pushed on. By the completion of the above road the greater part of the Otamatea County will be brought within easy reach of the railway.

Mareretu Section (92 m. 6 ch. to 96 m. 20 ch.; length, 4 miles 14 chains).—The main features of this section were the difficulties presented by the slip-cutting at 92 m. 15 ch., slip-bank at 93 m. 14 ch., slip-cutting at 94 m. 76 ch., slip-bank at 95 m. 2 ch., and several smaller slips. It was early seen, where deviation was impracticable, that a comprehensive scheme of stone drainage had to be taken in hand. This was done during the summer months, and it was gratifying to find that, where so much of the opened line suffered during the recent floods, these portions stood the test and showed practically no movement. Almost the whole of the section has received its third lift of ballast, and the principal work yet to do consists of the metalling in Mareretu yard and approach roads. An overbridge was constructed at 92 m. 49 ch., and a subway at 92 m. 2 ch. At Mareretu station-yard four cottages stockyard, platform, and loading-bank are completed, piles have been driven for the goods-shed, and it, together with the station-building, is well in hand.

Waikiekie Section (96 m. 20 ch. to 107 m. 28 ch.; length, 9 miles 66 chains).—The formation work on this section has been confined to the general clean-up of the section and the shifting of slips. Three steam-shovels have been engaged for eight months of the year lightening the batters of the cuttings at 97 m. 10 ch., 100 m. 8 ch., and 100 m. 45 ch. The material excavated has been, where possible, used for forming the Taipuha station-yard and approaches. Numerous small slips where steam-shovels could not operate have been dealt with by hand. Large stone drains have been put in at 102 m. 11 ch. and 105 m. 64 ch. to stabilize the fillings, which were slipping badly. The access road-bridge at Taipuha station-yard, 240 ft. long, road-bridge at 101 m. 18 ch., and overbridge at 100 m. 35 ch. were completed. The railway-bridges at 104 m. 2 ch., 104 m. 34 ch., and 106 m. 75 ch. were close-sleepered. Two and a half miles of second-lift and three and a half miles of third-lift ballasting were completed. The Waiotira station-yard was practically finished, and a considerable amount of ballast placed in Taipuha and Waikiekie station-yards. Two miles of fencing were erected. The strengthening of the Waikiekie Tunnel, where rendered necessary owing to the deformation of the lining due to the swelling of the ground, is in hand.

Supplies of timber for the station-buildings on this section have been received from the Department's sawmill at Donnelly's Crossing, and the erection, which is being carried out by co-operative contract, is proceeding satisfactorily. At Waikiekie the shelter-shed, goods-shed, platform, and loading-bank are practically complete. At Waiotira one platelayer's cottage, large station-building, engine-shed, turntable foundation, ash-pit, coal-shed, 5 chains of platform, loading-bank, stockyards, and 6,000-gallon vat have been completed. As nearly all the buildings are on embankment, it was necessary to carry all the structures on totara piles, 470 having been driven.

Arrangements are in hand to put in sidings to the Waikiekie Co-operative Company's limeworks, and during the current season the company propose to crush and pulverize limestone for consignment to various stations along the northern lines north of Helensville.

Kirikopuni Section (107 m. 28 ch. to 120 m. 0 ch.; length, 12 miles 52 chains).—On this section a vigorous construction policy has been adopted during the year, particularly in the formation of main-line culverts and tunnels, and the obtaining of timber and ironwork for the many bridges, the object being to co-ordinate the completion of the formation works with the piercing of the Tokatoka and Omana Tunnels, and enable platelaying and ballasting to proceed uninterruptedly in the coming spring. On the first five miles north of Waiotira the formation work, as indicated on the plans, is fully three-quarters complete, but the heavy winter rains have done considerable damage, and it is probable that a fair amount of slip trouble will be experienced. The work on this portion was undertaken by three methods: Between 107 m. 7 ch. and 109 m. 15 ch. four steam-shovels were employed in the heavy work; on the next half-mile, where the formation is in short ridge cuts and fills, hand labour was used; whilst beyond, where access was difficult, plough-and-scoop teams were employed to advantage. The formation works between 112 m. 0 ch. and 117 m. 66 ch. have been completed with steam-shovels and plough-and-scoop teams. Steam-shovels are actively engaged in the various cuttings

between the latter point and Paradise yard at 120 m. Through connections to various points along the works have been made by the use of temporary tram-lines and jig-lines. This has greatly cheapened the cost of transport as compared with the horse and bullock drays used in the past. From Waiotira to Tokatoka Tunnel, temporary track was laid to connect with a jig-line over the top of the Omana Tunnel. On the north side of this tunnel the temporary track is continued to 109 m. 41 ch., and from thence the permanent line has been laid to 110 m. 30 ch.

At the Wairoa River, Pukehuia, a construction depot and yard has been established, and a wharf built to receive goods and material from the river steamers and barges. From this wharf a temporary line (including 61 chains of permanent track) connects with a jig-line over the Omana Tunnel, from the south side of which temporary track is laid to Omana station-yard. Owing to the cuttings north of Omana Tunnel slipping badly, it was found necessary to apply preventive measures instead of waiting for the rails to come through from Waiotira. A good volcanic outcrop was located above the junction of the Mangakahia and Wairoa Rivers, and from this locality large stone was barged down, and stone drains have been successfully employed in wet cuttings, enabling them to be kept open for traffic. Owing to portion of the country being unstable it has been found necessary to make a number of slight deviations to avoid bad places. A number of culverts, ranging from 12 in. to 6 ft., have been placed, and several water-tunnels driven. Six miles of line have been fenced on both sides, the permanent bridges, consisting of three 30 ft. spans at Waiotira and two 30 ft. spans at 110 m. 23 ch., have been erected, and temporary bridges at 113 m. 65 ch. and 114 m. 70 ch. are in place.

Plans have been prepared for the large cylinder bridge at the Wairoa River, and ironwork has been ordered. Borings have been taken, and a start will be made very shortly with the cylinder-sinking on the main-span piers and the pile-driving of the piers for approach spans.

Supplies of rails and fastenings are to hand, and sleepers are arriving, so that as soon as the Tokatoka Tunnel is pierced, platelaying and ballasting can be pushed forward in earnest. Temporary tracks have been ballasted lightly, as without some hard material maintenance of a running top is impossible.

The piercing of the Tokatoka and Omana Tunnels has been the most important and urgent work of the period. Great difficulty was experienced in both these tunnels, owing to the very treacherous nature of the country. In both cases the heaviest class of lining, including invert, had to be adopted, and only the greatest care and perseverance enabled such good progress to be attained. These tunnels are now almost completed; and, as there only remain approximately 4 chains in the Tokatoka and 5½ chains in the Omana to be completed, it is anticipated that they will both be finished in September. (See photo.)

The formation of the Pikiwahine and the Omana station-yards has been completed. In the Pukehuia yard formation is well in hand, and a start has been made at Paradise.

The winter season so far has been the wettest on record, and but for the complete system of temporary track and jig lines it would have been impossible to deal with the transport necessary to keep the large amount of work in hand over such an extended section.

The departmental ownership of the large sawmill at Donnelly's Crossing has contributed in no small measure to the effective working of the section, by providing prompt and ample supplies of timber for the various requirements of the works, particularly provision of temporary buildings, and workmen's accommodation, as well as for the timber-supplies for station-buildings on the other sections. This latter work necessitated a large demand for first-grade timber at comparatively short notice. During the year ended 31st March last 1,927,350 superficial feet of timber has been cut.

North of the Wairoa River a new road is in process of construction between Kirikopuni and Parakao, in the Mangakahia Valley, a distance of 13 miles. This road will serve as a valuable feeder to bring the traffic of the fertile Mangakahia Valley to the railway.

Okaihau to Hokianga.

The question of further extension to Hokianga has been investigated from an economical and developmental point of view, and further investigations are being made in the matter of the best route beyond Rangiahua, a survey party being engaged on trial-line work beyond that point.

Whangarei Branch Railway.

Oakleigh Section (5 m. 27 ch. to 7 m. 60 ch.; length, 2 miles 33 chains).—In addition to the usual maintenance, the only work carried out on this section has been the stone walling of several cuttings, stone drainage of fillings at 7 m. 0 ch. and 7 m. 5 ch., and the close sleepering and decking of the Oakleigh Bridge at 7 m. 34 ch.

Tauraroa Section (7 m. 60 ch. to 14 m. 67 ch.; length, 7 miles 7 chains).—Although traffic is being carried over this section, considerable maintenance has been necessary, as several fillings between 8 m. and 10 m. have given a good deal of trouble. The completion of the Oakleigh station-yard in accordance with the final plan has been put in hand and the platelaying completed. At Mangapai Station the bridge has had decking and handrail placed. The platform and loading-bank are complete, and the station building and cottage for tablet-porter are practically complete. At Tauraroa the platform is complete and the station-building and extra platelayer's cottage well in hand.

Tauraroa Quarry.—The plant at this quarry has been considerably increased to give a monthly output of 5,000 cubic yards. The output for the last twelve months was 45,630 cubic yards, of which 12,000 cubic yards were supplied to local bodies, whose demand is ever increasing. All the requirements of the various railway sections for ballasting and road-metal have been filled from this quarry.

Waiotira Section (14 m. 67 ch. to 19 m. 75 ch.; length, 5 miles 18 chains).—The work on this section has consisted of maintenance and ballasting. Under the former heading is included the cleaning up, and adoption of preventive measures on several cuttings and fillings which have slipped badly. All the ballasting required on Whangarei Branch, except for maintenance and the completion of the Oakleigh yard, has been completed. The great settlement which takes place on all the North Auckland clay country will render the former a considerable item. On the Huarau–Portland Section, which comprises part of the North Auckland Main Trunk and of the Whangarei Branch, passenger traffic was inaugurated on the 21st December, 1922, and goods traffic on the 28th May, 1923. The traffic has been increasing throughout, and for the last ten months of the period 24,273 passengers and 78,695 gross tons of goods were carried.

Waipu Branch Railway.

Ruakaka Section (0 m. to 9 m. 20 ch.; length, 9 miles 20 chains).—The formation work on this section has been confined to the operation of one steam-shovel, making up filling between 0 m. and 2 m. This work is now complete, and, with the other formation done on this line, will form part of the up-to-date highway being constructed in lieu of the completion of the railway.

Huntly–Awaroa Railway.

(7 m. 20 ch. to 8 m. 75 ch.; length, 1 mile 55 chains.)

During the period the big slip at 7 m. 31 ch. to 7 m. 37 ch. was cleaned up, and the stone wall below the power-house on approach road to overbridge at 8 m. 50 ch. was also completed. Station-buildings, goods-shed, and latrines at Glen Afton were completed, and also the metalling of yard and approach. General maintenance was carried out over the whole of the section, and the line handed over to the Railway Department on the 16th June, 1924, although goods traffic had been carried out with profit by the Public Works Department for the twelve months prior to that date.

East Coast Main Trunk Railway—Waihi Eastwards.

Athenree Section (0 m. to 8 m. 68 ch.; length, 8 miles 68 chains).—All earthworks on this section have now been completed with the exception of a few minor alterations to station-yards and a small amount of bank-widening. Fencing has been completed and private crossings have been erected at 0 m. 17 ch., 0 m. 47 ch., 2 m. 55 ch., and 7 m. 37 ch. The following bridges have been completed during the year: Adams Street Bridge, at 0 m. 36 ch.; Ohinemuri Bridge, at 0 m. 55 ch.; Waimata Bridges, at 0 m. 67 ch. and 2 m. 62 ch.; and Waiau Stream Bridge, at 6 m. 60 ch. The Waiau Stream Bridges at 7 m. 23 ch., 7 m. 69 ch., and 7 m. 76 ch. are almost complete, practically all piers being built and girders riveted up ready for placing in position. (See photo.) Several small culverts have been placed. Rails have been laid from the Waihi station-yard to 6 m. 19 ch., and a first lift of ballast completed to 1 m. 34 ch., together with patch ballasting in the bad places to 4 m. 70 ch. Second lift of ballast is complete to 0 m. 40 ch. The ballast for this portion of the line has been obtained from a privately owned quarry at Karangahake, but the quantity available per day has been small and subject to considerable delays, the total quantity supplied being 2,845 cubic yards. A quarry is being opened up by the Department at 7 m. 23 ch., a siding having been put in, crusher erected, and preliminary work completed in readiness for commencing operations on a fairly large scale. Tenders have been invited for the station-building and extra cottages at Athenree, the sites for which have been prepared.

Katikati Section (8 m. 68 ch. to 16 m. 28 ch.; length, 7 miles 40 chains).—On this section work is in hand up to 14 m., the formation being practically complete with the exception of cutting at 11 m. 60 ch. One of the heaviest pieces of work on this section was the formation of the Tahawai station-yard, which was carried out by means of a steam-shovel. Reinforced-concrete piles for brigde at 10 m. 61 ch., and for the Tuapiro at 12 m., have been cast at Tauranga, and are now being transported to the site. Overbridge at 11 m. 59 ch. is completed, and those at 9 m. 19 ch. and 12 m. 59 ch. are in hand. Two platelayers' cottages have been erected at Katikati Station. The remainder of the work on this line from 14 m. to 34 m. 78 ch., comprising the balance of the Katikati, the Aongatete, Apata, and Te Puna Sections, has been let to Sir W. G. Armstrong, Whitworth, and Co., who have just made a start with the preliminary work, setting out of material, yard, &c.

Tauranga Section (34 m. 78 ch. to 41 m. 5 ch.; length, 6 miles 7 chains).—The formation of the centre-line has been completed from 39 m. 70 ch. to 41 m. 5 ch. The filling between centre-line and the Strand, Tauranga, is complete, and a very considerable portion of the extensive reclamation for Tauranga Station is finished. The formation of the low-level road between the Strand and Tauranga station-yard is in hand. The greater portion of the above bank material was obtained from the borrow-pit opposite 40 m. 23 ch. and 40 m. 30 ch., where a steam-shovel removed 63,516 cubic yards for the year. The stone pitching of bank from 40 m. 30 ch. to 41 m. 5 ch. has been completed, and is in hand at Tauranga Station. The overbridge at 40 m. 22 ch., with necessary approaches, has been completed, and a start has been made with the casting of reinforced-concrete piles for the Waikareao Bridge. The main-line rails have been laid from 39 m. 70 ch. to 41 m. 5 ch., and two sidings and eight sets of points and crossings laid in the Tauranga yard. A botton lift of ballast has been placed from 40 m. 5 ch. to 41 m. 5 ch., and the final lift completed from 40 m. 36 ch. to end of section. Three platelayers' cottages, goods-shed, platform, and loading-bank have been erected at Tauranga Station-yard, and the remainder of the buildings are well in hand. The portion of section from Tauranga Station to 41 m. 5 ch. and the Tauranga Bridge were officially opened in June, and since then the section has been open for all classes of traffic.

Matapihi Section (41 m. 5 ch. to 45 m. 0 ch.; length, 3 miles 75 chains).—The formation from 41 m. 5 ch. to the Tauranga Bridge has been completed, and both abutments of the bridge built up with stone. The Tauranga Harbour Bridge, consisting of fourteen 104 ft. steel spans, was completed in April, 1924. The work done during the year consisted of the completion of the fabrication at the Mount yard, while on the bridge itself piers A to H and O to P were completed, eleven spans completely finished, and the whole fourteen riveted and painted, including all necessary false work and the dismantling of same. (See photo.) Rails were laid from 41 m. 5 ch. to 42 m., the line over the Tauranga Bridge being only temporary, pending the arrival of the heavy rails and special sleepers. Ballasting has been completed from 42 m. to 41 m. 5 ch., and this portion of the section was opened for traffic in June. On the remainder of the section traffic was carried throughout the year.

Te Puke Section (45 m. to 54 m.; length, 9 miles).—This section has been open for traffic throughout the period. In addition to maintenance, a little extra ballasting and a few alterations to bridges and culverting were carried out. The heavy floods in April damaged this portion somewhat, and traffic was disorganized for a few days. At the quarry 15,318 cubic yards of ballast or road-metal were crushed, and 8,511 cubic yards of one-man size spalls for pitching purposes were delivered.

Paengaroa Section (54 m. 59 ch. to 59 m. 67 ch.; length, 5 miles 67 chains).—This section is open for traffic, and the usual maintenance was carried out; in addition all buildings and cottages were repainted and overhauled.

Otamarakau Section (64 m. 15 ch. to 71 m. 5 ch.; length, 6 miles 60 chains).—This section has been open for traffic and the usual maintenance carried out. In addition, a certain amount of construction was carried out in the widening of banks and formation at Pukehina and Otamarakau station-yards. Additional fencing and cattle-stops, and the completion of reinforced-concrete bridge at 70 m. 77 ch. were also carried out. About 1,245 cubic yards of ballast from the Matata pit was placed on the section.

Matata Section (71 m. 5 ch. to 79 m. 16 ch.; length, 8 miles 11 chains).—Section open for traffic. General maintenance carried out, and new construction, consisting of bank-widening, 8 ft. flat-topped culvert at 71 m. 62 ch., and slab-topped bridge at 72 m. 43 ch. 2,074 cubic yards of new ballast were placed on the section. The Matata ballast-pit has been fully opened up, the strippings used for bank raising and widening on various sections, and the shingle for ballasting and road-metal supplies to local bodies. The total output was 28,460 cubic yards spoil, 21,269 cubic yards metal, and 127 cubic yards rock spalls. A steam-shovel has been installed in pit for loading both strippings and ballast.

Rangitaiki Section (79 m. 16 ch. to 87 m. 45 ch.; length, 8 miles 29 chains).—This section was opened for traffic in November of last year. Construction work has consisted of widening and forming approaches to the Tarawera Bridge, and the completion of formation at Awakaponga, Rangitaiki, and Tarawera station-yards. The Tarawera Bridge, at 83 m. 50 ch., consisting of six 30 ft. girder spans on pile piers, was completed. A number of sidings were laid in Tarawera yard, and 6,960 cubic yards of ballast from the Matata pit were placed on the section. Station-buildings are all well in hand at Awakaponga, Rangitaiki, and Tarawera station-yards.

Awakeri Section (87 m. 45 ch. to 91 m. 40 ch.; length, 3 miles 75 chains).—This section was opened for all classes of traffic in November, 1923, and in addition to the usual maintenance the following new construction was carried out: The Awakeri station-yard was widened and road-deviation completed; 30 chains of sidings were laid in the Awakeri yard, and 2,315 cubic yards of ballast placed on the section; station-buildings at Awakeri were completed.

Taneatua Section (91 m. 40 ch. to 100 m. 6 ch.; length, 8 miles 46 chains).—Good progress was made with the formation, which is now practically completed. 2 miles 69 chains of fencing was completed, and two large culverts built. Three steam-shovels were employed on this section, and altogether 130 chains of earthwork was completed, including the extra heavy earthwork between 96 m. 50 ch. and 98 m. 27 ch. The formation of Peketahi and Taneatua Stations has been completed, and the large station at Kiwinui is in hand. The formation of a ballast siding to the shingle deposits in the Whakatane River is in hand, and it is hoped to start ballasting from this pit in three months. All piles have been driven for the slab-topped bridge of three 20 ft. spans over the Mission Creek Stream at 95 m. 38 ch. The Waioho Bridge, at 96 m. 73 ch., consisting of two 35 ft., three 25 ft., and one 20 ft. plate girder spans on pile piers, was completed. At the Whakatane Bridge all concrete piles have been cast, and temporary staging has been erected across the river. The piles in the first four piers have been driven. Concrete piers B and C are completed, and girders are being erected in the Mount yard. Permanent-way has been laid from 96 m. 50 ch. to 98 m. 27 ch., and 17 chains of sidings laid in the Peketahi station-yard. The erection of cattle-yards and platform-fronts at Peketahi station-yard is in hand.

Mount Branch (0 m. to 4 m 7 ch; length, 4 miles 7 chains).—The section has been open for traffic, but no new construction has been carried out. The usual maintenance was carried out. A large amount of work has been carried out in the Mount workshops, both for the local railway and for works in other districts. The principal work has been the fabrication of bridge girders, trusses, &c., for local railway and highway construction, as well as for similar work for the Auckland and Taumarunui districts. In addition to this, all engines and other rolling-stock, as well as plant generally, both for construction and general traffic purposes, have been maintained in good condition. General repair work has been carried out in connection with the Lands Department's dredges, and part of the new Waihou dredge has been fabricated. The general goods and passenger service between the Mount and Matata has been maintained, with extension to Awakeri on 12th November, 1923, and to Tauranga in June, 1924.

Gisborne–Napier Railway (North End).

Ngatapa Section (0 m. to 10 m. 40 ch.).—A considerable amount of maintenance work has been carried out on this section, particularly in the removal of slips from the cuttings at 7 m. 74 ch. and 8 m. 66 ch., in addition to clearing the water-channels, outward drains, and the widening of formation between 0 m. 2 ch. and 0 m. 14 ch. The bridges at 0 m., 5 m. 38 ch., 5 m. 62 ch., and 5 m. 74 ch. are completed. The temporary piers in bridge at 5 m. 38 ch. have been repaired, and the steelwork of girders for bridges at 5 m. 38 ch., 5 m. 62 ch., 5 m. 74 ch. is just to hand; that for 9 m. 66 ch. being in process of assembling. The final ballasting and boxing-in has been completed from Makaraka to 5 m. The whole section has been thoroughly cleaned up, and a passenger and goods train has been run as required to cope with the traffic. A 6,000-gallon water-vat and station-buildings have been completed at Ngatapa.

Waikura Section.—A steam-shovel was engaged in cutting at 13 m. 16 ch., but owing to the development of a slip at 12 m. it was moved back to this locality, and has been worked for the latter portion of the period here. Lately, owing to weather conditions being unfavourable, the shovel was shifted away, and the men placed on the Ngatapa Section. The first lift of ballast has been completed to 11 m. 74 ch. A considerable amount of maintenance work has been found necessary on this section during the year, on account of the number of slips which occurred.

Waikokopu Branch Railway.

Wairoa Section (0 m. to 1 m. 53 ch.; length, 1 mile 53 chains).—The formation of this section has been completed, and the second lift of ballast has been placed. The girders for bridge at 1 m. 21 ch. are riveted up ready for launching. Branch lines into the freezing-works and flax-mill have been laid, and are carrying goods traffic. The formation of the Wairoa station-yard is in hand.

Nuhaka Section (0 m. to 17 m. 12 ch.; actual length, 18 miles 65 chains).—The formation of this section is completed except for a portion of the Nuhaka station-yard and the completion of the Wairoa station-yard. With the exception of a short gap through the Whakaki station-yard, the whole section has been ballasted. The girders for the bridge at 1 m. 21 ch. are riveted up ready for launching, and branch lines have been laid into the freezing-works and flax-mill. These branch lines are now carrying goods traffic. Girders for bridges at 1 m. 23 ch., 3 m. 76 ch., 8 m. 43 ch., 9 m. 42 ch., 11 m. 30 ch., and 13 m. 62 ch. have been riveted up ready for launching. A number of special culverts have been laid on the soft formation bordering the Whakaki Lagoon.

Waikokopu Section (17 m. 12 ch. to 23 m. 28 ch.; length, 6 miles 16 chains).—Formation has been completed throughout with the exception of a portion of the Waikokopu station-yard, and the approach to the Waikokopu Wharf. Trouble was experienced with slips on the heavy section from 18 m. 30 ch. to 22 m., and it has been necessary to use steam-shovels to keep the line open. Platelaying is completed to 22 m. 75 ch., and a temporary track has been laid over the unfinished portion. Bridges at 19 m. 66 ch. and 22 m. 54 ch. have been completed. Girders for the bridges at 17 m. 50 ch., 18 m., and 21 m. 23 ch. have been received, and most of the spans riveted up. Ballast from the Nuhaka pit has been laid to 22 m. 24 ch.

Waikokopu Wharf.—A wharf with a depth of 18 ft. at low water, spring tides, and 200 ft. long, carrying two lines of railway, has been put in hand. The material for this wharf was received in a direct shipment from Australia in December last, and all the main piles have been driven, and sufficient of the superstructure has been finished to enable regular trading-vessels to use the wharf.

A permanent telephone-line has been erected from Wairoa to Waikokopu. A limited goods service has been in operation, including the carriage of live-stock for the freezing-works. The principal works still remaining to be done are the completion of the ballasting, the permanent superstructure of the bridges, private and level crossings, and station-buildings.

Gisborne–Napier Railway (South End).

Eskdale Section (0 m. 14 ch. to 10 m. 56 ch.; length, 12 miles).—This section was completed and handed over to the Railway Department during the year, except for the Port line deviation, which is now ready for platelaying. The work which was to be carried out by the Napier Harbour Board in forming the approaches to the Westshore Bridge, &c., has been completed.

Tutira Section (10 m. 56 ch. to 28 m. 15 ch.; length, 17 miles 39 chains).—Formation has been vigorously prosecuted between 14 m. 50 ch. and 20 m. during the year. The principal earthwork has consisted of the cutting at 14 m. 50 ch., the excavation in the Waipunga station-yard at 15 m. 29 ch., and the heavy formation between 16 m. 10 ch. and 17 m. 5 ch. Six steam-shovels have been engaged at the above locality. At 16 m. a service heading has been driven through the large cutting to facilitate and cheapen construction. The heavy earthwork between 17 m. 40 ch. and 20 m. has been commenced by hand-labour, which will shortly be reinforced by the use of some of the shovels which are at present engaged on the earlier formation. At 17 m. it has been found necessary to deviate the line to avoid putting in a tunnel in unstable country. A start has been made on the section between 20 m. and 27 m. with scoop teams, &c., on the lighter portions of formation, and with general preparatory work. During the period 234,458 cubic yards of earthwork have been shifted, about 60 per cent. by hand-labour and scoop teams and the balance by steam-shovels. At 11 m. 40 ch. piers and abutments of the bridge across the Maungakopikopiko Stream has been built, but the unprecedented heavy floods in March, 1924, washed out the two piers and the south abutment. A temporary bridge has since been constructed in order to re-establish communication. At 13 m. 35 ch. the concreting of the piers of the bridge over the Esk River is almost completed, and the riveting of the plate girder spans is in hand. The completion of this bridge was also considerably delayed by the flood. Twenty-two

culverts of varying sizes have been built throughout the section. At 17 m. 35 ch. the 10½-chain tunnel has been completed, and at 18 m. 30 ch. the work is well in hand. The approaches for the tunnel at 19 m. 70 ch. have been opened up, and a start will shortly be made with the actual driving itself.

A sawmill has been established north-east of Waikoau Station, and a road formed and metalled to it. It is anticipated that this mill will provide the majority of the timber required for these works from the beginning of next summer. Three platelayers' cottages in concrete blocks have been built at Waipunga station-yard, and a fourth is in hand. A construction depot has been established at Waipunga station-yard, and various temporary construction buildings have been built at Waikoau station-yard. Workmen's accommodation has entailed a considerable amount of work, twelve married men's houses, eighty-one huts, and two cookhouses having been built.

The most exceptional floods of March last did considerable damage to the railway-works and the lines of communication, and this caused considerable delay. The rainfall was phenomenal, and probably a record for intensity in New Zealand.

Stratford Main Trunk Railway (East End).

Matiere Section (0 m. to 10 m. 23 ch.; length, 10 miles 23 chains).—The formation on this section has been completed. The principal earthwork carried out during the year was in connection with the formation of station-yards at Tuhua and Matiere. The lining of tunnel at 4 m. 65 ch. has been completed in brick, the work being carried out while traffic was in progress. Road-deviations at 5 m. 50 ch. and 9 m. 64 ch. have been completed and metalled. At the Tuhua station-yard the overbridge, consisting of two 25 ft. and two 20 ft. spans, is practically finished, and the foundations of piers for the overbridge at 10 m. 23 ch. have been laid and are ready for the superstructure. The road-bridge at 6 m. 64 ch. on the Ohura Road deviation, consisting of one 30 ft. rolled-steel joist span, has been completed and painted. All permanent-way has been laid on the section with the exception of a small amount of siding in the Tuhua station-yard. The second lift of ballast has been placed throughout the section, and the Ohura County Council has been supplied with about 2,000 cubic yards of shingle for roadwork. Contracts are being let for the station-buildings at Tuhua and Matiere, and this, and the final lift of ballasting, is practically all that is now required to complete the section. A passenger and goods service has been maintained between Okahukura and Matiere, which has served the district well, although interfering somewhat with the working of ballast-trains, which are now running a distance of 20 miles each way.

Ohura Section (10 m. 23 ch. to 19 m. 10 ch., length, 8 miles 67 chains).—Formation work on this section is now completed to 13 m. 54 ch., except for small deviations at 11 m. 40 ch. and at 13 m. 16 ch. From 13 m. 54 ch. to 14 m. 50 ch. cuttings have been excavated and banks formed wide enough to allow the rails to be laid. The objective on this section has been to connect up with Toitoi at 16 m. in order to facilitate the conveyance of materials, goods, and passengers to this point. From Toitoi to Ohura Township there is a good metalled road, and every endeavour was made to reach this point in June. In order to do so a light line on temporary alignment, consisting of 40 lb. rails, was laid from 14 m. 50 ch. over easy country, and connected with the permanent centre-line again at 16 m. The object of this tram-line was to avoid the heavy earthworks between 15 m. and 16 m., and to avoid two crossings of the Ohura River at 15 m. 47 ch. and 15 m. 65 ch. The rails reached Toitoi on 30th June, but, owing to the very heavy rains, difficulty was experienced in maintaining the tram-line over the new banks. It is hoped, however, to inaugurate the goods and passenger service within a few weeks. Temporary bridges have been erected at 11 m. 40 ch., 13 m. 16 ch., and at 14 m. 64 ch. These will enable traffic to be dealt with and material to be carried forward whilst the permanent bridges are under construction. The material for the latter is now coming to hand, and a commencement will be made with the erection immediately. A number of culverts, ranging from 18 in. to 5 ft., have been constructed between 10 m. 50 ch. and 14 m. 34 ch. Road-deviations at 11 m. 23 ch. and 12 m. 16 ch. are almost completed, and 400 chains of fencing have been erected.

Stratford–Main Trunk Railway (West End.)

Tahora Section (42 m. 26 ch. to 47 m. 40 ch.; length, 5 miles 14 chains).—All formation work, platelaying, ballasting, &c., was completed on this section by March last, but unfortunately very heavy floods were experienced, and a considerable amount of damage took place, which will take some months to repair. As the section of this line which is under the control of the Railway Department had also been very seriously damaged, and many roads practically blocked, all workmen were taken off the section and utilized either to assist the Railway Department in clearing their section or in opening up some of the roads. The principal work carried out during the year was the completion of private crossings, approach fences at Tahora station-yard, the placing of concrete walls at bridge-ends at 42 m. 64 ch. and 43 m. 54 ch., and the final ballasting of the section. 4,760 cubic yards of ballast was placed on the section during the period. A bi-weekly passenger and goods service is being run over the section, connecting with the opened railway at Kohuratahi.

Raekohua Section (47 m. 40 ch. to 50 m. 60 ch.; length, 3 miles 20 chains).—The only work carried out on this section was the survey for service tram and the preparation of plans. The hard-wood timber for the road-bridges came to hand, and has been stacked at Te Wera pending the continuation of the work.

Heao Section (50 m. 60 ch. to 57 m.; length, 6 miles 20 chains).—Tram- and jig-line surveys have been carried out on this section, and some refinements of location between 53 m. and 54 m. are being investigated.

Te Wera Quarry.—During the first nine months of the period crushing was carried on continuously, and a total of 17,266 cubic yards was produced. Of this metal 5,920 cubic yards were utilized in ballasting on the Tahora Section and the quarry line and road; 11,346 cubic yards were sold to various local bodies throughout the district. During the last three months of the period the men were taken off quarrying and employed on flood-damage repairs, both on the open portion of the railway and on the Ohura Road. Additional stripping was carried out, further building accommodation provided for the workmen, and general maintenance on machinery, &c., attended to. This quarry is filling a long-felt want in the district, where the provision of crushed stone at a reasonable price has always been a difficult problem.

Opunake Branch Railway.

Kapuni Section (0 m. to 7 m.; length, 7 miles).—This section was opened for goods traffic on the 1st August last, and all freight offering has been handled by the Public Works Department. In addition to maintenance work, a great deal of work has been carried out on the completion of cuttings and banks by means of muck-trains. At the Skeet Road crossing, at 0 m. 42 ch., a concrete overbridge and approach filling, which contained 1,200 cubic yards of earth, have been constructed. The whole has been metalled with crushed metal, blinded with ballast, and opened for traffic. At the Kapuni station-yard, at 6 m. 54 ch., three sidings have been laid, thus completing all platelaying on this section. The ballasting of the main line throughout, and also sidings in Matapu, Duthie Road, and Palmer Road Stations, has been completed. The metalling of approach roads to the various stations is well in hand, and the only ballasting yet to do on the section is the final lift for sidings at Kapuni station-yard, which have received first and second lifts throughout. Loading-banks have been constructed with concrete fronts at Matapu, Duthie Road, Palmer Road, and Kapuni station-yards. The permanent telephone-line has been erected.

Auroa Section (7 m. to 12 m.; length, 5 miles).—The concrete piers for the Mangawhero River Bridge at 9 m. 41 ch., and the Otakeho River Bridge at 11 m. 37 ch., have been erected. Temporary timber superstructures were provided in order to enable platelaying to proceed. The plate girder spans for these bridges have now arrived, and the assembling and riveting up is in an advanced state. Permanent-way has been laid from the commencement of the section to 11 m. 37 ch., including the siding at Mangawhero station-yard at 9 m. 78 ch. The first and second lift of ballast has been completed on the main line to 11 m. 30 ch., and the third lift to 11 m. 25 ch. Ballasting of sidings on the Mangawhero Road station-yard is completed.

Pihama Section (12 m. to 16 m. 40 ch.; length, 4 miles 40 chains).—The work on this section has been mainly confined to formation work, the erection of bridge piers, and a road overbridge. Banks at 14 m. 78 ch. to 15 m. 4 ch., and 15 m. 8 ch. to 15 m. 13 ch. have been completed to a width of 12 ft. on top. The cutting at 15 m. 44 ch. has been gulletted through, and the formation of the Pihama station-yard at 16 m. 40 ch. is in hand. The concrete piers for the Oeo River Bridge at 15 m. 6 ch. and the Ouri River Bridge at 16 m. 10 ch. have been erected. The plate girders for the superstructure of these bridges is now in hand, and a start is being made with the assembling. An overbridge has been erected at the Oeo Road at 13 m. 52 ch.

Opunake Section (15 m. 40 ch. to 23 m.; length, 7 miles 40 chains).—A very considerable amount of formation work has been carried out on this section. The cuttings have been in most cases gulletted, and the banks built to 12 ft. wide, with the intention of taking down the batters of the cuttings and widening the banks by means of a muck-train after the permanent-way has been laid. Formation on these lines is well in hand. Good progress was made in the long cutting at 21 m. 36 ch. This cutting is nearly a mile in length, and excavation is being carried out by a steam-shovel, the material being run to bank and dumped from trestles. Eight culverts, ranging from an 18 in. pipe to double 10 ft. arched concrete culverts, have been placed. The concrete foundation of pier B for the Punehu River Bridge at 17 m. 53 ch. has been completed. Considerable difficulty was experienced with this excavation. At the Mangahume River, at 20 m. 75 ch., a service bridge has been erected, and a start made with the concreting of abutments. At the Waiaua River Bridge, at 22 m. 8 ch., both abutments have been finished, and foundations of the other four piers completely concreted. A stone gabion stop-bank across the east channel and gabion facing around the eastern approach toe has been completed. During the period forty-one 8 ft. by 10 ft. huts have been erected for the accommodation of workmen.

Midland Railway.

Kawatiri Section (59 m. 17 ch. to 63 m. 10 ch.).—Earthwork is in hand and almost completed up to 63 m. 10 ch. The principal formation work dealt with during the period has been the cuttings at 61 m. 64 ch., 63 m. 8 ch., and the completion of the tunnel at 62 m. 43 ch. A start has been made with the piers of the Sandy Creek Railway-bridge at 62 m. 36 ch. and the Sandy Creek Road-bridge at the same chainage. At the Hope River Bridge, 62 m. 41 ch., consisting of three 51 ft. spans, the concrete abutments and two piers have been completed.

Murchison Section.—Formation on this section is in hand between 63 m. 10 ch. and 64 m. 15 ch., and the clearing up to 65 m. 30 ch. The principal work on this section consists of the excavation of cuttings at 63 m. 23 ch. (which is being transported to form a large bank at 63 m. 45 ch.), 63 m. 52 ch., 63 m. 73 ch., and 64 m. 15 ch.

Further hut accommodation was provided to the extent of thirty single and fifteen married men's huts. A new cookhouse was erected at Letterbox, and canteen store built and opened at Pikomanu. A recreation-hall was also erected. The increased housing was necessary to accommodate a number of men transferred from Otira.

Arthur's Pass Tunnel.—The electrical equipment of the railway from Otira Station to Arthur's Pass Station has been completed, and the line was opened for traffic on the 4th August, 1923, using electric haulage entirely over the section, since when traffic has been handled steadily and satisfactorily. The necessary staff has been trained for operating the electric locomotives and the electric generating-station. The tunnel has been lit electrically throughout, and outside structures completed and painted. Engine-sheds and a turntable have been provided at Arthur's Pass, and both station-yards lit electrically. A hydro-electric plant has been installed at Goat Creek as an auxiliary to the steam station. This plant utilizes the condensing-water before it reaches the main reservoir, and generates the power for operating the auxiliary plant and signals. It also lights the village and station-yards, thus obviating the keeping of any steam plant in commission after the last electric tram of the day has been run. Machinery and buildings used for construction purposes are being partly dismantled and removed. The section was handed over to the Railway Department on the 26th May, 1924.

Westport–Inangahua Railway.

Cascade Section.—A start has been made with the prosecution of this work between Te Kuha Station, at 5 m. 70 ch., and Cascade Creek, at 9 m. 1,200 cubic yards of slips have been removed, and the formation trimmed ready for platelaying to 7 m. 25 ch. The diversion of the Cascade Falls by means of a stone drive is in hand, and should be completed shortly. 360 tons of rails and fish-plates have been procured and stacked at Te Kuha, and contracts for the supply of 4,000 sleepers have been let. Surveys have been made for the proposed temporary siding at Cascade, and plans and estimates prepared. The erection of temporary buildings and accommodation for workmen is in hand.

Lawrence–Roxburgh Railway.

Miller's Flat Section (34 m. 70 ch. to 49 m. 45 ch.; length, 14 miles 55 chains).—The work on this line was carried on under relief conditions up till the 1st September last, at which date relief rates of pay were abolished and construction carried on under normal conditions. Formation has been completed to 46 m. 45 ch. Beyond this point work is being pushed ahead on the cuttings at 46 m. 47 ch., 46 m. 58 ch., and the siding at 47 m. 24 ch. From this point onward formation is very light, and the work is rapidly nearing completion. A work-train has been employed more or less continuously, widening cuttings and banks between Beaumont and the railhead, and satisfactory progress has been made in this direction. Craig Flat siding, at 42 m. 15 ch., has been completed and metalled. A considerable amount of road-deviation has been necessary where the existing road was interfered with by the railway, and during the past year six deviations have been completed. 350 chains of fencing has been erected, and fifteen culverts, ranging from 12 in. to 10 ft., have been completed. The bridge over the Beaumont River at 35 m. 25 ch. has been completed, and rails and sleepers laid. At the Corstorphone Stream Bridge, at 39 m. 9 ch., the superstructure has been completed, and a start is being made with the sleepering and laying of permanent track. The piers of the Tallaburn Bridge, at 40 m. 25 ch., have been erected, steelwork has been assembled, and riveting is on the point of completion. Rail traffic across this stream is being carried on by means of a temporary bridge. Jessie's Creek Bridge, at 42 m. 62 ch., was completed, and the concrete piers of the Minzionburn Bridge, at 46 m. 35 ch., have been erected, and the steelwork is being assembled. During the year the railhead has been carried forward from 39 m. 54 ch. to 46 m. 13 ch., a distance of 6 miles 39 chains. A siding has been laid at the Craig Flat at 42 m. 15 ch., and a 20-chain line has been built in the ballast-pit at 43 m. 65 ch. The first lift of ballasting has been placed from 36 m. 6 ch. to 46 m. 12 ch., and a second lift from 34 m. 74 ch. to 44 m. 54 ch. The majority of this ballast has been obtained from the pit at 35 m. 40 ch. The loading was carried out by means of a steam-shovel, which has been in constant use up to the end of April. It was then removed to a new ballast-pit at 43 m. 65 ch. Land-plan surveys were carried out and completed during the period.

Orepuki–Waiau Railway.

Orawia Section (48 m. 23 ch. to 56 m. 47 ch.; length, 8 miles 24 chains).—The formation and fencing on this section has now been completed. Rails were laid from 50 m. 18 ch. to 54 m. 75 ch., including the Pukemaori Siding. The bridge at 53 m. 27 ch. across the Ellis Stream, consisting of two 25 ft. steel-plate spans on concrete piers, has been completed. The bridge at 55 m. over the Orawia River, consisting of eighteen 20 ft. and three 30 ft. steel-plate spans on timber piers, is still in hand, all piers being completed and about half the steel girders placed. The first lift of ballast has been laid from 38 m. 23 ch. to 54 m. 75 ch., and 4½ miles of second lift and 1½ miles of third lift were also laid.

SURVEYS OF LINES UNDER CONSTRUCTION, NEW RAILWAYS, ETC.

North Auckland Main Trunk Railway.

Okaihau Northwards.—Surveys are in hand investigating the question of the best route beyond Rangiahua to connect with Hokianga waters, and a considerable amount of data has been secured.

Rotorua–Taupo Railway.

The trial survey has been completed from 3 m. to 28 m. Plans have been plotted and quantities calculated. Various alternative routes have been examined in detail, a total of 40 miles of survey having been carried out.

East Coast Main Trunk Railway.

Taneatua–Opotiki.—The permanent survey has been extended to 114 m., and permanent-line plans are complete to 113 m. Trial line has been extended up to 124 m., and explored up to 126 m. 40 ch. In all 13 miles 62 chains of trial work was completed.

Gisborne–Napier.—Permanent survey has been completed from the Napier end as far as Wairoa, and plans of this are nearing completion. Exploration surveys are in hand for alternative routes between Gisborne and Wairoa.

Waimana–Wairoa.—An exploration survey of this line has been made from Waimana to Wairoa via the Waimana Tauranga and Ruakitauri Valley.

Glenhope–Murchison.

The permanent survey was completed to the 67 m. peg, and several deviations were investigated.

Wellington – Tawa Flat.

Surveys have been carried out for the proposed Wellington – Tawa Flat deviation of the Wellington Railway. Alternative routes have been surveyed, and plans and estimates are being prepared.

A number of lines are provided for in the Railways Authorization Bill which require a little explanation. The Lawrence–Roxburgh line is at present only authorized to Miller's Flat. This railway has been known as the Lawrence–Roxburgh line for the last twenty or thirty years, and I propose this year to authorize the final section of it, but this does not indicate that construction will be immediately proceeded with. Further investigation must be made into the economical aspect before a decision to proceed is arrived at.

With regard to the Rotorua–Taupo Railway, the Royal Commission which took evidence and inquired into the matter in 1922 reported that there was no possibility of the railway to Taupo being a payable proposition under present conditions, but with regard to the portion to Waiotapu they stated:—

"We respectively beg to endorse the opinion that in order to realize the value, both present and prospective, of these plantations, means of transit by railway must be provided, and we may add that a railway from Rotorua, terminating at a suitable point in the vicinity of the Waiotapu plantations, would reasonably serve the present settlement in the Waiotapu Valley, and would open up a further large area of land for development. There is also a possibility that the indigenous forests to the west of the Waikato River can be tapped by such a line."

It is proposed therefore only to authorize the first portion to Reparoa, which is on the flat country just beyond Waiotapu. A terminus at this point will serve all the agricultural interests for some years to come, and will provide the necessary means of access, without which the extremely valuable forests which have been constituted by the Government's planting operations cannot be brought into a profit-producing stage.

With regard to the Dargaville–Kirikopuni Section, this was also inquired into by the Railway Commission in 1922; and, although this is being authorized this year, it will not be possible to carry on with any construction until some of the extensive operations now in hand in the North are drawing to a close.

With regard to the Whakatane Branch, the Government appears to some extent to be committed to the providing of railway connection, but although being authorized this year it is not proposed to go on with the actual construction until it can be shown that the same is justified.

As a sub-appendix to this report there will be found at the conclusion copies of the reports made by Railway, Agriculture, and Public Works Departments concerning the Balclutha – Tuapeka Mouth Railway, reports by the Public Works and Railways Departments concerning the Waihao Downs Railway, reports by Public Works Department concerning Waipu Branch Railway, and, in addition, a number of reports bearing on the question of the route of the railway between Wairoa and Gisborne. These reports are submitted in order to show the manner in which such subjects are approached.

CONSTRUCTION AND MAINTENANCE OF ROADS AND BRIDGES.

The following are some of the principal works which have been completed during the year, or are still in hand:—

Kirikopuni – Parakao (Hobson County).—Two miles of dray-road completed and 8 miles in hand. Limiting grade 1 in 25, and curvature 2½ chains.

Wairoa River Bridge, Dargaville (Hobson and Otamatea Counties).—It is expected that this bridge, consisting of thirty 40 ft. and eight 20 ft. spans and one 60 ft. lifting span, will be completed early next year. The substructure is ferro-concrete throughout, with a superstructure of steel joists and hardwood decking.

Mangamuka – Victoria Valley (Mongonui and Hokianga Counties).—Six miles of dray-road formation have been completed, and 3 miles metalled. The damage caused by floods has seriously delayed the completion.

Coromandel – Colville Coast Road (Coromandel County).—Two miles 35 chains bridle-track in difficult country widened to dray-road.

Putaruru – Arapuni Road (Matamata County).—To provide access from the Rotorua Railway to the proposed Arapuni hydro-electric works a large amount of work has been done, including 7 miles of dray-road formation, 6 miles metalled, and 4 miles of metalling in hand.

Waipa River Bridge, Whatawhata.—It consists of three 111 ft. and two 25 ft. spans, all in hardwood. All is now completed except the stringers, decking, and handrails.

Rangiriri Hills Deviation (Waikato County).—Practically all the formation work on the deviation has been completed, and most of the formation, and the remainder, as far as Rangiriri Township, is already well in hand. Up to date approximately 4½ miles have been metalled between Whangamarino Creek and Tekauwhata Junction. There is metal already delivered for a further 3 miles, and arrangements have been made for the delivery of metal necessary for the completion of all metalling between Mercer and Huntly. These supplies of metal are coming from four distinct sources, and it is confidently anticipated that the whole will be completed before next winter.

Lichfield–Atiamuri Deviation (Taupo County).—4 miles 12 chains of 16 ft. dray-road have been completed and made available for traffic since February last.

Gisborne–Wairoa via Morere (Cook and Wairoa Counties).—A very large amount of work has been done on this important link. Many improvements in alignment and grading between Kopua, at 21 miles, and Tarewa, at 38 miles, have been carried out. Seven miles of road have been metalled by means of a fleet of sixteen lorries, with leads up to 7 miles. The whole length of the Wharerata and Tarewa hills has now been metalled; 16 chains have been sealed with bitumen, and sufficient materials delivered for a further 4 miles of sealing. Arrangements are now being made for the supply of materials for the sealing of the balance of the road along the main range, measuring approximately 7 miles.

Rotokautuku Bridge (Waiapu County).—This bridge has four 144 ft. spans on reinforced-concrete piers founded on cylinders. All cylinders have been sunk, and two piers are finished. All material for the superstructure is on the site, and a contract for erection has been let.

Wairoa–Waikaremoana Road (Wairoa County).—The metalling from 19 miles to 32 miles, which was in hand last year, has been completed, and the whole length handed over. The renewals of four bridges on concrete piers and with hardwood superstructure have been completed. The road is now fit to carry the heavy machinery which will be required in connection with the Waikaremoana hydro-electric development.

Mimi–Mokau (Clifton County).—Improvements in formation by deviating, widening, and regrading have been effected, notably to the north of the Tongapoutu River. A new quarry of limestone, 3 miles up the Mokau River, has been opened up, and a barge service installed; 1mile 77 chains of metal laid, and 29 chains grouted with bitumen.

Patea River Bridge, Stratford.—This bridge, consisting of a reinforced-concrete arch, 64 ft. span and 97 ft. 6 in. wide, has been completed.

Dummy Hill Deviation (Akitio County).—31 chains of dray-road formed and 538 lineal feet of "Armco" and concrete culverts constructed.

Rimutaka Hill (Hutt and Featherston Counties).—The widening and metalling of both sides of this hill have been completed, together with 6 miles of fencing.

Mungaroa Hill (Hutt County).—1 mile 40 chains of formation and metalling on very heavy sideling almost completed.

Ruamahunga Bridge (Featherston County).—A reinforced-concrete bridge, consisting of four 55 ft. and five 27 ft. spans, with a width of 18 ft., has been completed.

Paekakariki Hill (Hutt County).—The widening of 2 miles of this road in very heavy country has been almost completed, and partly fenced.

Branch River Bridge (Marlborough County).—Approach embankments and stop-banks have been raised and widened; abutments protected by stone gabions, and all material at site for five 40 ft. steel-joist spans on hardwood piers.

Karamea River Bridge (Buller County).—This bridge, consisting of four 112 ft. spans in hardwood is now under construction by contract.

Greymouth–Westport Coast Road (Buller and Grey Counties).—6 miles 60 chains of dray-road formed, and 35 chains of metalling completed, thus leaving only 2 miles in the whole length that is still impassable for vehicular traffic. A great deal of bridging is still to be done.

Inangahua Junction Bridge (Inangahua County).—This bridge, consisting of nine 60 ft. spans, is now under construction by contract. It consists of superstructure of rolled-steel joists and hardwood decking upon cylinder piers and concrete abutments.

Waitangi River Bridge, Main South Road (Westland County).—This bridge of five 61 ft. spans, has been completed. It consists of hardwood superstructure on hardwood piles.

Double Hill Runs Road (Ashburton County).—Formation of 6 miles of dray-road and 4½ miles of metalling have been completed.

Pomahaka River Bridge (Clutha County).—This bridge, consisting of two 121 ft. spans, has been completed. It consists of hardwood superstructure on central cylinder pier with concrete abutments.

HYDRO-ELECTRIC WORKS.

Arapuni.

The principal work done in connection with this scheme during the year was the letting of a contract for the construction of practically the whole of the hydro-electric development from the water up to the outgoing feeders. Tenders were invited for the work, divided into two contracts—No. 1 being more essentially the hydraulic development, including diversion tunnel, with its regulating-gates, temporary dams, permanent dam, head-race, spillway weir, and the gates giving access to the

penstocks. The second contract continued on from this point through the powerhouse, turbines, electrical generators, transformers, switching-gear to the main outgoing feeders, and including all the innumerable auxiliaries necessary to produce a complete plant in going order. The contracts laid it down that preference would be given to any firm tendering for both contracts, as the absence of friction between two contractors whose interests would not have been coincident, and whose works would have to be co-ordinated, and the saving in supervision, would have justified the payment of a higher sum in order to get the work let to one contractor. However, the Department was fortunate in that a satisfactory tender by a British firm for both contracts was very considerably less than any other combination. The successful tenderers were Messrs. Sir W. G. Armstrong, Whitworth, and Co., and the price £1,170,991 13s. 8d.

One of the conditions of the contract was that the Department would provide certain access, and the greater part of the work done on the ground by the Department during the past year has been in the direction of providing this access, and preparing accommodation for the Department's staff which will have to supervise the work. The access may be assumed to commence at the Putaruru Railway-station, the nearest point to the works on the existing railway system, and from this point a good metal road is being constructed to the site of the contractors' probable activities on both sides of the river. This involves a very considerable bridge, which must be sufficiently strong to carry 40-ton loads across the Waikato River. The first section from Putaruru, 0 m. to 2 m. 60 ch., has been completed. From 2 m. 60 ch. to 5 m. 30 ch. the road has been trimmed up and the bottom layer of coarse sand has been laid. Owing to non-completion of the Waipa Bridge, due to difficulty in procuring hardwood, no shingle could be laid on this length before the weather broke at the beginning of winter, and little could be done since on account of the continuous bad weather, and, as a result, portions of this length are now in bad order. Five motor-trucks and a number of teams are at present at work, and, given a month's reasonable weather, will soon make good the damage.

The third section, from 5 m. 20 ch. to 8 m. 50 ch., has been completed, and the remaining 1 mile 4 chains to the dam-site has been sanded, and is now ready for the shingle. The bridge itself was constructed in the Department's workshop at Tauranga at a price considerably below that of the lowest public tender, and in less than contract time.

Piers and abutments, which are of concrete, are now in hand, all the excavation being completed, and the large pier on the east bank being also concreted. In order to facilitate this work a 2-ton cableway was erected, and is being utilized also for transporting men and material from bank to bank. On the farther side of the river the portion of the road from the Waikato Bridge to the head-race bridge-site is partly completed, but has been delayed owing to the failure of the contractor. The piers of the bridge over the head-race (which will become the Waikato River) are proceeding satisfactorily, and the foundations will shortly be completed. The bridge will consist of four 40 ft. rolled-steel joist spans on concrete and timber piers. The principal material for the superstructure is on the ground. From the head-race bridge to the point where the new roads join the existing Pukeatua Road the formation is practically completed, and 35 chains have been sanded. In addition, 22 chains of shingle has been done on the finished portion of the abandoned contract between the two bridges referred to above. The fencing of the main access road on the right bank to the camp reserve is now finished.

Throughout the year investigations were carried out in considerable detail, both on the Maungatautari Mountain and along the Waikato River, in order to try and find a more favourable quarry-site than the one which was referred to in the contract specifications, and on which the tenders were to be based. In spite of several very hopeful clues, however, nothing better could be found than the deposit at Muku Creek on which the contractors were asked to tender.

The permanent-village site was fenced, cleared, and sown in grass. The main street was formed and metalled. Four permanent cottages and the main Public Works office were erected. A high-tension transmission-line was carried from Horahora to Arapuni, from which power is being obtained in connection with the works referred to above, and from which the lighting and heating for the village-site and buildings are being obtained.

During the year various small surveys in connection with the proposed bridge-sites, land boundaries, &c., together with two hydrographical surveys, were completed.

On the main access road referred to above, bridges were erected at 2 m. 50 ch., 3 m. 29 ch., 5 m. 29 ch., and another at 7 m. 63 ch. is almost completed. All the bridges on this road are special, being practically as strong as railway-bridges, owing to the very heavy loads that will have to be transported in connection with the power-house and other machinery.

Horahora.

The principal work carried out during the year has been the erection of the new power-house extension and installation of machinery, the deepening of the tail-race, and the investigation regarding the permanent weir. The excavation of the power-house site was carried out by means of power excavators and trucks, this work being carried out simultaneously with the completion of the head-race and tail-race walls and the underpinning of the old power-house on the side adjacent to the extensions. The concreting of the power-house has now been completed with the exception of 4 ft. at the top of the down-stream wall. The work of building this power-house was more than usually difficult, owing to the somewhat intricate nature of the boxing, for the draught-tubes particularly. A difficulty was experienced in the excavation of the tail-race owing to a leakage from the old tail-race, which is only separated by a comparatively thin division. A total of 5,123 cubic yards of concrete was placed.

Castings and machinery for one complete unit have been transported from Hinuera Railway-station, a distance of eleven miles, over exceptionally bad roads. Foundation castings for one turbine are now in position, and the work of assembling is going ahead smoothly.

In order to demolish the old head-race wall built by the Waihi Company the station was shut down during the Easter holidays. Pneumatic drills were operated over the whole face of the wall, which was then blasted in layers, the disposal of the spoil being effected by the use of power-driven excavators and trucks, together with a barge; 450 cubic yards of concrete were removed in this manner.

Another portion of the work which requires careful handling is the deepening of the old tail-race. The bottom of this tail-race, which consists of volcanic tuffs, requires to be broken up before it can be handled by dredging. The method adopted is to drill holes by pneumatic drills, operating through stand-pipes, at an average depth of 12 ft. below water-level; the holes are then loaded through these stand-pipes and fired electrically. So far an area of 650 square yards has been dealt with. In order to handle the blasted material from this excavation, a cableway drag-line excavator is to be used for dredging the 8,500 cubic yards of spoil. This drag-line has a maximum range of 700 ft. The erection of the machine is practically complete, and a start with the actual excavation will be made almost immediately.

The new bay of the transformer-house has been started, and minor alterations to the workshop carried out.

A considerable amount of investigation work has been carried out to enable a suitable site for the permanent weir to be located. An examination discloses unsuitable foundations at some of the earlier-selected sites, but the line of the weir has now been definitely fixed, and a comprehensive plan of the layout has been prepared.

Two permanent-staff cottages have been built, and various temporary and maintenance works have been attended to.

Mangahao.

Very substantial progress has been made with the construction of these works during the past year. The most difficult portion was the construction of the lower Mangahao dam. In order to enable the foundations of this dam to be put in, two separate methods of construction had to be followed. One half of the dam is an earthen dam with a concrete core wall. This core wall had to be carried down some 70 ft., and the excavation required very substantial and carefully placed timbering in order that the material in place, which was to act as the major part of the dam, might not be in any way disturbed, and more particularly in order that the large number of men working in the confined spaces below might not be injured by falling stones or other substances. This work, though tedious and extensive, presented no unusual difficulties. The other half of the dam, however, had to be built of solid concrete, and founded in a narrow gorge in which the water was from 12 ft. to 14 ft. deep at normal times, and might be twice that in less than half an hour if heavy rain fell in the hills. The first operation was to divert the river by means of a by-pass tunnel, and construct elaborate coffer-dams to lay bare the site of the foundation. A heavy crib log pile and concrete dam was first required to divert the river through the by-pass tunnel; secondly, two double rows of steel sheet piling, filled with stones, clay, and concrete, were built, one above and one below, and heavy pumps were installed in duplicate to prevent interruption; and finally, when the site had been pumped dry and excavation had progressed considerably, a watertight reinforced-concrete temporary dam, both above and below the permanent work inside the main coffer-dam, had to be built.

The work was inundated by floods repeatedly, often with hardly any warning, so that men sometimes barely escaped with their lives; but, although these floods caused considerable delay, the detail arrangements for removal and securing of men and material were so successful that practically no plant or temporary work was lost. Every opportunity was taken when circumstances were favourable, and work was carried out night and day by means of three shifts.

In order to prevent an undue rise of the flood-waters as the work progressed, which would have resulted in flooding the No. 1 tunnel, and also to enable aggregate for concrete to be obtained from the river-bed, a gap 40 ft. wide was left in the main portion of the dam as soon as the foundations were brought up to ordinary water-level. This gap will be filled in after the gates have been placed in position.

The gates for the by-pass tunnel and for inlet No. 1 tunnel are now being placed in position. Great trouble has arisen from the non-arrival of these gates, the contract for which was let long before the excavation started.

The total quantity of concrete in this dam will be 21,827 cubic yards, and of this amount 16,019 cubic yards had been placed at the end of the period. The last 3,000 yards will be complicated reinforced-concrete work in connection with the automatic regulating-gates; but, quite apart from the construction of this portion of the regulating-gates, water can be diverted to the power-house and the same put into commission.

The Tokomaru dam is nearing completion. The excavations of the foundations were carried out in the early part of the year, and since then 18,698 cubic yards have been placed out of a total quantity of 21,800. As there were no deposits of shingle or stone adjacent to the work, all the stone for the concrete had to be quarried and crushed, and the sand made by pulverizing the quarried rock with special machines. The tunnels connecting the two dams, carrying on from the Tokomaru dam to the surge-chamber, which were driven last year, have been lined throughout, and only the closing-up of adits, fitting of gates, and grouting of packing requires to be done. There will be no difficulty in diverting water to the power-house as soon as works there and beyond are ready. The surge-chamber is practically complete, and only requires the erection of gates and screens, which are on the ground. The pipe-lines have been practically completed, with the exception of the 72-in.-diameter pipes between No. 1 anchor block and the entrance to the tunnels leading to the surge-chamber. The pipes themselves are all on the site, and have been riveted up in long lengths in order to facilitate their final placing, which will be proceeded with as soon as the crushing and concrete-mixing plant, which is located at this spot, is finished with and removed.

The power-house has been completed, and the erection of the machinery is in hand. It had been hoped that this power-house would have been completed somewhat earlier, but great difficulty has been experienced in obtaining sufficient carpenters and other skilled men, and this hindered the work somewhat.

As the water from the tail-race now discharges into the Mangaore Stream, it was considered advisable to raise the banks of this stream over the low-lying country from below the railway-line to the Manawatu River, a distance of 1 mile 56 chains. The Makarua Drainage Board, which controls this area, was itself proposing to carry out a scheme of banking to deal with the flood-water of this river, quite independently of the Department's tail-race proposals. Arrangements were accordingly made for the Board to carry out the banking on lines set out by the Department. The Makarua Drainage Board, the Buckly Drainage Board, the Horowhenua County Council, and the Foxton Borough, all of whom receive benefits from the work, have agreed to contribute to the cost of the work. It was also necessary to erect a new bridge, 80 ft. long, on the Foxton–Shannon Road, on the same level as the top of the banks.

A very difficult feature in connection with this installation has been the erection of the main transmission and telephone lines. Altogether some 200 miles of transmission-poles and 160 miles of telephone-poles have been erected. Cables were run for 150 miles of transmission-line and over practically the whole length of the telephone-line. The difficulty of the work was largely on account of the very rough nature of the country traversed; consequently a great deal of preparatory work was involved, requiring the construction of some 30 miles of track, and the installation of no less than 600 gates. Owing largely to the cost and difficulty of transporting the long and heavy ironbark poles across country, the roughest sections, notably between Paekakariki and Khandallah, were designed for the use of steel towers, which could be sledged into position in small bundles.

The scope of the work extended on the west coast from Wellington to Wanganui, and on the Wairarapa side from Masterton to Waipukurau. This work is well in hand, and will shortly be completed.

The erection of substation buildings at Bunnythorpe, Masterton, Mangamaire, Woodville, and Dannevirke is in hand, and all the material for the equipment is on order.

A contract for the building of the Khandallah substation was placed during the year, and is now well advanced. The structural steelwork for the switchgear is completed, and switches mounted thereon.

All subsidiary buildings have been erected, and oil-tanks and lightning-arresters are in position.

WAIHOU AND OHINEMURI RIVERS IMPROVEMENT.

Upper Waihou River.

Mangaiti–Tirohia Section.—During the period 148 chains of final stop-bank have been constructed by a small drag-line and the dredge "Waihou," and 226 chains of preliminary stop-bank by hand-labour, leaving only 26 chains on the section untouched.

Tirohia–Ngararahi.—Left bank: All drainage on this section has been reversed into drain H, and the temporary flood-gates thus rendered inoperative have been removed. Right bank: The Waihou dredge, working two shifts, has built the stop-bank to final section, completing 53 chains during the period. The soiling of same has also been completed.

Lower Waihou River.

Ngahina–Netherton.—Left bank: All interior drainage has been completed, with flow mainly into drain H. The gaps in preliminary stop-bank down to Netherton have been closed, and the breaches, 4 chains in length, caused by the flood of the 27th May, are being closed. Right bank: A small drag-line has extended the preliminary stop-bank to the mouth of Morrison's drain at 5 m. 62 ch., a length of 90 chains, and has also widened the railway outfall drain at Waimarie Bend to 12 ft. bottom width for the complete length of 31 chains.

Netherton–Wharepoa.—Morrison's drain at 5 m. 62 ch. (right bank) is complete, and in Alexander's drain the dipper dredge has excavated from the river for 47 chains. About 3 miles of willows on both banks have been ring-barked.

Komata Creek.—The excavation of the creek-bed was completed by a small drag-line, and stop-banks have been trimmed on both banks to the high ground, with the exception of 16 chains on the right bank below the railway. The spoil for the raising of the railway and bridges is in position.

Ohinemuri River.—Left bank: The log-hauler has commenced operations at the new junction, and has already cleared 25 chains of bank. One of the large drag-lines has constructed 126 chains of stop-bank to final section from 7 m. 36 ch. to 5 m. 30 ch., and the Waihou dredge has completed a length of 9 chains where the critical line crossed the Waihou meander to 6 m. 40 ch. and 6 m. 70 ch. The construction of the stop-banks over the Tapu Kopuarahi at 6 m. is being done by hand-labour.

The second large drag-line has constructed 192 chains of stop-bank to final section, from 3 m. 55 ch. to 1 m. 26 ch., and from 0 m. 14 ch. to 0 m. 6 ch., connecting to the final stop-bank completed by relief works from 0 m. 14 ch. to 1 m. 26 ch. This machine has now in hand the section 3 m. 72 ch. to 5 m. 15 ch., to connect with the stop-bank being erected by No. 2 Ruston. Of this 3 m. 72 ch. to 4 m. 68 ch. has been completed. The deviation of the Paeroa–Waihi Railway at 0 m. on the stop-bank chainage is now in hand by the contractor. Numerous small culverts have been

constructed under the stop-bank to connect existing house-drainage, &c., to the river. The stop-bank and road-deviation over the Kauoiti Creek and the three-barrel flood-gates at 3 m. 70 ch. are completed. The removal of the houses that foul the stop-bank line is now in its final stages, only two structures remaining to be dealt with.

Rotokohu Outlet Drain.—This drain has been excavated from the temporary outlet into the Waihou River at Mill Road to the four-barrel flood-gate at 7 m. 45 ch. on Ohinemuri River (left bank). One of the small drag-lines excavated to 0 m. 70 ch., was then removed from the work, underwent overhaul, and was transferred to Tokatoka. The remainder of the work was completed by the dipper dredge in November last, and the by-pass at Mill Road filled in.

Ngahina Bridge.—The structure and approaches have been finally completed by the erection and metalling of the left-bank approach.

Ngahina Wharf.—This structure has received attention by the concreting of the loading-ramp, minor alterations to the shed, and the metalling of the approach road.

General.—Since the beginning of April last the progress of the work has been impeded by four floods. Not only has a certain amount of damage been incurred, but the high state of the rivers has for a time made working-conditions impossible. The opportunity presented by these floods has been grasped to collect a considerable amount of flood data bearing on the scheme.

MARINE.

Lighthouses.

Three Kings Islands.—In my last report I detailed the investigation which had been made in order to determine the best navigational aid to establish for or on these islands. Full estimates were made of the cost of erecting and equipping two lights, one at either end of the Big King, in order to reduce the blind sector which one light would produce over the Western King and the Princes Isles. Information was obtained regarding the very latest types of fog-signal suitable for this locality, and an estimate prepared for its installation in conjunction with the proposed lights. At the same time an examination was made as to the possibilities of a direction-finding station located at Cape Maria van Diemen or elsewhere. A number of tests were carried out by the Post and Telegraph Department, in collaboration with the officers of the "Tutanekai," with eminently satisfactory results, and these tests effectively demonstrated that the erection of a modern direction-finding station suitably placed in an accessible locality would enable mariners to locate their position accurately whatever the condition of the weather, and thus remove the menace of the Three Kings perhaps more effectively than could be done by means of the lights and fog-signal. It is proposed to carry out a further series of tests in the presence of representatives of the Shipmasters' Guild, and it is anticipated that these tests will demonstrate the advantages of the wireless direction-finder as an aid to navigation, and convince shipmasters of the correctness of the Department's contention that lights and a fog-signal on the Three Kings are not at present justifiable.

Tiritiri.—The apparatus has been ordered and is now to hand for the conversion of this light from a watched light to an automatic. The work of conversion will be put in hand shortly.

Ohena Island.—The erection of an automatic flashing light on a concrete base has been completed, and the light is now in operation.

Matakaoa Point.—Plans and estimates have been prepared and apparatus ordered for an automatic flashing light at this point. This light will be erected at a height of approximately 100 ft., and will have a range of 14 miles, and an arc of visibility of 199° 30′. This light will serve a twofold purpose. Owing to the shifting of the East Coast Lighthouse from the island to the mainland there is a small dark sector to the northward. The new light on Matakaoa Point will be of great assistance to shipmasters coming from the north for turning the Matakaoa Point before they come actually within the range of East Cape Light; secondly, it will act as a port light in connection with the new wharf now being constructed at Hicks Bay by the Hicks Bay Harbour Board.

Kaipara South Head Beacon.—A small automatic acetylene flashing light was installed at this beacon in place of the oil-burning lamps, which required an attendant. The new light is giving satisfactory service.

Somes Island.—This light was converted from a watched oil-burning to an unwatched automatic acetone-acetylene light with a very considerable amount of saving, and handed over to the Wellington Harbour Board.

Stephen Island Lighthouse.—The installation of two oil-engine hauling-winches to take the place of the original horse-operated whims has been completed.

Cape Foulwind.—Surveys have been made and plans prepared for the erection of a new lighthouse at this spot. The existing light-tower, which is of wood, is commencing to deteriorate, and a new concrete tower will be required. The new lighthouse will be an automatic one of the Dalen type, utilizing an incandescent acetylene burner with automatic mantle-exchanger. This is the latest development in the design of automatic lights for the higher-powered stations. No lighthouse-keepers will be required, and there will be a great saving in connection with fuel, as well as attendants, which will pay off the capital cost of the conversion within a very few years.

Chatham Islands.—It is proposed to erect a small electrically operated light on the wireless mast at the Chatham Islands. Details are being prepared and arrangements have been made with the Post and Telegraph Department to allow the use of their mast and electric supply. It is anticipated that this light will be of great assistance to vessels wishing to make Waitangi after nightfall. At present the shipmasters do not care to approach these islands in darkness, owing to the dangerous outlying reefs.

Kahurangi.—This is at present a second-order watched oil-burning light; it is proposed to convert it to an automatic acetylene light. Plans and estimates have been made, and it is hoped to make a start with the conversion very shortly.

Anglem Point.—The necessary apparatus for the conversion of this light to an automatic flashing type has been obtained, and is at present undergoing tests prior to installation.

The Brothers.—New rollers and roller-paths have been fitted to the revolving portion of this light to take the place of the original ones, which had become badly worn.

General repairs and maintenance works were carried out at the various light-stations, cottages, &c.

Harbour-works.

Gisborne.—A great deal of controversy has arisen concerning the proper solution of the Gisborne Harbour problem, and, with the idea of endeavouring to come to a settlement, I accompanied the Hon. Minister of Marine to Gisborne, and discussed with the Board and its officers the whole question. It was finally decided that certain definite questions concerning a scheme put forward by Mr. G. H. Lysnar should be answered by me, and after a great deal of investigation the questions were answered and the Board definitely decided to adhere generally to the scheme of harbour-improvement devised by Mr. Leslie Reynolds, and approved some years ago by the Department. The Harbour Engineer is now working up the detail plans, which will be forwarded for formal approval in due course.

Waikokopu.—The Waikokopu Harbour Board having amalgamated with the Wairoa Harbour Board, the combined Board decided to do nothing further in the way of improvement with the Wairoa Harbour, but to concentrate on Waikokopu. However, after spending a considerable amount of money in an unsuccessful attempt to dredge out the inner basin, the Board found itself unable to proceed further for want of finance and public confidence. Eventually the Minister of Public Works agreed that his Department would erect a wharf in such a position and of such extent and depth of water as would cater for all coastal and lighter traffic, and would yet fit in without loss with the major breakwater scheme, should that be put in hand at a later date. The wharf was pushed on with, and will be ready for use very shortly. Being connected with the railway to Wairoa and the freezing-works and other industries, it will be of great assistance to the district generally, and also to the Government, in landing material for its works.

Westport.—The principal work in connection with this port has been he maintenance dredging at the bar and at the berthages. The "Eileen Ward" removed 472,705 tons from the entrance, and the "Mawhera," which was chartered from he Greymouth Harbour Board, dredged 67,350 tons from the berthage area. The "Eileen Ward" has not handled as large a quantity during the past year as usual. This is owing to the fact that dredging was suspended during the coal strike, as there was at that time practically no shipping working the port. Weather conditions were such that a sufficient depth of water was maintained on the bar to adequately serve any vessels visiting the port at that time. No additional work was carried out on the breakwater, the work which had previously been carried out proving very satisfactory and maintaining its position well. While the dredge was idle the work of painting and repairing all buildings in connection with the harbour-works was put in hand, and these buildings are now in first-class order. The fleet and all plant necessary for the prosecution of the works has been carefully attended to and kept in first-class repair throughout the year. A survey of the roadside has been made and all soundings plotted on regularly.

Waitangi Harbour, Chatham Islands.—A number of requests for improved harbour facilities at Waitangi having been received, arrangements were made to visit these islands and report on the position generally. Surveys were made, and the various propositions put forward investigated. The present wharf is unsatisfactory in that the depth of water is insufficient at low tide for the boats lightering cargo from the steamers. This aspect of the question can be improved by extending the wharf and deepening the channel, but not sufficiently to enable steamers to unload direct. It is naturally desired by the residents to have a wharf at which small steamers could lie while loading and unloading, and it has been proposed that a small breakwater might be constructed. Unfortunately, this would be a fairly expensive undertaking, and the present volume of trade is not sufficient to justify it. There is at present no local authority with power to control and finance any improvement scheme, and until such is established matters are not likely to improve to any great extent. A movement is now in progress to form a County Council, which could also act as a Harbour Board and attend to such matters.

Bruce Bay.—The crane-landing and approach bridge at the Flowerpot Rock has been completed and is in operation. Considerable difficulty was experienced in erecting some of the piers owing to very heavy weather when the concrete bases were being set. Loading and unloading can now be satisfactorily carried out here.

Kaipara Beacons.—These have been repaired, and arrangements made for protection work to be carried out at the North Head to guard against the sand erosion.

Tryphena Wharf, Great Barrier Island.—A very full investigation has been made to ascertain the best locality in which to erect this wharf. A subsidy has been provided by the Government, and immediately the local interests are agreed the work can proceed.

General repair and maintenance works were carried out at the various small harbours under the control of this Department, and regular surveys have been made and complete records are being obtained of the various changes which have taken place at the Wairau bar.

General.

As usual, a number of applications have been received from local bodies and private individuals for the approval of works involving marine interests. These have all been carefully investigated, and, where desirable, approved. Some of the principal items were:—

Wharves.—Onekaka; Otanerau; Queen Charlotte Sound; Nelson Street Jetty, Auckland; Hicks Bay; Kutarere, North Auckland; Endeavour Inlet; Maori Beach, Stewart Island; Wairoa River; Warkworth Harbour; Hokianga Harbour; Whananaki, Whangarei; Pakawa Estuary; Nelson Electric-power House; Kennedy Bay.

Foreshore Leases.—Heathcote Estuary; Mongonui; Mercury Island; Hokianga Foreshore; Paremata; Purakunui; Stewart Island.

Harbour-works.—Gisborne; Hicks Bay; Bluff; Castlecliff; New Plymouth.

IRRIGATION.

During the past year the development of the various irrigation projects in Central Otago has been steadily carried on. No new construction works were started, but those in hand have been vigorously pushed on and extended.

Although the profit on the older schemes is not expected to pay a high rate of interest on the outlay (owing to excessive war costs, &c.), an examination of their position shows that in due course they will pay a reasonable rate of interest, besides rendering considerable indirect benefits. All the later schemes, estimated upon steadier known costs and experience gained, are based on water rentals calculated to return sound rates of interest.

Of the various schemes, two—that is, Ida Valley and Galloway, with which is incorporated Olrig Terrace scheme—are now in operation on regulation lines, although a certain amount of construction work still remains to be completed on each. So far water has only been used on about half the area now commanded, and the water rentals on the areas actually served have not nearly reached their intended maximum. Practically every other scheme under construction is now in its final stages of development, and all were in partial working order during the year. It is expected that all of these will have attained to full working-order during the current year, though it will take a few more years before the areas are fully settled, and the land prepared to receive full advantage of the works.

The area actually irrigated under all Government schemes was 14,667 acres, divided among 200 settlers, as against 8,200 acres in the previous year. In their partial stages of completion the works are now ready to serve 47,430 acres, but on full completion, which is aimed at by the end of the current year, the total area commanded will be increased to 61,390 acres.

In addition to the Government schemes, individual company and local-body schemes are completed or in final stages of development to serve 18,000 acres of land. It is therefore evident that, as settlement increases and full advantage is taken of the water-supply made available, the next few years should see a great increase in the productivity of Central Otago.

The results of irrigation have everywhere been most satisfactory, as has been very noticeably exemplified on Galloway Flat. This small area, of about 1,200 acres, which was previously one of the most useless tracts of land, and which is yet only in the making as regards farm development, is now supporting twenty settlers. It is regularly carrying and wintering fifty horses and 250 head of cattle, and producing large quantities of surplus hay. During the year 120 tons of pressed lucerne hay, bringing as much as £7 per ton on truck, were railed away, and in addition about 2,500 sheep from adjoining runs are being wintered on the flat, by arrangement with the small settlers, who feed out lucerne hay to them. The feature of the small settlers providing winter feed for runholders as a side line is remunerative to them, and is affording such a saving in winter losses on the runs as to vastly improve the value of the run properties. Dairying is steadily increasing, and there are good openings for experienced dairy-farmers throughout the district. One ex-North-Island dairy-farmer has carried and is wintering thirty-one dairy cattle on a 62-acre farm, which is yet only partially developed.

A particular feature of the year has been the carrying-out of investigation for water-supply, and surveys and estimates necessary for consideration of further possible irrigation schemes. Further schemes have been fully investigated and proved satisfactory with respect to 74,000 acres of irrigable land in the upper Manuherikia Valley amd Maniototo districts, and 6,500 acres in the vicinity of Arrowtown. Besides these, several other large prospective schemes are still under survey.

Progress of Individual Works.

Ida Valley Scheme.—With the exception of a few small distributary races which may be required to be constructed from time to time to cope with the requirements of various farms, all irrigation works in the whole Ida Valley scheme are now completed. The chief works completed during the past year were Poolburn weir, one measuring-weir at the Poolburn and another at Moa Creek, and approximately 2 miles of distributary race. The crest level of the Moa Creek weir was also raised, enabling better regulation to be attained and more economical use to be made of the water stored in the Manorburn reservoir. During the past season water was supplied to forty-four irrigators, who had under irrigation a total area of 7,200 acres.

Galloway Scheme.—Under this heading is now included the contiguous Olrig Terrace scheme. On Olrig Terrace it was originally intended to irrigate 1,600 acres, but works have not been constructed to supply this full area. It has now been decided to irrigate a lesser area, and the balance of the water previously allocated to the Terrace lands can now be diverted to Ida Valley. The total area commanded by races on the combined schemes is 2,250 acres, and of this an area of 1,650 acres was irrigated during the past season.

Manuherikia Scheme.—During the 1922–23 season only partial irrigation was available, but during the past season, although construction work was still proceeding, a full water-supply was available for all irrigators up to 18 miles. After the end of October, forty-three irrigators, who had a total area

of 2,050 acres under irrigation, were supplied with water. To increase the effectiveness of the scheme, some large areas for which the owners had refused to enter into irrigation contracts are in process of being resumed, and will be subdivided for closer settlement. At the end of November, 1923, an extensive break occurred in the concrete-lined race in the Manuherikia Gorge, and temporary measures had to be resorted to to bring in the necessary water-supply. Preparations are now being made for the erection of an iron flume across the unstable ground. During the past year such works as the enlarging of a 3-mile section of the former borough race, the construction of distributary races, and other details were carried out.

Earnscleugh Scheme.—Half of this scheme is now completed and is in working-order. An extension which will increase the total area commanded by the races to 2,843 acres is being put in hand. Some small extensions and the completion of details comprised the bulk of the work done on this scheme during the year. The number of irrigators, thirty-five, supplied with water shows an increase of ten over the previous year's figures, the total area under irrigation being 1,110 acres.

Ardgour Scheme.—This scheme has been in working-order during the past season, when water was supplied to eighteen irrigators. The area under irrigation was 1,146 acres, and a substantial increase in this area is to be expected during the current year. The results so far obtained on this scheme have fully justified expectations.

Last Chance Scheme.—The major portion of this scheme is now nearing completion, and the main race is being extended northwards from Butcher's Creek to supply lands lying nearer Alexandra, thus making it possible to throw open a few new Crown sections for settlement. It is expected that the whole scheme will be available for use by the beginning of next irrigation season. During the year ten miles of main race were constructed and 2,000 ft. of steel-pipe siphon lines laid. Water was supplied by means of some auxiliary races to six irrigators on the Fruitlands Settlement, the area under irrigation being 696 acres.

Tarras Scheme.—Construction work on this scheme is now well advanced, and it is hoped to have the scheme generally completed before next irrigation season. During the past year 5½ miles of new main race were constructed, and 4½ miles of the existing main race enlarged. The new concrete headworks are now practically completed, and the work of constructing the steel-pipe siphon lines is in progress. As the land brought under this scheme is of excellent quality and lends itself well to irrigation, most favourable results may be expected when the scheme is in operation.

Teviot River Scheme.—This scheme has been carried out in conjunction with a hydro-electric-power scheme supplying Roxburgh and the surrounding district. The water is drawn from the Teviot River, and after passing through the turbines on the power-house is discharged into the irrigation-canals. The progress of work on this scheme has been of a very satisfactory nature. All work in connection with the power pipe-line and power-house foundations was completed by the end of last December, and the Teviot Power Board was thus enabled to put its power scheme into official commission by the end of March. Work on the irrigation system has been pushed on apace, and it is anticipated that the main scheme will be in operation by the beginning of September, 1924. A future extension of the scheme to lands lying across the Clutha River is being considered. During last irrigation season twenty-six irrigators were supplied with water from a race purchased from a mining company for incorporation in the distribution scheme. During the past year 10 miles 45 chains of irrigation race were constructed, and 2,300 ft. of pipe siphons were laid; a bridge was constructed across the Teviot River to carry 18 in. and 30 in. diameter siphon pipe-lines. The concrete foundations of the power-house were laid, and the pipe-line at the head of the race was generally renovated.

Bengerburn Scheme.—This scheme, which draws its supply from the Bengerburn Stream at Ettrick, was commenced at the request of the settlers, who were, at the time, applying for the forfeiture of certain private water rights held in the Bengerburn. An agreement was arrived at by which the Crown acquired a portion of the water rights, and construction work commenced about the beginning of last November. The scheme has now been brought to a state of completion, and is capable of irrigating an area of 1,000 acres. The works involved were the construction of a small dam, the renovating of 2½ miles of old race, and the construction of 1 mile of new race.

General Surveys.

On the Upper Manuherikia scheme the permanent survey is now practically completed. The survey for the Roaring Meg scheme (Cromwell Flats and Lowburn) is nearing completion, and an extension of the Roaring Meg scheme to serve Crown lands reserved for settlement on the Pisa Flats is under consideration.

As in previous years, surveys, gaugings of streams, and investigations of rainfall and other matters affecting the irrigation possibilities of many other districts have been carried out. The following are the schemes still under investigation: Hawea Flat, Maniototo, Bendigo Flat, Chapman's Gully, Teviot River Extension, Luggate Burn, and Miller's Flat.

Water-supply.

Hanmer.—During the year surveys were made and plans prepared for the provision of a new water-supply at Hanmer. This work involves the supply of 14,000 ft. of 12 in. main, and 1,500 ft. of 6 in. and 6,820 ft. of 4 in. pipe for the reticulation, together with the necessary valves, bends, &c. This material, which is being manufactured from non-corrosive iron, is well in hand, the majority of the pipe having been received.

Rotorua.—A complete new water-supply is being provided for the township. 151 chains of 12 in. cast-iron main was laid, and the balance of the pipes for the completion of the scheme were delivered. The foundation of the Diesel engine as a standby for power-generation was completed, and the erection of the power-house finished.

TRAMWAYS.

Auckland.—A number of works, consisting of duplication and extensions, were carried out by the City Council, the approval of plans and final inspection being dealt with by this Department. The principal works completed were: Great South Road extension: This work, from Manukau Road to the Harp of Erin Hotel, 144 chains in length, was completed, inspected, and opened for traffic. Old Mill Road extension, comprising 53 chains of double track from Grey Lynn section to the New Zoological Park. Onehunga duplication: 1 mile 37 chains of single track was duplicated. Work is now proceeding on the Edendale extension. Ten new cars have been inspected and passed for traffic.

Napier.—Two cars were examined and passed for traffic.

Wanganui.—Proposals have been put forward by the Borough Council for an extension to St. John's Hill. These proposals, which involved considerable street-alterations, have now been approved.

Gisborne.—During the year the Ormond Road extension from the Gladstone Road line to the borough boundary was completed and inspected.

New Plymouth.—Plans were examined and approved for the Liardet Street extension, and the work inspected on completion.

Wellington.—A considerable amount of work was carried out on the Wellington City Tramways during the year. Plans were examined and dealt with for a number of works, and inspections made and certificates issued on their completion. The principal works completed and in hand are duplication of track, Coutts Street, Kilbirnie, and Thorndon Quay; extensions along Clyde Quay, Wakefield Street, Victoria Street, and Wallace Street. Ten new cars were completed and put through the necessary tests.

Christchurch.—The principal works carried out during the period on this system were the Clyde Road loop and the Riccarton Road duplication. Three new cars were added to the plant and duly tested.

Dunedin.—Plans were examined and approved for the Opoho extension, and the work of construction is in hand.

Recently a conference was held between the representatives of the tramway management, the Tramway-men's Union, and the Hon. Minister to consider the question of bringing in regulations.

F. W. Furkert, M.Inst.C.E., Assoc.M.I.Mech.E.,
Engineer-in-Chief.

ANNEXURE I TO APPENDIX B.

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924.

NORTH ISLAND.

NOTE.—Column 11: For detail information as to dates of openings of such portions of lines as are not given in this table see tables of lengths of lines in Public Works Statements, 1904–20.

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch	M. ch.	M. ch.	M. ch.
Kawakawa-Grahamtown (Onerahi)	Kawakawa ..	7 16	Opua Wharf - Kawakawa	7 16	0 57	7 73	..	..	..	..	..	..	..	..	..	7 16
	Kawakawa-Kamo ..	41 48	Kawakawa-Towai ..	21 18	0 61	21 79	..	..	..	12 April,1911	..	..	..	..	..	21 18
			Towai-Hukerenui ..	4 30	0 33	4 63	..	..	..	2 May, 1910	..	..	..	..	..	
			Hukerenui-Kamo ..	16 0	3 29	19 29	..	..	..	..	..	..	..	..	..	27 2
	Kamo-Grahamtown	9 22	Kamo-Kioreroa ..	6 52	2 27	8 79	..	..	..	..	..	..	..	..	..	
			Kioreroa-Onerahi ..	2 50	1 16	3 66	..	..	..	2 Oct., 1911	..	..	..	..	..	2 50
	Kawakawa-Hokianga	45 28	Otiria-Kaikohe ..	16 25	1 45	17 70	..	..	..	1 May, 1914	..	..	..	..	..	16 25
			Kaikohe-Okaihou ..	8 20	0 34	8 54	..	..	..	..	..	..	..	..	..	..
			Okaihou-Hokianga ..	20 63	2 06	22 69	18 0	2 63	..	29 Oct., 1923	..	..	..	..	8 20	8 20
Kaihu Valley	Kaihu Valley ..	24 32	Dargaville-Booms ..	17 21	0 75	18 16	..	..	..	..	..	..	..	..	..	19 58
			Booms-Tarawhati ..	2 37	0 25	2 62	..	..	..	1 June, 1914	..	..	..	..	..	
			Tarawhati-Donnelly's Crossing	4 54	0 38	5 12	..	..	..	5 Feb., 1923	..	..	..	..	4 54	4 54
North Auckland Main Trunk Railway	Kaipara Northwards	86 18	Extension	25 30	3 7	28 37	2 53	10 31	12 26	..	..	..	..	..	..	..
			McCarrol's - Paparoa	4 51	0 25	4 76	..	..	4 51	..	..	..	..	..	..	..
			Paparoa-Huarau ..	1 70	0 36	2 26	..	..	1 70	..	..	..	..	..	..	..
			Huarau-Maungaturoto	2 5	0 38	2 43	..	..	..	1 April, 1920	..	2 5	..	..	..	2 5
			Maungaturoto-Ranganui	4 25	0 61	5 6	..	..	..	1 April, 1920	..	4 25	..	..	..	4 25
			Ranganui-Kaiwaka ..	2 35	0 62	3 17	..	..	..	1 Aug., 1914	..	.	..	..	..	2 35
			Kaiwaka - Te Hana ..	8 65	1 3	9 68	..	..	..	18 Mar. 1913	..	..	..	..	..	
			Te Hana-Wellsford ..	3 27	0 58	4 5	..	..	..	16 May, 1910	..	..	..	..	..	
			Wellsford-Wayby ..	3 18	0 28	3 46	..	..	..	1 April, 1909	..	..	..	..	..	
			Wayby-Hoteo ..	3 40	0 13	3 53	..	..	..	13 May, 1908	..	..	..	..	..	
			Hoteo-Kaipara Flats	2 45	0 13	2 58	..	..	..	11 June, 1907	..	..	..	..	..	45 42
			Kaipara Flats-Woodcock's	3 5	0 16	3 21	..	..	..	17 Nov., 1905	..	..	..	..	..	
			Woodcock's-Ahuroa	2 41	0 16	2 57	..	..	..	18 May, 1905	..	..	..	..	..	
			Ahuroa-Helensville ..	18 41	1 75	20 36	..	..	..	..	..	..	..	..	..	

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued*

NORTH ISLAND—*continued.*

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
Whangarei Branch Railway	Whangarei Branch..	19 79	Kioreroa-Portland ..	5 23	0 37	5 60	..	..	..	3 April, 1920	..	5 23	..	..	..	5 23
			Portland-Waiotira ..	14 56	1 39	16 15	..	..	14 56	..	..	..	..	..	..	..
Waipu Branch	Waipu Branch Rly.	16 45	Oakleigh-Waipu ..	16 45	0 25	16 70	5 45	11 0	..	..	..	..	..	..	..	..
Kaipara-Waikato	Kaipara-Newmarket	35 73	Helensville-Newm'rk't	35 73	6 66	42 59	..	..	..	..	..	..	..	..	..	35 73
	Onehunga Branch ..	2 73	Penrose - Onehunga Wharf	2 73	1 70	4 63	..	..	..	..	..	..	..	..	..	2 73
	Auckland-Waikato ..	100 13	Auckland-Te Awamutu	100 13	16 66	116 79	..	..	..	..	..	..	..	..	..	100 13
	Auckland-Penrose—Deviation via Beach	6 50	Deviation via Beach	6 50	..	6 50	6 50	..	..	..	..	..	..	..	..	..
	Auckland City Branch—Kingsland Station to Auckland Station via Western Park and Freeman's Bay	2 60	Auckland City Branch	2 60	..	2 60	2 60	Prelim.	..	..	..	..	..	..	..	..
Waiuku Branch	Waiuku Branch Railway	12 69	Paerata-Patumahoe	5 4	0 78	6 2	..	..	..	10 Dec., 1917	..	..	..	..	..	5 4
			Patumahoe-Waiuku	7 65	1 3	8 68	..	..	..	10 May, 1922	..	..	..	7 65	..	7 65
Huntly-Awaroa	Huntly-Awaroa ..	9 0	Huntly-Awaroa ..	9 0	..	9 0	..	..	1 55	..	..	..	..	..	..	7 20
Survey, new lines	Waikokowai Branch Railway	8 25	Waikokowai ..	8 25	..	8 25	8 25	..	..	..	..	..	..	..	..	..
Surveys, new lines	Paeroa-Pokeno ..	40 15	Paeroa-Pokeno ..	40 15	..	40 15	40 15	..	..	..	..	..	..	..	..	..
Waikato-Thames	Waikato-Thames ..	62 58	Frankton Junction-Thames	62 58	10 17	72 75	..	..	..	..	..	..	..	..	..	62 58
Hamilton-Cambridge	Hamilton-Cambridge	12 2	Ruakura Junction-Cambridge	12 2	3 14	15 16	..	..	..	..	..	..	..	..	..	12 2
Paeroa-Waihi	Paeroa-Waihi ..	12 40	Paeroa-Waihi ..	12 40	1 30	13 70	..	..	..	9 Nov., 1905	..	..	..	..	..	12 40
East Coast Railway	Waihi-Opotiki, or East Coast Railway	143 18	Waihi-Tauranga ..	38 71	..	38 71	18 66	18 52	1 33	..	..	..	..	..	..	..
			Tauranga-Te Maunga Junction	3 75	0 17	4 12	..	..	3 75	..	..	..	..	..	..	..
			Te Maunga Junction-Te Puke	9 0	1 38	10 38	..	..	9 0	..	..	..	..	..	..	..
			Te Puke-Paengaroa..	5 67	1 16	7 3	..	..	5 67	..	..	..	..	..	..	..
			Paengaroa - Pongakawa	4 13	0 47	4 60	..	..	4 13	..	..	..	..	..	..	..
			Pongakawa-Otamarakau	7 5	0 31	7 36	..	..	7 5	..	..	..	..	..	..	..
			Otamarakau-Matata	8 11	0 43	8 54	..	..	8 11	..	..	..	..	..	..	..

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued*.

NORTH ISLAND—*continued*.

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Plate-laying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
East Coast Railway—*contd.*	Waihi-Opotiki—*ctd.* ..		Matata-Rangitaiki	8 55	0 48	9 23	..	..	8 55	..	..	..	..	..	..	..
			Rangitaiki-Awakeri	3 49	0 58	4 27	..	..	3 49	..	..	..	..	..	..	..
			Awakeri-Taneatua ..	8 47	..	8 47	..	3 15	5 32	..	..	..	..	..	..	..
			Taneatua-Opotiki ..	29 73	..	29 73	3 73† / 12 0* / 14 0‡	..	..	..	..	..	..	..	..	..
	Branch Lines ..	..	Mount Maunganui - Te Maunga Junction	4 27	0 67	5 14	..	..	4 27	..	..	..	..	..	..	..
			Te Puke Quarry ..	3 0	0 20	3 20	..	..	3 0	..	..	..	..	..	..	..
			Moturiki Quarry § ..	1 0	0 10	1 10	..	..	..	..	..	..	..	..	..	..
			Whakatane Branch	7 5	..	7 5	7 5†	..	..	..	..	..	..	..	..	..
Thames Valley - Rotorua	Thames Valley-Rotorua	69 33	Morrinsville-Rotorua	69 33	5 27	74 60	..	..	..	..	..	..	..	..	..	69 33
Gisborne-Rotorua	Gisborne-Opotiki ..	92 44	Gisborne Wharf-Kaiteratahi	13 10	2 45	15 55	..	..	..	..	..	..	..	..	..	
			Kaiteratahi-Karaka	5 5	0 71	5 76	..	..	..	13 April, 1905	..	..	..	..	..	
			Karaka-Puha ..	1 75	0 24	2 19	..	..	..	20 May, 1907	..	..	..	..	..	
			Puha-Waikohu Bridge	3 29	..	3 29	..	..	..	28 May, 1908	..	..	..	..	..	
			Waikohu Bridge-Waikohu	0 35	0 32	0 67	..	..	..	1 April, 1909	..	..	..	..	..	49 32
			Waikohu-Otoko ..	7 75	0 32	8 27	..	..	..	6 April, 1912	..	..	..	..	..	
			Otoko-Rakauroa ..	6 60	0 32	7 12	..	..	..	2 Nov., 1914	..	..	..	..	..	
			Rakauroa-Matawai ..	5 65	0 50	6 35	..	..	..	2 Nov., 1914	..	..	..	..	..	
			Matawai-Motuhora	4 78	0 61	5 59	..	..	..	26 Nov., 1917	..	..	..	..	..	
			Motuhora-Motu ..	2 10	..	2 10	2 10	..	..	..	..	..	..	..	..	..
			Motu-Opotiki ..	41 2	..	41 2	41 2	Estim.	..	..	..	..	..	..	..	..
New survey	Napier-Gisborne ..	143 44	Napier - West Shore	3 30	0 25	3 55	..	..	..	23 July, 1923	..	..	..	..	3 30	11 73
			West Shore-Bay View	3 61	0 22	4 3	..	..	..		..	..	..	..	3 61	
			Bay View-Eskdale ..	4 55	0 64	5 39	..	..	..		..	..	..	..	4 55	
			Eskdale-Tutira ..	17 47	..	17 47	1 73	12 34	3 0	..	..	..	..	..	..	..
			Tutira-Wairoa ..	42 11	..	42 11	42 11	..	..	..	..	..	..	..	..	..
			Wairoa River-Gisborne	72 0	..	72 0	44 0	2 17	..	..	..	..	..	..	..	..
	Gisborne-Napier ..	72 42	Gisborne Station - Makaraka	3 5	..	3 5	..	..	..	..	..	..	..	..	..	..
			Makaraka-Ngatapa ..	11 51	1 29	13 0	..	..	11 51	..	..	..	..	..	..	..
			Ngatapa-Wharekopae	4 69	..	4 69	0 19	3 0	1 50	..	..	..	..	..	..	..
			Wharekopae-Waikura	5 40	..	5 40	5 40	..	..	..	..	..	..	..	..	..

†Preliminary survey *Trial survey. ‡Permanent survey. § Rails taken up.

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued.*

NORTH ISLAND—*continued.*

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
New survey —*contd.*	Napier-Gisborne—*ctd.*		Waikura-Waterfall ..	6 66	..	6 66	5 6	Perm.	..	..	..	..	..	..	..	..
							1 60	Prelim.	..	..	..	..	..	..	..	..
			Waterfall-Hangaroa	4 0	..	4 0	4 0	"	..	..	..	..	..	..	..	..
			Hangaroa-Te Reinga	17 11	..	17 11	17 11	"	..	..	..	..	..	..	..	..
			Te Reinga-Marumaru	9 40	..	9 40	9 40	"	..	..	..	..	..	..	..	..
			Marumaru-Wairoa ..	10 0	..	10 0	4 0	Perm.	..	..	..	..	..	..	..	..
							6 0	Prelim.	..	..	..	..	..	..	..	..
	Wairoa-Waikokopu..	24 72	Wairoa-Nuhaka ..	18 65	1 61	20 46	..	..	18 65	..	..	..	..	..	..	..
			Nuhaka-Waikokopu	6 7	0 55	6 62	..	..	6 7	..	..	..	..	..	..	..
Napier-Woodville and Palmerston North	Napier-Woodville ..	96 65	Napier Spit-Woodville	96 65	15 5	111 70	..	..	..	..	..	..	..	..	..	96 65
	Woodville-Palmerston North	17 21	Woodville-Palmerston North	17 21	0 51	17 72	..	..	..	..	..	..	..	..	..	17 21
Wellington-Woodville	Woodville-Wellington	115 79	Woodville-Wellington [Te Aro]	115 79	21 73	137 72	..	..	..	..	..	..	..	..	..	115 79
	Greytown Branch ..	3 7	Woodside-Greytown	3 7	0 64	3 71	..	..	..	..	..	..	..	..	..	3 7
	Featherston-Martinborough	11 50	Featherston-Martinborough	11 50	..	11 50	11 50	..	..	..	..	..	..	..	..	..
	Greytown-Martinborough	4 62	Greytown-Martinborough	4 62	..	4 62	4 62*	..	..	..	..	..	..	..	..	..
Rimutaka Incline Deviation Surveys	Coach-road Route ..	9 0	Kaitoke-Featherston	9 0	..	9 0	9 0	Prelim.	..	..	..	..	..	..	..	..
	Tauherenikau Route	21 30	Upper Hutt-Woodside	21 30	..	21 30	21 30	..	..	..	..	..	..	..	..	..
	Wainui-o-mata Route	31 40	Petone-Pigeon Bush	31 40	..	31 40	31 40	..	..	..	..	..	..	..	..	..
	Coast Route ..	52 0	Petone-Pigeon Bush	52 0	..	52 0	52 0	..	..	..	..	..	..	..	..	..
	Coast Route ..	70 0	Petone-Carterton, via Martinborough	70 0	..	70 0	70 0	..	..	..	..	..	..	..	..	..
	Wellington-Manawatu	83 37	Wellington-Longburn	83 37	15 76	99 33	..	..	..	7 Dec., 1908†	..	..	..	..	..	83 37
Foxton-New Plymouth	Foxton-Patea ..	120 44	Foxton-Patea ..	120 44	14 75	135 39	..	..	..	..	..	..	..	..	..	120 44
	Route Improvement Surveys	26 7	Turakina-Matarawa	11 67	..	11 67	11 67	..	..	..	..	..	..	..	..	..
			Aramoho-Goat Valley Tunnel	7 40	..	7 40	7 40	..	..	..	..	..	..	..	..	..
			Kai Iwi-Okehu ..	3 60	..	3 60	3 60	..	..	..	..	..	..	..	..	..
			Nukumaru-Waitotara	3 0	..	3 0	3 0	Prelim.	..	..	..	..	..	..	..	..

* Trial survey. † Date of purchase.

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued.*

NORTH ISLAND—*continued.*

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
Foxton-New Plymouth —*contd.*	Patea Waitara and New Plymouth	72 29	Patea-New Plymouth Breakwater	72 29	11 52	84 1	..	..	..	..	..	..	..	..	..	72 29
	Bull's Branch ..	3 79	Bull's Branch ..	3 79	..	3 79	3 79	Prelim.	..	..	..	..	..	..	..	..
	Wanganui Branch ..	3 29	Aramoho-Wanganui	3 29	2 23	5 52	..	..	..	..	..	..	..	..	..	3 29
Stratford-Main Trunk	Stratford-Main Trunk	91 50	Stratford-Toko ..	6 26	0 40	6 66	..	..	..	..	..	..	..	..	..	
			Toko-Oruru ..	4 72	0 36	5 28	..	..	..	1 Mar., 1905	..	..	..	..	..	
			Oruru-Huiroa ..	4 50	0 35	5 5	..	..	..	1 April, 1908	..	..	..	..	..	
			Huiroa-Te Wera ..	6 77	1 16	8 13	..	..	..	20 June, 1910	..	..	..	..	..	
			Te Wera-Pohokura	8 55	0 65	9 40	..	..	..	1 Aug., 1912	..	..	..	..	..	42 26
			Pohokura-Whangamomona	6 13	0 45	6 58	..	..	..	1 July, 1914	..	..	..	..	..	
			Whangamomona-Kohurutahi	4 53	0 29	5 2	..	..	..	7 Jan., 1918	..	..	..	..	..	
			Kohurutahi-Tahora	5 14	0 37	5 51	..	..	5 14	..	..	..	..	..	..	..
			Tahora-Ohura ..	25 0	..	25 0	4 0	Perm.	..	..	..	..	..	..	..	..
							13 0	Prelim.	..	..	..	..	..	..	..	..
			Ohura-Matiere ..	8 67	1 21	10 8	..	7 79	0 68	..	..	..	..	..	..	..
			Matiere-Okahukura ..	10 23	1 10	11 33	..	..	10 23	..	..	..	..	..	..	..
	Stratford-Ongarue—Deviations	33 40	Mangaroa-Puketutu	33 40	..	33 40	33 40	Prelim.	..	..	..	..	..	..	..	..
		14 0	Aramatai-Hangatiki	14 0	..	14 0	14 0	Prelim.	..	..	..	..	..	..	..	..
	Puketutu-Mangaroa Deviation	30 0	..	30 0	..	30 0	30 0	Prelim.	..	..	..	..	..	..	..	..
	Opunake-Mountain Rd.	23 10	Opunake-Eltham ..	23 10	..	23 10	23 10	..	..	..	..	..	..	..	..	..
	Te Roti-Moturoa ..	55 65	Te Roti-Kapuni ..	7 0	1 19	8 19	..	..	7 0	..	..	..	..	..	..	..
			Kapuni-Auroa ..	5 0	0 33	5 33	..	0 43	4 37	..	..	..	..	..	..	..
			Auroa-Pihama ..	4 40	0 27	4 67	..	4 40	..	..	..	..	..	..	..	..
			Pihama-Opunake ..	5 70	1 3	6 73	..	5 70	..	..	..	..	..	..	..	..
			Opunake-Stony River	18 70	..	18 70	18 70	..	..	..	..	..	..	..	..	..
			Stony River-Moturoa	14 45	..	14 45	14 45	..	..	..	..	..	..	..	..	..
	Manaia Branch ..	5 50	Manaia-Kapuni ..	5 50	0 78	6 48	..	4 25	1 25	..	..	..	..	..	..	..
	Mount Egmont Branch	8 77	Manganui Section ..	5 74	2 3	7 77	..	..	..	1 April, 1908	..	..	..	..	..	6 0
			Quarry Section ..	3 3	0 60	3 63	..	1 58	1 25	..	..	..	..	..	..	..

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued*.

NORTH ISLAND—*continued*.

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
North Island Main Trunk Railway	Marton-Te Awamutu	209 69	Marton Junction-Mangaweka	31 67	4 61	36 48	..	..	..	..	..	..	..	..	..	
			Mangaweka-Taihape	13 1	1 61	14 62	..	..	..	10 Sep., 1904	..	..	..	..	..	50 58
			Taihape-Mataroa ..	5 70	0 61	6 51	..	..	..	1 June, 1907	..	..	..	..	..	
			Mataroa-Waiouru ..	18 10			..	..	..	30 June, 1908	..	..	..	..	..	
			Waiouru-Erua ..	30 63	12 50	97 28	..	..	..	13 Feb., 1909	..	..	..	..	..	84 58
			Erua-Taumarunui ..	35 65			..	..	..	9 Nov., 1908	..	..	..	..	..	
			Taumarunui-Te Awamutu	74 33	6 20	80 53	..	..	..	..	..	..	..	..	..	74 33
	Waipa Gravel Access Branch	7 40	Otorohanga ..	7 40	..	7 40	..	..	..	..	..	..	..	..	..	..
	Raetihi Branch ..	8 50	Raetihi Section ..	8 50	1 7	9 57	..	..	..	18 Dec., 1917	..	..	..	..	..	8 50
	Central Route Deviation Surveys	30 0	Ohakune to Mokau-Retaruke Divide	30 0	..	30 0	30 0	Prelim.	..	..	..	..	..	..	..	..
		34 0	Makatote Gorge-Marae-Kowhai	34 0	..	34 0	34 0	Prelim.	..	..	..	..	..	..	..	..
		20 0	Marae-Kowhai-Ohura Valley	20 0	..	20 0	20 0	Explor.	..	..	..	..	..	..	..	..
	Ngaire-Ongarue ..	103 58	Ngaire Section ..	38 73	..	38 73	38 73	..	..	..	..	..	..	..	..	..
			Tangarakau Section	26 0	..	26 0	26 0	..	..	..	..	..	..	..	..	..
			Heao Section ..	10 70	..	10 70	10 70	..	..	..	..	..	..	..	..	..
			Ohura Section ..	27 75	..	27 75	27 75	..	..	..	..	..	..	..	..	..
	Waitara-Tangarakau	46 75	Waitara Section ..	46 75	..	46 75	46 75	..	..	..	..	..	..	..	..	..
	Urenui Route ..	12 0	Urenui to Tangitu River	12 0	..	12 0	12 0	Prelim.	..	..	..	..	..	..	..	..
	Hastings-Te Awamutu	170 0	Hastings-Te Awamutu	170 0	..	170 0	170 0	Prelim.	..	..	..	..	..	..	..	..
	Totals ..	2751 22	..	2751 22	218 3	2969 25	1122 30	88 47	171 30	..	1279 10	11 53	..	7 65	24 60	1323 35

NOTE.—Taonui and Lichfield Branches not mentioned above, as the rails have been taken up.

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued*.

SOUTH ISLAND.

NOTE.—Column 11: For detail information as to dates of openings of such portions of lines as are not given in this table see tables of lengths of lines in Public Works Statements, 1904-20.

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920-21.	1921-22.	1922-23.	1923-24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
Nelson-Roundell	Nelson-Belgrove ..	22 73	Nelson-Belgrove ..	22 73	2 52	25 45	..	..	..	..	..	..	..	..	..	22 73
Midland Railway	Stillwater - Belgrove (via Tadmor)	146 74	Stillwater-Reefton S.	37 30	4 79	42 29	..	..	..	..	..	..	..	..	..	
			Reefton S.-Reefton N.	1 30	1 0	2 30	..	..	..	31 Mar., 1907	..	..	..	..	..	
			Reefton N.-Cronadun	5 38	0 56	6 14	..	..	..	7 Aug., 1908	..	..	..	..	..	57 32
			Cronadun-Landing ..	8 40	0 45	9 5	..	..	..	June, 1914	..	..	..	..	..	
			Landing-Inangahua	6 0	0 10	6 10	1 26	..	..		..	..	..	..	..	
			Inangahua-Murchison	23 53	..	23 53	23 53	(Prelim	..	..	..	..	..	..	..	..
			Murchison-Kawatiri	22 70	..	22 70	16 35 / 4 0	,, (Perm)	2 35	..	..	..	..	..	..	..
			Kawatiri-Glenhope ..	3 73	0 15	4 8	..	3 73	..	..	..	..	..	..	..	..
			Glenhope-Tui ..	9 42	0 55	10 17	..	..	..	2 Sep., 1912	..	..	..	..	..	
			Tui-Kiwi	3 17	0 34	3 51	..	..	..		..	..	..	..	..	
			Kiwi-Tadmor ..	5 9	0 29	5 38	..	..	..	18 Dec., 1908	..	..	..	..	..	37 61
			Tadmor-Kohatu ..	10 29	0 69	11 18	..	..	..	7 Aug., 1906	..	..	..	..	..	
			Kohatu-Belgrove ..	9 44	0 62	10 26	..	..	..	..	..	..	..	..	..	
	Brunner-Springfield	92 68	Brunner-Otira ..	42 27	2 68	45 15	..	..	..	..	..	..	..	..	..	42 27
			Otira-Arthur's Pass	8 14	5 38	13 52	..	..	8 14	..	..	..	..	..	..	..
			Arthur's Pass - Cass	14 67	0 20	15 7	..	..	..	1 July, 1914	..	..	..	..	..	
			Cass - Broken River ..	15 22	1 29	16 51	..	..	..	10 Dec., 1910	..	..	..	..	..	
			Broken River - Otarama	7 40	0 30	7 70	..	..	..	29 Oct., 1906	..	..	..	..	..	42 27
			Otarama-Springfield	4 58	0 16	4 74	..	..	..	29 Oct., 1906	..	..	..	..	..	
Blackball Railway	Ngahere-Blackball ..	3 40	Ngahere-Blackball ..	3 40	1 20	4 60	..	..	..	16 July, 1910	..	..	..	..	..	3 40
Greymouth-Nelson Creek	Greymouth - Nelson Creek	7 51	Greymouth-Brunnerton-Stillwater	7 51	6 18	13 69	..	..	..	..	..	..	..	..	..	7 51
Westport-Ngakawau	Westport-Ngakawau	19 56	Westport-Ngakawau	19 56	8 12	27 68	..	..	..	..	..	..	..	..	..	19 56
Westport-Ngakawau Extension	Ngakawau - Mokihinui	7 12	Ngakawau-Mokihinui	7 12	1 18	8 30	..	..	..	..	..	..	..	..	..	7 12
	Mokihinui Colliery Line	3 69	Mokihinui-Seddonville	3 69	0 25	4 14	..	..	..	..	..	..	..	..	..	3 69
Westport-Inangahua	Westport - Inangahua Junction	26 0	Westport - Te Kuha ..	5 74	0 10	6 4	..	..	..	1 April, 1912	..	..	..	..	..	5 74
			Te Kuha - Inangahua Junction	20 6	..	20 6	16 6	4 0	..	..	..	..	..	..	..	..

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued.*

SOUTH ISLAND—*continued.*

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.										
							Surveyed.	Under Formation.	Under Platelaying.	Opened.							
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
State Colliery, or Coal Creek Railway	Greymouth - Point Elizabeth Collieries	5 1	Greymouth-Runanga Colliery	5 1	2 10	7 11	..	..	..	1 Dec., 1904	..	..	..	..	..	5 1
	Extension ..	3 69	Runanga Colliery-Point Elizabeth Collieries	3 69	2 20	6 9	..	..	..	21 Jan., 1914	..	..	..	..	..	3 69
	" ..	2 44	Runanga to Seven-mile	2 44	1 40	4 4	..	..	2 44	3 Sept., 1923	..	..	..	..	2 44	2 44
Greymouth-Hokitika	Greymouth-Hokitika	24 37	Greymouth-Hokitika	24 37	2 10	26 47	..	..	..	..	..	..	..	..	..	24 37
Kumara Branch	Kumara Branch ..	4 10	Kumara Branch ..	4 10	..	4 10	4 10	..	..	..	..	..	..	..	..	..
Hokitika-Ross	Hokitika-Ross ..	15 75	Hokitika-Ruatapu ..	7 10	0 61	7 71	..	..	..	9 Nov., 1906	..	..	..	..	..	7 10
			Ruatapu-Ross ..	7 21	0 69	8 10	..	..	..	1 April, 1909	..	..	..	..	..	7 21
			Survey to Ross Township	1 44	..	1 44	1 44	..	..	..	..	..	..	..	..	..
New survey	Ross-Waitaha ..	10 0	Ross-Waitaha ..	10 0	..	10 0	2 54	..	..	..	..	..	..	..	..	..
Picton-Waipara	Picton - Kaikoura ..	92 38	Picton-Seddon ..	33 45	3 26	36 71	..	..	..	..	..	..	..	..	..	
			Seddon-Kaparu ..	6 30	0 76	7 26	..	..	..	13 April, 1911	..	..	..	..	..	56 6
			Kaparu-Ward ..	8 15	1 20	9 35	..	..	..		..	..	..	..	..	
			Ward-Mirza ..	3 38	0 30	3 68	..	..	..	4 Dec., 1915	..	..	..	..	..	
			Mirza-Wharanui ..	4 38	0 34	4 72	..	..	..		..	..	..	..	..	
			Wharanui-Kekerangu	7 0	..	7 0	7 0	1 18	3 20	..	..	..	..	..	..	..
			Kekerangu - Hapuka River	29 32	..	29 32	29 32	..	..	..	..	..	..	..	..	..
	Hapuka River-Mendip Hills	40 50	Hapuka River-Limestone Creek	23 0	..	23 0	23 0	Prelim.	..	..	..	..	..	..	..	..
			Limestone Creek-Conway River	7 0	..	7 0	..	..	..	..	..	..	..	..	..	..
			Conway River - Mendip Hills	10 50	..	10 50	..	..	..	..	..	..	..	..	..	..
	Mendip Hills - Parnassus	5 61	Mendip Hills ..	5 61	..	5 61	2 0	3 61	..	..	..	..	..	..	..	..
	Parnassus-Waipara	44 14	Parnassus-Mina ..	8 43	1 14	9 57	..	..	..	1 Sept., 1912	..	..	..	..	..	
			Mina-Domett ..	3 63	0 70	4 53	..	..	..	1 Aug., 1910	..	..	..	..	..	
			Domett-Tormore ..	3 10	0 66	9 24	..	..	..	14 Nov., 1906	..	..	..	..	..	44 14
			Tormore-Ethelton ..	5 28			..	..	..	21 Mar., 1907	..	..	..	..	..	
			Ethelton-Scargill ..	8 51	0 51	9 22	..	..	..	3 Nov., 1905	..	..	..	..	..	
			Scargill-Waipara ..	14 59	1 2	15 61	..	..	..	..	..	..	..	..	..	
Hurunui-Waitaki	Main Line.. ..	206 7	Culverden-South Waitaki	206 7	64 68	270 75	..	..	..	..	..	..	..	..	..	206 7
		13 0	Culverden-Achray ..	5 23	0 10	5 33	..	..	..							
			Achray-Rotherham ..	1 75	0 43	2 38	..	..	..	15 Dec., 1919	13 0	..	..	..	..	13 0
			Rotherham-Waiau ..	5 62	1 3	6 65	..	..	..							

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued*.

SOUTH ISLAND—*continued*.

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.									
							Surveyed.	Under Formation.	Under Platelaying.	Opened.						
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
Hurunui-Waitaki —*contd.*	*Branches,—*															
	Rangiora - Oxford	21 76	Rangiora-Oxford West	21 76	2 36	24 32	..	..	..	..	..	..	..	..	..	21 76
	Eyreton (from Main Line)	20 7	Main Line - West Eyreton-Bennett's	20 7	1 61	21 68	..	..	..	..	..	..	..	..	..	20 7
	Lyttelton ..	6 26	Lyttelton - Christchurch	6 26	..	6 26	..	..	..	..	..	..	..	..	..	6 26
	Southbridge ..	25 31	Hornby-Southbridge	25 31	3 17	28 48	..	..	..	..	..	..	..	..	..	25 31
	Little River-Akaroa	42 10	Lincoln - Little River	22 46	2 5	24 51	..	..	..	..	..	..	..	..	..	22 46
			Reconnaissance ..	19 44	..	19 44	19 44	Prelim.	..	..	..	..	..	..	..	..
	Springfield ..	30 60	Rolleston-Springfield	29 63	3 7	32 67	..	..	..	..	..	..	..	..	..	30 60
			Springfield-Coal-mine	0 77												
	Whitecliffs ..	11 38	Darfield-Whitecliffs	11 33	1 53	13 11	..	..	..	..	..	..	..	..	..	11 38
			Whitecliffs to Bridge	0 5												
	Rakaia - Ashburton Forks	22 20	Rakaia-Methven ..	22 20	2 65	25 5	..	..	..	..	..	..	..	..	..	22 20
	Ashburton ..	29 46	Tinwald-Springburn	27 29	1 52	29 1	..	..	..	..	..	..	..	..	..	27 29
			Extension ..	2 17	..	2 17	2 17	..	..	..	..	..	..	..	..	..
	Opawa and Albury to Fairlie Creek and Burke's Pass	55 8	Washdyke-Eversley	36 5	2 45	38 50	..	..	..	..	..	..	..	..	..	36 5
			Preliminary survey ..	19 3	..	19 3	19 3	Prelim.	..	..	..	..	..	..	..	..
	Waimate ..	17 43	Studholme-Waimate	4 42	1 3	5 45	..	..	..	..	..	..	..	..	..	12 63
			Waimate-Waihao Downs	8 21	0 54	8 75	..	..	..	..	..	..	..	..	..	
			Waihao Downs-Serpentine	2 65	..	2 65	..	2 65	..	..	..	..	..	..	..	..
			Serpentine-Kelcher's	1 75	..	1 75	..	1 75	..	..	..	..	..	..	..	..
Canterbury Interior Main Line	Oxford-Temuka ..	83 0	Oxford-Sheffield ..	11 44	0 27	11 71	..	..	..	..	..	..	..	..	..	11 44
			Surveyed ..	21 7	..	21 7	21 7	..	..	..	..	..	..	..	..	..
			Reconnaissance ..	50 29	..	50 29	50 29	Prelim.	..	..	..	..	..	..	..	..
Waitaki-Bluff and Branches	Main Line ..	246 69	South Waitaki-Bluff	246 69	59 13	306 2	..	..	..	..	..	..	..	..	..	246 69
	Branches,—															
	Duntroon - Hakateramea	37 33	Pukeuri-Duntroon ..	21 75	1 35	23 30	..	..	..	..	..	..	..	..	..	21 75
			Duntroon - Hakateramea	15 38	1 5	16 43	..	..	..	..	..	..	..	..	..	15 38
	Ngapara ..	14 76	Waiareka-Ngapara ..	14 76	1 31	16 27	..	..	..	..	..	..	..	..	..	14 76
	Livingstone ..	16 40	Windsor-Tokorahi ..	12 0	0 50	12 50	..	0 5	..	..	..	..	..	..	..	11 75
			Survey (trial) ..	4 40	..	4 40	4 40	Prelim.	..	..	..	..	..	..	..	..
	Palmerston - Waihemo	8 55	Palmerston-Dunback	8 55	0 54	9 29	..	..	..	..	..	..	..	..	..	8 55
		0 65	Surveyed ..	0 65	..	0 65	0 65	..	..	..	..	..	..	..	..	..

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued*.

SOUTH ISLAND—*continued*.

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.										
							Surveyed.	Under Formation.	Under Platelaying.	Opened.							
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
Waitaki-Bluff and Branches —*contd.*	*Branches*—contd.															
	Inch Valley Railway	2 29	Inch Valley-Lime Kiln	2 29	0 23	2 52	..	..	..	..	..	..	..	..	..	2 29
	Port Chalmers ..	1 9	Glendermid - Port Chalmers	1 9	3 40	4 49	..	..	..	..	..	..	..	..	..	1 9
	Green Island ..	2 44	Burnside-Saddle Hill	2 44	0 52	3 16	..	..	..	..	..	..	..	..	..	2 44
	Green Island to Brighton	4 65	Surveyed	4 65	..	4 65	4 65	..	..	..	..	..	..	..	..	..
	Fernhill Colliery Line	1 60	Abbotsford to Fernhill Colliery	1 60	0 24	2 4	..	..	..	..	..	..	..	..	..	1 60
	Kaikorai Valley Railway	2 60	Surveyed	2 60	..	2 60	2 60	..	..	..	..	..	..	..	..	..
	Outram ..	8 78	Mosgiel-Outram ..	8 78	0 68	9 66	..	..	..	..	..	..	..	..	..	8 78
	Lawrence ..	21 76	Clarksville-Lawrence	21 76	2 2	23 78	..	..	..	..	..	..	..	..	..	} 34 65
	Lawrence-Roxburgh	37 44	Lawrence-Big Hill	7 33	0 44	7 77	..	..	..	1 Aug., 1910	..	..	..	..	..	
			Big Hill-Beaumont	5 36	0 45	6 1	..	..	..	15 Dec., 1914	..	..	..	..	..	
			Beaumont-Miller's Flat	14 55	0 38	15 13	..	5 70	8 65	..	..	..	..	..	..	..
			Miller's Flat-Roxburgh	10 0	..	10 0	10 0	Prelim.	..	..	..	..	..	..	..	..
	Lovell's Flat-Tuapeka Mouth	23 20	Surveyed	23 20	..	23 20	23 20	..	..	..	..	..	..	..	..	..
	Balclutha-Tuapeka Mouth	22 0	Surveyed	7 0	..	7 0	..	..	..	..	..	..	..	..	..	..
			Trial Survey ..	15 0	..	15 0	..	..	..	..	..	..	..	..	..	..
	Crichton-Tuapeka Mouth	11 60	Surveyed	11 60	..	11 60	11 60	..	..	..	..	..	..	..	..	..
	Stirling-Hill End (via Stoney Creek)	11 43	Trial Survey ..	11 43	..	11 43	11 43	..	..	..	..	..	..	..	..	..
	Balclutha-Appleby Junction or Catlin's-Seaward Bush	105 49	Balclutha-Owaka ..	19 20	1 63	21 3	..	..	..	..	..	..	..	..	..	} 42 67
			Owaka-Catlin's ..	3 38	0 30	3 68	..	..	..	1 Aug., 1904	..	..	..	..	..	
			Catlin's-Houipapa ..	2 30	0 9	2 39	..	..	..	17 Dec., 1909	..	..	..	..	..	
			Houipapa-Puketiro ..	7 11	0 43	7 54	..	..	..	1 Feb., 1915	..	..	..	..	..	
			Puketiro-McLennan	5 29	0 59	6 8	..	..	..	1 Feb., 1915	..	..	..	..	..	
			McLennan-Tahakopa	5 19	0 38	5 57	..	..	..	1 Feb., 1915	..	..	..	..	..	
			Tahakopa-Marinui ..	23 63	..	23 63	23 63	Prelim.	..	..	..	..	..	..	..	..
			Marinui-Tokanui ..	6 0	..	6 0	6 0	..	..	..	..	..	..	..	..	..
			Tokanui-Waimahaka	8 27	0 64	9 11	..	..	..	20 Sept., 1911	..	..	..	..	..	} 32 79
			Waimahaka-Appleby	24 52	1 50	26 22	..	..	..	..	..	..	..	..	..	
	Waipahi-Heriot Burn	26 23	Waipahi-Heriot ..	20 3	2 3	22 6	..	..	..	..	..	..	..	..	..	} 26 23
			Heriot-Edievale ..	6 20	0 45	6 65	..	..	..	15 Feb., 1905	..	..	..	..	..	
	Extension to Roxburgh, via Rae's Junction and Ettrick	28 10	Surveyed ..	28 10	..	28 10	28 10	Prelim.	..	..	..	..	..	..	..	..
	Via Spylaw ..	25 70	Surveyed ..	25 70	..	25 70	25 70	Prelim.	..	..	..	..	..	..	..	..

TABLE OF LENGTHS OF GOVERNMENT LINES AUTHORIZED, CONSTRUCTED, AND SURVEYED UP TO 31ST MARCH, 1924—*continued.*

SOUTH ISLAND—*continued.*

Appropriation.	Division.	Mileage.	Section.	Main Line.	Sidings.	Total.	State of Line.										
							Surveyed.	Under Formation.	Under Platelaying.	Opened.							
										Date.	To Mar. 31, 1920.	1920–21.	1921–22.	1922–23.	1923–24.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.		M. ch.	M. ch.	M. ch.	M. ch.	M. ch.	M. ch.
Waitaki-Bluff and Branches —*contd.*	*Branches*—contd.															
	Waimea Plains District Ry.	36 39	Gore-Lumsden ..	36 39	1 34	37 73	..	..	..	..	..	..	..	..	..	36 39
	Kelso-Gore ..	24 0	Surveyed ..	9 58	..	9 58	9 58	..	..	..	..	..	..	..	..	..
			Preliminary survey ..	14 22	..	14 22	14 22	Prelim.	..	..	..	..	..	..	..	..
	Gore-Waikaka ..	12 65	Waikaka Section ..	12 65	1 51	14 36	..	..	..	26 Nov., 1908	..	..	..	..	..	12 65
	Riversdale-Switzers	13 70	Riversdale-Waikaia	13 70	1 40	15 30	..	..	..	1 Oct., 1909	..	..	..	..	..	13 70
	Edendale-Toitois ..	19 30	Edendale-Glenham	9 36	0 72	10 28	..	..	..	...	..	..	..	..	..	9 36
			Surveyed ..	9 74	..	9 74	9 74	..	..	..	..	..	..	..	..	..
Otago Central	Waitaki Bluff Main Line to Lake Hawea	182 45	Wingatui-Ida Valley	98 18	5 62	104 0	..	..	..	..	..	..	..	..	..	
			Ida Valley-Omakau	13 20	1 16	14 36	..	..	..	1 Sept., 1904	..	..	..	..	..	
			Omakau-Chatto Creek	7 36	0 34	7 70	..	..	..	14 July, 1906	..	..	..	..	..	
			Chatto Ck.-Alexandra	10 39	1 6	11 45	..	..	..	15 Dec., 1906	..	..	..	..	..	147 27
			Alexandra-Clyde ..	5 45	0 77	6 42	..	..	..	27 Mar., 1907	..	..	..	..	..	
			Clyde-Cromwell ..	12 29	0 69	13 18	..	..	..	10 July, 1921	..	..	12 29	..	..	
			Surveyed ..	35 18	..	35 18	..	..	..	..	..	..	..	..	..	..
Invercargill-Kingston and Branch, Lumsden-Mararoa	Invercargill-Kingston	87 4	Invercargill-Kingston Wharf	87 4	5 15	92 19	..	..	..	..	..	..	..	..	..	87 4
	Lumsden-Mararoa ..	30 0	Lumsden-Mossburn	10 40	1 0	11 40	..	..	..	..	..	..	..	..	..	10 40
			Surveyed	8 20	..	8 20	8 20	..	..	..	..	..	..	..	..	..
			Reconnaissance ..	11 20	..	11 20	11 20	Prelim.	..	..	..	..	..	..	..	..
	Winton-Heddon Bush	11 0	Surveyed	11 0	..	11 0	11 0	..	..	..	..	..	..	..	..	..
Forest Hill Railway	Winton to Hedgehope	12 40	Winton-Hedgehope	12 40	0 65	13 25	..	..	..	..	..	..	..	..	..	12 40
Western Railways, Orepuki-Waiau River	Orepuki-Waiau ..	60 64	Makarewa-Orepuki ..	35 41	6 37	41 78	..	..	..	..	..	..	..	..	..	
			Orepuki-Waihoaka ..	4 48	0 58	5 26	..	..	..	..	..	..	..	..	..	
			Waihoaka-Tuatapere	8 7	1 10	9 17	..	..	..	1 Oct., 1909	..	..	..	..	..	48 16
			Tuatapere-Orawia ..	8 8	..	8 8	..	2 36	5 52	..	..	..	..	..	..	
			Orawia-Clifden ..	4 40	..	4 40	4 40	..	..	..	..	..	..	..	..	
	Otautau Branch ..	22 15	Thornbury-Wairio ..	22 15	..	22 15	..	..	..	..	..	..	..	..	..	22 15
	Orawia Branch ..	11 0	Surveyed	11 0	..	11 0	11 0	..	..	..	..	..	..	..	..	..
	Totals ..	2351 25	..	2351 25	265 12	2616 27	476 50	26 5	30 60	..	1727 57	..	12 29	..	2 44	1742 50

ANNEXURE II TO APPENDIX B.

INTERDEPARTMENTAL CORRESPONDENCE IN CONNECTION WITH PROPOSED NEW RAILWAY-WORKS.

I. TUAPEKA MOUTH RAILWAY.

Tuapeka Mouth Railway.

The Director-General, Department of Agriculture, Wellington. Wellington, 8th July, 1922.

In connection with the proposal to construct a railway from the Main South line to Tuapeka Mouth, some twenty miles above Balclutha, a number of different routes have been surveyed, as shown in red, blue, purple, and green on copy of P.W.D. 54645 forwarded herewith.

The original proposal of the Public Works Department was to run the line shown in purple up the river-bank, but considerable agitation arose in the Hillend district, having for its object the deviation of the line via Hillend, the contention being that a line up the river-bank would be of no help whatever to the high country generally known as Hillend and also that lying in the valley of the Dullburn or Awamangu.

As there is a very considerable difference in the cost of constructing and working these lines, I will be glad to have an expression from your Department as to the probable amount of traffic to be obtained from the country to be served by each of these railways.

You will notice on the lithograph I am forwarding you some hatched borders purporting to indicate the areas served by different routes, but I do not think that you need regard these as very definite. Possibly your Field Inspectors, with their local knowledge, may consider that some of the land shown as served will actually run to other existing railways and *vice versa*.

One of the great points made by the Hillend people was the necessity for manures in their district, which manures cannot be carted by road from the present railway, and which position would not be in any way improved by a railway up the river-bank.

F. W. Furkert, Engineer-in-Chief.

Tuapeka Mouth Railway.

The General Manager, New Zealand Railways, Wellington. Wellington, 8th July, 1922.

As you are no doubt aware, a railway was mooted to serve the Tuapeka Mouth district, lying some 20 miles up the Clutha River above the Town of Balclutha. When the first survey was made it was run approximately parallel to the river with a junction actually at Stirling, although the proposed line did not diverge from the present main line until it reached almost to the end of the Balclutha Railway-bridge. The reason for this was that your Department was of the opinion that Balclutha was too congested to enable the junction to be made there.

Some time afterwards considerable agitation arose with the idea of having the line taken via Hillend, it being maintained by the people in that locality that a river-bank railway would be no use whatever to them. There is a good deal of truth in this contention. Alternative lines have been run, therefore, to connect the up-river district with the main line at Crichton or Lovell's Flat, and by three different routes, and on one of the routes there were two alternative grades.

In order that it may be clearly seen whether the probable extra traffic obtained by going via Hillend would in any way justify the difference in working and interest charges, I should be glad if you would advise me what your Department considers would be the annual cost of working the railway via the different routes, and to enable you to do this I am forwarding herewith lithograph showing the alignment, and a tracing showing the profiles via the different routes.

F. W. Furkert, Engineer-in-Chief.

New Zealand Government Railways, Head Office, Wellington, 11th April, 1923.

Tuapeka Mouth Railway.

Engineer-in-Chief, Public Works Department, Wellington.

The annual cost of working the Tuapeka Mouth Railway may be roughly measured by the provisions necessary for handling the traffic now carried on the river between Balclutha and Tuapeka Mouth (both ways). This traffic is estimated to amount to 3,500 tons per annum, averaging 11 tons per diem. A portion of this traffic which comes from the right bank of the river would be unlikely to be carried by rail. Allowing liberally for such development of the district and consequent increase of traffic which would be brought about by the opening of the railway, it is evident that one train each way daily would be more than sufficient to cope with the business.

Regarding the various routes proposed, I desire to make the following comments :—

1. *Riverbank Route : Stirling to Tuapeka.*—The objection to the branch line leaving the main line near Balclutha —namely, congestion of traffic at Balclutha Station—referred to by you, has been modified considerably by the rearrangement of the Balclutha Station. The objection, however, has greater force at Stirling than at Balclutha, owing to the congestion at the former station.

There is little doubt that if the riverbank route were adopted those using the branch railway would prefer Balclutha as a junction station. It would appear, therefore, that the junction with the main line should be at the north end of the Clutha River Bridge, and the trains should be run to and from the Balclutha Station. This would involve the employment of signalmen at the junction, and certain rearrangement of the accommodation at Balclutha.

2. *Lovell's Flat—Hillend—Tuapeka Route.*—There is not sufficient information before me to indicate whether, in the event of the proposed railway being constructed by this route, those using the railway would prefer train connections towards Dunedin and Milton or towards Balclutha. Suitable connections would be somewhat difficult to arrange, and would doubtless involve additional main-line train-mileage.

3. *Crichton–Hillend–Tuapeka Route.*—There are very serious objections to Crichton as a junction station : (*a*) The provision of the necessary accommodation would be exceedingly costly, and at best only limited accommodation could be provided. No water-supply is available. (*b*) There is no officer in charge, and the provision of the necessary staff would involve unnecessary expense. Apart from these objections, it would, without doubt, be necessary to make branch train connections to and from Milton, which would increase the cost of working. A further objection is that Crichton is not a suitable stopping-place for express trains, and Milton Station is already congested.

The estimated annual cost of working the various routes is as follows : (1.) Riverbank route, Balclutha to Tuapeka, £12,823 ; (2) Lovell's Flat–Hillend–Tuapeka route, £16,950 ; (3) Crichton–Hillend–Tuapeka route, £21,166.

It is quite evident from these figures that there is no hope for the traffic on this branch returning sufficient revenue for very many years to cover the cost of working, much less the interest on cost of construction. At the present time the Department is losing on the working of the Lawrence Branch at the rate of about £200 per mile per annum, allowing for interest on the cost of construction. The opening of another branch in this district would inevitably withdraw some of the traffic that at present finds an outlet by means of the Lawrence Branch, so that added to the loss arising from this railway would be an increase in the deficit upon the working of the Lawrence Branch.

I cannot too strongly emphasize my opinion that there is no justification at the present time for the construction of this line. The nature of the country is not such as to give any encouragement for the development of traffic commensurate with the cost of the undertaking, and the line would become another of the many unpaying branch lines of the Dominion, and would add to the heavy burden carried and very largely responsible for the unfinancial state of the South Island system.

R. McVilly, General Manager.

Department of Agriculture, Wellington, 6th September, 1922.

Tuapeka Mouth Railway.

The Engineer-in-Chief, Public Works Department, Wellington.

YOUR memorandum 19/74 of 8th July last: As desired, a report on the proposed railway routes to Tuapeka Mouth has been prepared by the District Superintendent and the Instructor in Agriculture, Dunedin, and I forward their report herewith for your information.

C. J. REAKES, Director-General.

Department of Agriculture, Dunedin, 31st August, 1922.

Director-General of Agriculture, Wellington.

WITH reference to your memorandum of 12th July, in which you ask for a report on the proposed railway routes to Tuapeka Mouth: We have gone into this question as fully as possible, and have studied the various routes from a purely agricultural point of view. In going into the matter we viewed the subject in the light that you wished to report, giving particulars as to which route would serve the greatest number of settlers, taking into consideration the existing means of transport to and from the respective localities. At the outset we wish to make it clear that, owing to lack of information in so far as the agricultural statistics of products is concerned, we are unable to give in actual data the amount of produce and stock that would be conveyed on the routes. This report therefore gives only in a general way an indication of which route would to our mind seem most advantageous to the district as a whole, our opinion being based on the type of country, in conjunction with the existing and potential farms which the various routes might serve, together with the produce and stock which would probably be raised in those districts, thus becoming available for railway transport.

In the case of two routes—namely, Crichton to Tuapeka Mouth via Hillend, and Lovell's Flat to Tuapeka Mouth via Lovell's Creek and Hillend—these pass through inferior grazing-country, very poorly cultivated and sparsely settled. To our mind neither of these routes need be considered. In regard to the proposed route from Stirling through Balclutha and along the Clutha River to Tuapeka Mouth, this route follows the bank of the river and only serves the country adjacent to it on the Bruce County side. For the first nine miles the country is of no agricultural consequence. Thereafter the route passes through fairly good second-class country until it enters the Greenfield district. The Greenfield district need not be taken into consideration, as it would be equally well served by either of the other proposed routes. In our opinion this is not the route which would be of most economic importance from an agricultural point of view.

We are of the opinion that the proposed route from Lovell's Flat via Stony Creek and Hillend is the best, from the fact that it passes through good second-class agricultural land throughout its whole length. We would expect large quantities of produce and stock to be transported from the districts through which it would pass, and greater facilities would be given to develop that part of the country by conveying to the farmer manures, lime, &c. The country through which this route would pass is very well developed and fairly closely settled, and these factors certainly must be taken into consideration. We have no hesitation in recommending this particular route, which undoubtedly would be the greatest possible use to the country by developing a district which is already one of considerable agricultural importance.

The map forwarded for our information is returned under separate cover.

R. B. TENNANT, N.D.D., Instructor in Agriculture.
W. D. SNOWBALL, District Superintendent.

Tuapeka Mouth Railway.

The Director-General, Department of Agriculture, Wellington. Wellington, 19th September, 1922.

I HAVE to thank you for yours of the 6th instant, forwarding report by Messrs. Tennant and Snowball, of your Dunedin office, with reference to the probable traffic over the Tuapeka Mouth Railway. I regret, however, that this report does not come down to £ s. d. Without any knowledge of agriculture, a casual inspection from a motor-car leads one to exactly the same conclusion as that given by Messrs. Tennant and Snowball; but the line via Stony Creek and Hillend is much more expensive both to construct and work than one via the river-bank, and what we wished was actual estimates, if records are not available, of the amount of produce which would probably be brought off the land served by each of the routes after the line was made, and, conversely, the amount of traffic likely to be carried on to the land in the form of manures and other things. In that way we would be able to balance the increased revenue likely to be derived from the Hillend line against the greater cost of interest and working-expenses. In the absence of some figures, either estimated or recorded, you will see that we cannot really come to a valuable decision.

There is another point, mentioned in my fourth paragraph, which your officers have not dealt with at all—that is the question of whether the areas shown as tributary to each of the lines fairly represent the actual conditions.

F. W. FURKERT, Engineer-in-Chief.

Department of Agriculture, Wellington, 17th October, 1922.

Tuapeka Mouth Railway.

The Engineer-in-Chief, Public Works Department.

WITH further reference to your memorandum 19/74, dated 19th September: A further report has been obtained from Messrs. Tennent and Snowball, and is now submitted herewith.

C. J. REAKES, Director-General.

Department of Agriculture, Dunedin, 14th October, 1922.

Tuapeka Mouth Railway.

Director-General of Agriculture, Wellington.

FURTHER to your memorandum of the 20th ultimo in regard to the above proposed railway: We have noted the Engineer-in-Chief's remarks upon our previous report on this subject, and have again considered the question since reading Mr. Furkert's comments.

We find it quite impossible to give in actual figures an estimate of the amount of inward and outward traffic that is likely to accrue from each of the proposed railways, and feel assured that any estimates given by us would only be misleading and of no material value. What we would like to stress, however, is the fact that a line from Lovell's Flat via Stony Creek and Hillend will carry at least twice the amount of freight inward and outward that may reasona bly be expected from any of the other proposed routes. The district through which this route passes has potential possibilities far in excess of the other proposed routes, and we feel assured in our own minds that the adoption of any other route in preference to the one recommended in our previous report, whilst probably being cheaper to construct, would prove of less value to the district as a whole, and would not offer such facilities for developing the country.

In regard to the areas tributary to lines hatched out on the map, these on the whole are fairly correct. It should be noted, however, that the area on the map hatched in red and supposed to represent the additional area shown by he river-bank route is within a few miles of Balclutha, and even if a railway does not proceed along that route those armers in that locality are already well served.

Under separate cover the map of proposed lines is returned.

R. B. TENNENT, N.D.D., Instructor of Agriculture.
WM. D. SNOWBALL, M.R.C.V.S., District Superintendent.

Balclutha–Tuapeka Mouth Railway.

Hon. Minister.

WITH reference to the request of the Secretary of the Clutha Valley Railway League to be supplied with figures of the cost of a railway or road from Balclutha to Tuapeka Mouth. I have just received the report below from the District Engineer, giving his ideas of the standard and cost of the road to be adopted in lieu of a railway. The whole position may now, therefore, be summarized as requested in your minute of 25th February last.

The only figure that cannot be given is the amount of probable revenue that would be derived. The railway Department and the Agriculture Department have both been asked if they can supply this figure, but they cannot give us any indication.

The present traffic is estimated at 3,500 tons on the river, and this is not very likely to be much exceeded on a railway along the river-bank. The Agriculture Department state that twice as much traffic would be obtained if the route from Lovell's Flat via Stony Creek and Hillend were adopted, but the estimate for this line is more than double that for the river-bank route, being £330,000 more, which at 3¾ per cent. interest charge is £12,375. It is evident this would neutralize any additional revenue that might be obtained. Giving a liberal estimate of 16s. per ton freight on 3,500 tons, and allowing up to £2,000 for passengers, which is in accordance with some of the best South Island branches, and is, therefore, very optimistic for this railway, a revenue of £5,000 might be obtained. These figures are very approximate, but will give some indication.

The position with regard to the railway can then be summed up as follows :—	£
Interest on cost of construction (river-bank), £248,000 at 3¾ per cent.	9,300
Annual working-expenses (supplied by Railway Department)	12,823
Total annual cost	£22,123
Approximate revenue	£5,000

You will see by this that the amount of freight would have to be more than four times as great as it is at present to make the line pay.

With regard to a road from Tuapeka Mouth to Balclutha instead of a railway, the District Engineer, allowing for a road with metal 15 ft. wide and 9 in. deep and formation widths to suit, estimates the cost at £21,000. This is for a water-bound macadam road, which, with the amount of traffic to be carried, is quite good enough.

The cost of a bridge over the Clutha River at the most suitable place (which the District Engineer states to be at Clydevale) is estimated at £35,000. He considers that the time has not yet arrived for the bridging of the Clutha in this locality, nor does he think the local bodies could contribute their share to the cost of such a bridge.

28th April, 1924. F. W. FURKERT.

II. WAIHAO DOWNS RAILWAY EXTENSION.

Waihao Downs Railway Extension.

Your 1914/2966, No. 19575, of 30/8/1923. 1st November, 1923.

General Manager.

THIS extension, according to the Public Works plans, would be 4 miles 60 chains in length, from Waihao Downs Station to a locality known as "Kelchar's Corner," with an intermediate station at "Serpentine."

For fully a mile the earthworks are heavy, cuttings running to 60 ft. in depth and banks to 50 ft. in height; otherwise the works are of a light character. There would be numerous concrete, &c., culverts, and apparently only one small bridge is contemplated. The minimum radius of curves proposed is 7½ chains. The accompanying diagram shows the gradients proposed. The ruling gradient would be nominally 1 in 50, but, allowing for curve resistance, the actual ruling gradient would be about 1 in 42, practically the same as between Waihao Forks and Waihao Downs. All the gradients rise towards the terminus.

Most of the earthworks were completed some years ago, and from the Public Works Statements (Table 3) it appears about £30,000 have been expended on the extension.

The Public Works Department estimates the cost to complete the extension at £31,000. The District Railway Engineer estimates the cost at considerably more than this, but for the purpose of this report we consider it will be sufficient to assume that the cost will be, say, £35,000, including the removal of the engine-shed, &c., now at Waihao Downs to the terminus.

Financial Position with respect to Operating-costs.—In considering the financial position we have assumed—

(*a.*) The total cost of construction and completion as £65,000, with interest thereon at 4 per cent.

(*b.*) The train-mileage to be one train each way per day, as at present, with an allowance for special trains which are now run from Waihao Downs to Arno, or McLeans, in consequence of the steep grade from Waihao Forks to the latter station.

(*c.*) Operating-costs to be for maintenance of track, £200 per mile. (NOTE: The average cost for New Zealand in 1923 was £344 per mile, and for the Waimate Branch £167 per mile. For a series of years, and considering the heavy earthworks, the cost would probably be much higher than £200 a year.)

(*d.*) Operating-costs for traffic, locomotive, and car and wagon at the 1923 costs per train mile = 10s.

(*e.*) Revenue likely to accrue on account of extension as stated by the Commercial Agent and Assistant Traffic Manager, Christchurch, in their report—namely, £1,000 a year.

On the basis of these assumptions we consider the financial position would be somewhat as follows :—

		£	£
Expenditure—			
Interest on cost £65,000 at 4 per cent.		2,600	
Maintenance of line, 5 miles at £200		1,000	
Train-mileage costs—			
Train-miles, 10 miles × 313	3,130		
Specials	170		
	3,300 at 10s.	1,650	
			5,250
Revenue—			
Revenue as estimated			1,000
Estimated loss on working extension			£4,250

We are of opinion that the extension of the railway would not materially affect the motor traffic on the roads in competition with the railway.

H. B., Chief Traffic Manager.
F. W. M., Chief Engineer.

Waihao Downs Railway Extension.

The Resident Engineer, Public Works, Christchurch. Wellington, 16th June, 1924.

I SHALL be glad if you would again go into the question of the extension of the line from Waihao Downs to Kelcher's Corner, and advise what is absolutely the minimum for which the line could be extended to Kelcher's Corner.

Formation could be reduced in width and ballast reduced, platform and buildings (except a very cheap goods-shed) omitted, and any other economies you can think of made. It may be possible to make deviations which will reduce the earthwork without actually steepening the grades, unless the steepening is so situated that it can be regarded as a momentum grade.

I shall be glad if you will go into this matter as early as possible, as the information is required now. Also go into the question of probable revenue. Railways have done so already, but I want you to do it independently, and allow for any increase of production which may result from the extension. Send litho indicating land now served by Waihao Downs, and in another colour or hatching the area which would be served by that station and Kelcher's Corner. Divide approximately into " agricultural " and " pastoral."

F. W. Furkert, Engineer-in-Chief.

Public Works Department, Christchurch, 24th July, 1924.

Waihao Downs Railway Extension.

Memorandum for the Engineer-in-Chief, Public Works, Wellington.

In reply to your P.W. 19/84 of 16th ultimo: It is estimated that £38,000 is as low a figure as it is considered possible to complete the construction of the extension from Waihao Downs to Kelcher's.

The formation is so far forward now that the matter of alterations in grade would not reduce the cost by any appreciable amount. The only alteration in grade proposed is in the Kelcher's station-yard, which at present has not been touched, and which it is suggested be lowered by 18 in.

Regarding the enclosed estimate, it will be noticed that the completion of the formation is estimated to cost £6,810. This includes £3,000 for a deviation between 2 m. 5 ch. and 2 m. 30 ch., which it is considered will have to be adopted in order to avoid traversing a bad slip with a heavy embankment. You will, I think, agree that much curtailment cannot be made in the earthwork. Fencing, gates, and cattle-stops are, I think, as low as possible, and material to the value of £400 in store at present has been taken into consideration. Culverts are estimated as low as is reasonable.

Bridges: 374 lineal feet of bridges are estimated for, and the estimate allows an average of approximately £13 per lineal foot, which I think cannot be reduced.

Ballasting: Ballasting is allowed for at 6s. per cubic yard and platelaying at 1s. 3d. per lineal yard. The amount of ballast has been estimated allowing for 6 in. of ballast under the sleepers.

Station-buildings: As requested, these have been curtailed. At Serpentine, a small station-building and a loading-bank are estimated to cost £110; at Kelcher's, station-building, £70; goods-shed, £300; loading-bank, £40; stockyards, £200; buffer-stops, £50; water-supply and vat, £500; and two platelayers' cottages, £1,400—giving a total of £2,560—have been allowed for. Engine-shed, coal-store, and latrines have been omitted. I do not think any of the items included can be left out.

Permanent-way material has been estimated upon prices quoted in Stores Manager's circular of 27th May last. It will be noticed that this amounts to £15,330 at Waihao Downs, which is a large proportion of the total estimate to complete.

On the accompanying litho you will see the area that will be served by Kelcher's and Serpentine Stations, coloured pink. It is estimated to have an area of 81,500 acres. Coloured blue is shown the area that will still be served by Waihao Downs Station upon the completion of the extension.

I am of the opinion that the increase in productivity by the extension of the railway will be very small indeed, unless considerable variation in the produce-markets occurs. Certainly a considerable area is particularly well adapted to wheat-growing, but the present market prices allow the farmer to make more profit from sheep than from growing grain. There is no doubt that if the extension was completed the farmers would still confine their attention to sheep in preference to grain, unless there was a decided drop in the price of sheep or a rise in the price of wheat. I do not think it reasonable to allow much for increase of productivity.

A committee of settlers went into the matter of prospective traffic, and I understand that thirty-three of the thirty-five settlers concerned agreed to have all goods transported by rail in the event of the extension being completed. This, of course, would not be binding upon any new settler coming into the area, and hence cannot be given too much weight. This committee have compiled a schedule of probable weights that would be carried by rail. A copy of this schedule is enclosed.

Regarding the area of Douglas and Elephant Hill districts, lying east of Kelcher's Corner, which is referred to by the committee, it is clear from the map that this is estimated on the large side. To be on the liberal side the freight of this portion is estimated at 50 per cent. of what the settlers estimate for the area canvassed.

The increased revenue resulting from the extension is then estimated approximately as follows:—

	£	s.	d.
(1.) Sheep, 53,000 (say, 900 trucks) at 3s. 6d.	157	10	0
(2.) Wool, 1,800 bales at 4s.	360	0	0
(3.) Grain, 240 tons at 3s. 11d.	92	0	10
Grain, 470 tons at 5d.	9	15	10
(4.) Manure, 320 tons at 6d.	8	0	0
(5.) Seeds received by rail, 200 tons at 6d.	5	0	0
(6.) Machinery and plant, 75 tons at 6d.	1	17	6
(7.) Coal, 500 tons at 1s.	25	0	0
(8.) Cattle, 360 head (say 60 trucks) at 3s. 6d.	10	10	0
(9.) Miscellaneous goods, 200 tons at 1s.	10	0	0
(10.) Passenger fares, say	100	0	0
	£779	14	2

(1.) Sheep practically all go by rail at present to Paeroa, a distance of 30 miles from Waihao Downs. The increase in revenue is represented by the extra freight that would be charged from Kelcher's instead of from Waihao Downs as at present.

(2.) Wool: The increase represents the full rail freight on all wool from Kelcher's to Timaru. At present practically all is carried to Timaru by motor transport.

(3.) Grain is at present about half carried by rail and half by motor, chiefly to the flour-mills at Waimate. Increase in revenue is based on all being carried by rail.

(4–9.) Increase in revenue is taken upon the increased length of line from Waihao Downs to Kelcher's.

(10.) Passenger fares: The assumption is that an average of four passengers travel each way per day over the extension.

No comparison has been made with the actual freights carried from Waihao Downs during a period of one year by the railway.

It is clear that a much larger increase in revenue would be necessary to justify the extension of the railway. If 10,000 acres were cropped with wheat each year and an average of 27 bushels to the acre obtained, 10,000 tons of additional freight would result. Allowing this to be railed to Timaru, a freight of £3,700 would result. It appears to require something upon these lines to justify the extension.

Taking the interest on £38,000 (for completion only, irrespective of the money already spent) at 4 per cent. £1,520 per annum is the result. The cost of running one train per day on the extension at 13s. per train-mile (which figure is an estimate of the Railway Department's) is approximately £2,000 per annum.

Indications are certainly against there being any possible chance of the extension being a payable proposition.

F. Langbein, Resident Engineer.

Waimate Branch Railway: Summary Estimate to complete, 23rd July, 1924.

	£
Fencing, gates and cattle-stops	1,064
Grading, including sidings and station-yards and deviation at 2 m. 5 ch. to 2 m. 30 ch.	6,810
Culverts	1,000
Bridges	4,708
Ballast and platelaying in main line and sidings	4,722
Carriage of rails, sleepers, from Timaru	650
Station-buildings	2,670
Rails, sleepers, fastenings and points and crossings (value delivered in Timaru)	14,780
Engineering office and contingencies	1,596
	£38,000

III. WAIPU BRANCH RAILWAY.

Engineer-in-Chief.

With reference to the question of possible traffic and expenditure in the Waipu Branch Railway, I have to report as follows:—

The population served by the railway is approximately 2,500.

The occupied land in the Waipu district that would be served by the railway is about 86,000 acres. Of this 43,000 acres has been grassed and 7,000 acres is in naturally grassed country. The remainder is poor gum-land and some 12,000 acres of standing forest. So far as traffic for the railway is concerned we need only consider the production from the 50,000 acres of grass land. I doubt if much timber will be taken out by the railway.

The stock at present carried on the 50,000 acres of improved land is 13,000 cattle, of which 3,000 are dairy cows, and 18,000 sheep, of which about 8,000 are breeding-ewes. The production in butterfat of the whole area can be put down at 300 tons, and 8,000 sheep or lambs might be carried each year on the railway, as well as 300 bales of wool. About 3,000 cattle might also be carried each year, but it is doubtful if they would be all carried on the railway. However, I will allow for this quantity.

The present outward traffic freights, therefore, on the railway can be put down as follows:—

	£
300 tons butter at 11s.	165
300 bales wool at 1s. 9d.	26
8,000 sheep—160 trucks at 21s.	168
3,000 cattle—400 trucks at 21s.	420
	£779

This is approximately 900 tons per annum, and the total exports would not exceed at present, I think, 1,000 tons per annum, the figure given me by the District Engineer.

The imports are quoted at 2,000 tons per annum. This is, I think, high, because, in a comparison with other stations on the North Auckland line, I find the imports are generally in a ratio of 1·6 to 1, with the exports making the total in this case of 1,600 tons. However, giving it the benefit of the doubt, I will take the imports at 2,000 tons, and the average freight would be about 12s. per ton, giving a revenue of £1,200. The total revenue would then be, taking 100 extra tons of exports at 12s. per ton—Outward, £860; inward, £1,200; passengers, £1,050: total, £3,110. I have allowed for about sixty passengers per week, but I doubt if this would be reached, as the car services are much more suitable for passenger traffic.

The working-expenses are as follows: Maintenance (16 miles at £200), £3,200; train-mileage (5,200 at 4s.), £1,040; traffic expenses, £1,000: total, £5,240. The train-mileage is for costs of engine, train and crew of engine and guard. The mileage allows for two trains per week over the 26 miles between Whangarei and Waipu. Traffic expenses include salary of Stationmaster and porter's and clerical expenses.

We must now add to our annual expenses 3¾ per cent. of £170,000, the probable cost of the railway, making the total annual expenses—Running expenses, £5,240; interest charges, £6,375: total, £11,615.

The present-day-traffic returns would therefore amount to about 27 per cent. of the annual expenditure. There is a possibility that the local people may ask for and obtain three trains per week, in which case the annual expenses would be increased by another £500; but I have left it at two trains per week.

You asked me to estimate the probable amount of traffic on the assumption that the whole of the land was being worked to its full capacity. I will assume that dairying is most likely to be developed. With the exception of inward manures, dairying does not greatly increase the railway freights. If, however, the 50,000 acres were carrying 12,000 cows instead of the present 3,500, the output in butter would be about 1,100 tons per annum. I am assuming that the butter-factory would be at Waipu, and all cream would be taken to it by motor-lorry. Most of the land lies near Waipu, and very little, if any, cream would be taken by train. It is to be noticed that I have taken one cow to 4 acres. This means that the land would need to be worth about £25 per acre on an average all over. It is about £5 per acre at present. If the 50,000 acres are all in dairying the traffic in sheep or cattle will not be increased to any great extent, particularly as the amounts I have already allowed for this traffic are probably too high. The inward revenue I will increase to a value in tons 60 per cent. greater than the outward, a ratio which other station returns in the North show to be a fair one. Passenger traffic would not be increased, because I think by the time the land is brought to produce the estimated output the roads will be in such good order as to practically take nearly all passenger traffic off the railway. It must be remembered that Maungaturoto and Mareretu Stations are only about eleven miles from Waipu.

The prospective revenue will then be—

		£
Outward—	1,100 tons butter at 11s.	605
	Sheep, wool, and cattle, &c.	695
Inward—	3,000 tons at 12s.	1,800
	Passengers	1,050
		£4,150

Expenditure would be about £500 more = £12,115. The percentage of revenue to expenditure, about 34 per cent.

11th April, 1924. J. Wood, Inspecting Engineer.

Hon. Minister of Public Works.

Some time ago, when speaking of the Waipu Railway, you remarked that the probable returns from such a railway did not appear from the files to have been gone into very closely in the past.

The probable business in the Waipu district, if a railway were constructed, has now been estimated, and is set out on attached report by Mr. Wood, Inspecting Engineer. It appears from this that at the present time the probable receipts would be £3,110, and the expenditure, including interest, £11,615. Later on, when the country is much more developed, the probable revenue would be £4,150, and the expenditure £12,115. It will be seen that neither now nor within measurable future will the railway even pay working-expenses.

16th April, 1924. F. W. Furkert.

IV. GISBORNE–NAPIER RAILWAY.

Gisborne–Wairoa Railway.

The Engineer-in-Chief.

With reference to the suggested alteration of the railway route between Gisborne and Wairoa, I have again looked into this matter on the ground. I found the surveys had not advanced very far, but sufficient information had been obtained to locate the position and decide the length of a tunnel under the Wharerata ridge. On the present information it appears advisable to construct a tunnel 3½ miles in length under this ridge, at an elevation of 900 ft. above the sea on the Wairoa side and 800 ft. on the Gisborne side. This will necessitate grades of 1 in 50 on each side of the tunnel for distances of about 7 miles on each side. It is to be noticed that the greatest elevation of this line will be 900 ft., whereas the Ngatapa route rises to a height of 1,040 ft. above sea-level.

I have gone carefully into the surveys on the latter route, and have gone over the ground where no surveys have been made, so that if I am not able to give exact estimates of either route I can safely make comparative estimates of each. I estimate the Ngatapa route will be at least 50 per cent. dearer than the Wharerata route. The one and only thing in favour of the Ngatapa route is the fact that it opens up more land than the Wharerata route. I shall show presently that the traffic to be derived from the greater area of land opened up is insufficient to pay even ½ per cent. on the additional expenditure that will be incurred on the Ngatapa route. Before doing so, however, I wish to make a closer comparison than I was able to do in my last report, since I have now been able to get closer estimates of the two lines, and the lengths of each. The estimates are based to a great extent on my experience of construction in similar country, and will need to be checked by accurate surveys, but they are close enough at least to show the necessity of making surveys before any more work is done on the present authorized route.

I have no hesitation in saying that I consider the Wharetata so much better in every way than the Ngatapa route that no more work beyond Ngatapa should be done, and that trial line surveys by a large party should be at once started on the Wharerata route.

The following gives briefly a comparison of each route:—	Wharerata.	Ngatapa.
(1.) Length of line, Gisborne to Wairoa	63 miles	74 miles.
(2.) Length of new line to construct	39 miles	60 miles.
(3.) Cost of construction	£1,200,000	£1,800,000.
(4.) Length of summit tunnel	3½ miles	1½ miles.
(5.) Area of country opened up by railway along route	54,000 acres	215,000 acres.

An apparent disadvantage of the Wharerata route is the longer summit tunnel; but this tunnel can be fairly easily and economically ventilated by shafts, so that no disadvantage will be occasioned on this account.

Although they were given in my last report, I will again enumerate the advantages of the Wharerata route as disclosed by the above comparison, and from a general consideration of the character of each line:—

(1.) A saving of 11 miles in length. This means, apart from the saving in time on a main line, a reduction in expenditure per annum on maintenance of £4,000, or the equivalent to a capital cost of £80,000.

(2.) A saving of 21 miles of line to construct. At a rate of expenditure consistent with a fair allocation of money to various lines throughout the country it is probable that it would take three years longer to complete the Ngatapa than the Wharerata route. As neither route is likely to pay until completed, at the above rate of progress there will be an increase in interest charges at 5 per cent. on the Ngatapa route, amounting to £225,000 over similar charges on the Wharerata route. This should be added to the capital cost of the Ngatapa route.

(3.) After examining the country I am convinced that the trouble from slips will be considerably less on the Wharerata route than on the Ngatapa. The former route lies almost entirely in sandstone country, whereas the latter is in papa country for a considerable portion of its length. It is hard to estimate the additional cost due to this, but it is more likely to be over £50,000 than under.

(4.) The incorporation of the Waikokopu Branch Railway into the main line does away with a 25-mile branch line, which is very unlikely to pay any interest on its cost of construction. It simply means you have 25 miles of additional line tapping country that a main line can serve if located in the proper place. I cannot see how this line can pay as a branch to a main line connecting the ports of Napier and Gisborne, and taking away a larger portion of the traffic it might have otherwise obtained. If this be correct, we have interest charges on the £500,000 that this branch has taken to construct to add on to our already heavy interest bill on the Ngatapa route.

(5.) In the construction of a railway through rough country a good service road is a necessity, and modern methods of transport require a metalled road. On the Wharerata route we will have an excellently metalled road all the way, whereas on the Ngatapa route it will be necessary to construct and metal a considerable length of service road. The extra cost of service roads on the latter route will amount to something like £40,000, and even then the road will not be nearly so good as the Wharerata Road. If the roads are not brought up to a high standard on the Ngatapa route the costs of transport will be excessive in comparison with the Wharerata route. The present Wharerata Road gives an ideal access to the long tunnel under the saddle.

To sum up the conditions in favour of the Wharerata route from a financial point of view, this route will cost £995,000 less than the Ngatapa route. This is made up as follows:—

	£
(1.) Construction cost of railway	600,000
(2.) Cost of service roads	40,000
(3.) Capitalization of maintenance	80,000
(4.) Estimated cost of slips	50,000
(5.) Interest charges while under construction (three years)	225,000
	£995,000

Of course, the fifth item on this list can be reduced by constructing the line at a faster rate, but it is doubtful if the amount under this head can be made less than £150,000, thus reducing the total cost to £920,000.

I have stated above that I consider there is only one thing in favour of the Ngatapa route, and that is the fact that it serves a greater area of country between Wairoa and Gisborne. It must not be forgotten, however, that the Wharerata route also serves a fair area of country. However, I shall consider the local traffic from the Ngatapa route separately before making further comparisons.

The whole of the land served is sheep-country, and the traffic must be considered only on this basis. There is certainly dairying-land at either end, but it is too close to Wairoa or Gisborne to be considered as revenue-producing to this railway.

It is a reasonable assumption to make that the land will carry a sheep and a half to the acre, giving a total of, say, 320,000 sheep. The revenue from this can be estimated as follows:—

	Freight. £
Outward—	
Sheep, 110,000	2,640
Wool, 5,600 bales	700
Inward—	
Manures, 500 tons	150
Coal, 300 tons	90
Merchandise, 3,000 tons	2,700
Passengers, 12,000	1,660
	£7,850

This has been taken on a liberal scale, and is not likely to be any greater than shown for a great many years. The estimated cost of running this traffic is £3,050 per annum, making a net revenue of £4,800. On the same scale of traffic returns based on acreage, the Wharerata route should show a net revenue of £1,200.

The advantage gained by the Ngatapa route from local traffic and on a monetary basis is £3,600. This will earn interest on a sum of £72,000. It hardly seems necessary to say any more by way of comparison between the two routes.

In my opinion there is no justification for doing anything more on the Ngatapa route, not even to complete the survey. The Wharerata route should now, however, be properly surveyed, and a strong party should be put on to this work. As soon as this survey is completed work should be commenced as vigorously on this line as on the railway between Napier and Wairoa. I consider the through railway from Napier to Gisborne will be a paying proposition, but at no stage in its progress between these places is it likely to pay its way; therefore it should be constructed as quickly as possible.

With regard to the opening-up of the land lying along the Ngatapa route, this can be quite satisfactorily done by a good metalled road from Ngatapa to Wairoa, passing through Hangaroa, Tiniroto, and Te Reinga. There are about 32 miles of this road from Te Reinga to Ngatapa still to be metalled. This would cost probably £2,500 per mile to widen and metal, making the total cost approximately £80,000.

I consider this would be the better way to open up the country, and is quite sufficient for the trade of the district. It would pay the country to contribute the whole of this money rather than to construct the railway along this route.

4th August, 1924. J. Wood, Inspecting Engineer.

Gisborne–Wairoa Railway.

Hon. Minister of Public Works.

In connection with the above railway, you will recollect that some time ago Mr. Wood, Inspecting Engineer, after visiting the district in connection with the extreme difficulty that was being experienced with slips on the Ngatapa Section, reported that it appeared to him that even at this late stage the question of whether the railway should go by Ngatapa at all should be seriously reconsidered. Instructions were therefore given to have flying surveys made of possible other routes via Oputama and Wharerata, or via the Nuhaka Valley and Wharerata. The result of these investigations and further exploration in connection with the Ngatapa–Hangaroa route have been made, and it now appears that there is such a difference in the costs between the two lines that the expenditure of any further money beyond Ngatapa should be immediately stopped, and detail surveys made of the Nuhaka route in order to ascertain definitely that the railway can be built for the figures estimated.

Investigations as far as they go seem to indicate that only in one factor is the Ngatapa route superior. Shortly, the Nuhaka–Wharerata route is 11 miles shorter in through distance, and involves the construction of 21 miles less new railway, and its cost for construction will be approximately £600,000 less; in other words, it will only be two-thirds of the Ngatapa costs. The Ngatapa line will take approximately three years longer to construct, and would thus involve further interest charges of over £200,000, in addition to the £600,000 indicated.

Coming now to the question of the extra country served: The position is indicated on a lithograph (P.W.D. 60293) attached; and, allowing the carrying-capacity of the country served by the inland route on a reasonable basis, it appears that the advantages in the way of traffic from local sources along the Ngatapa route would pay interest on a sum of approximately £72,000. From this it will be seen that, even if this estimate were in error five times, it would still be insufficient to pay half the difference between the two routes herein contrasted.

In considering the advantages of the Nuhaka route above I omitted to mention that, while the grades are equal in each case, the summit-level by the Wharerata route is 140 ft. less than that by the Ngatapa route.

In view of the figures put forward, I recommend that work beyond Ngatapa be immediately stopped, except in so far as is necessary to secure the work already done and to remove the plant; that the surveys of the Nuhaka–Wharerata route be vigorously pushed on with, and that as soon as these are sufficiently advanced the heaviest work be put in hand; and that provision be made for a first-class road to serve the Hangaroa country, which would have been served by the route now being followed by the railway: the cost of this road (a great part of which is already made) would be approximately £80,000. Really, the country along this road might be expected to assist in the construction, particularly the metalling; but, in view of the fact that they have in the past been led to expect a railway, they would probably not view any request for a contribution favourably, and I therefore recommend that the Government accept the position and announce that they intend to make a first-class road. Even though the road were to cost twice as much as I have indicated, and the trade from that area be five times more than I have estimated, the Nuhaka–Wharerata route, on the score of first cost and later operation and maintenance expenses, would be much the better.

30th August, 1924. F. W. Furkert.

Gisborne–Napier Railway.

Mr. Furkert.

With reference to the figures and information supplied by the deputation from Gisborne and Wairoa on the question of alternative routes for the railway between Gisborne and Wairoa, I have examined them, and, although I think the figures are much exaggerated, for purposes of comparison I will accept them as correct.

The deputation says 420,000 sheep would be carried on the country supplied by the railway along the Ngatapa route, instead of the 320,000 as stated by me. This would increase my revenue figures for sheep and wool by £1,100.

If we take the land said by the deputation to be opened up as 350,000 acres, instead of the 215,000 acres given by me, on this basis we might expect the outward revenue to be increased by £2,200 and inward by £2,000. This allows for 525,000 sheep on the land. Mr. Lysnar, M.P., says 500,000 acres will be opened up, but I have not taken account of this, as this area is far too large. In any case I have taken more than the number of sheep given by the deputation.

My figures for passenger traffic are not altered, as I had already assumed a much greater population than that given by the deputation—namely, 317 settlers, instead of 137 given by them.

The total revenue, on the deputation figures, on basis of area of land opened up, should be—

	£
Outward—sheep and wool	5,540
Inward—coal, manures, and general merchandise	4,940
Passengers	1,660
	12,140
Cost of running traffic	5,300
Net revenue	£6,840

This will earn interest on a capital expenditure of £136,800.

On the same basis, if we take the deputation figures for Wharerata route—which however, are as much too small, as their Ngatapa figures are too large—the net revenue would be from this route £800, which would pay interest on £16,000.

This means we have enough revenue to justify us in spending about £120,000 more on the Ngatapa than on the Wharerata, whereas it will really cost anything from £600,000 to £995,000 more.

With regard to a route via Waikohu, this will make the distance about 88 miles between Gisborne and Wairoa as far as can be ascertained from the map of the district, and will mean at least 65 miles of new line to construct. I should think it would cost £100,000 more than the Ngatapa route, estimating on a distance basis, and would be 16 miles longer between Gisborne and Wairoa. I do not think this route is worth further consideration. The country it would open up would be very little more than the Ngatapa route, and I doubt if the extra country would pay interest on the additional cost. The distance between Waikohu and Ngatapa is only about 12 miles, so that it is apparent that traffic between these points is easily handled by good roads.

Taking the points put forward in favour of inland or Ngatapa route by the deputation notes, I have to remark as follows on such of them as necessitate an answer. There are a great many repetitions in the notes, so I have not answered them seriatim.

(1.) That the present Gisborne–Motu Railway is one of the few lines in New Zealand that pays even moderate interest. This is an argument in favour of constructing a railway between Wairoa and Gisborne, but not for the construction of the most expensive route if it cannot pay interest on its extra cost. As a matter of fact, the Gisborne–Motu line only earned 0·6 per cent. last year.

(2.) The main advantages quoted—*i.e.*, serving greatest number of people and greatest area of land and opening up new areas—are all taken into consideration in my statement that the route cannot pay interest on one-fifth of its additional cost. The country cannot afford to expend money on a railway that will only return ½ per cent. to 1 per cent. on capital outlay, even if it does open up a little more land. Good roads are the only reasonable solution for such problems, and many of our present railways are evidence of this.

(1.) The statement that the Wharerata route passes through land incapable of further settlement is not correct. The land on this route is just as good as that on the Ngatapa route.

(2.) Cost of Ngatapa route already done will be £280,000, not £350,000 as stated by deputation, and £210,000 of this will be available as an operating railway within a month.

(3.) Cost of Waikokopu Branch will be about £500,000 when completed—double that given by deputation. Neither of these lines need be scrapped as suggested by the deputation. It is intended to open and work both of them—in fact, they are now being worked.

(4.) Waipaoa freezing-works will be about 6 miles nearer to Hangaroa Valley by Waikohu than by Ngatapa and Makaraka, but Gisborne will be 16 miles farther away. It is not likely that Waipaoa works will receive all the fat-stock trade.

(5.) The Wharerata route does not mean a saving of only £150,000: it is £600,000 or more. The revenues and interest charges on both routes have already been fully discussed.

The total cost of each line from Wairoa to Gisborne will be approximately—

	Ngatapa Route. £	Wharerata Route. £
Already expended	275,000	443,000
Estimate to complete	1,805,000	1,267,000
	£2,080,000	£1,710,000

Answers to questions that deputation asked Minister:—

(1.) The Ngatapa route was not condemned because it was impossible to construct it, but it certainly can be condemned as economically impossible because it cannot pay interest on its additional cost over and above a shorter and more easily maintained route.

(2.) Yes, an alternative route to avoid the Ngatapa slip has been made, but the country in the locality offers no better location for the avoidance of slips.

(3.) The Waikohu route has been considered, but it is too long and too costly to warrant its further consideration; no survey is necessary to satisfy the Department on this question.

All things considered, I see no reason to depart from my previous recommendation to adopt the Wharerata route, and the detail surveys should be vigorously undertaken.

17th September, 1924. J. Wood, Inspecting Engineer.

Gisborne–Napier Railway.

Hon. Minister of Public Works.

With reference to the above, and in reply to the arguments in favour of the Hangaroa route as brought forward by the deputation which waited on you on the 11th instant, Mr. Wood has gone very carefully into the matter, and, although we are of the opinion that the deputation's figures err on the optimistic side, nevertheless if they are accepted as correct in every particular the result still is that there is a difference of something like £600,000 by which the inland route is too expensive to justify construction. In other words, if all the advantages claimed are admitted to the inland route and their capitalized value subtracted from its cost, and if all the money spent beyond Ngatapa be added to the cost of the Wharerata line, there will still be something like £600,000 in favour of the latter. With regard to the three questions which the deputation put to you, the answer to the first one is that the Government Engineers have never condemned the Ngatapa line as impossible, but they have condemned it as an economic impossibility: in other words, its cost would be so great as to rule it out in an argument.

Secondly, Engineers have surveyed alternative routes to avoid the Ngatapa slip—or, rather, the slippery hillside in the vicinity of Ngatapa (it is not a matter of one slip)—but none of the alternatives in that locality appear to offer any adequate advantage, hence the decision to try in an entirely different part of the country.

Thirdly, the Waikohu line, as it is called, has not been surveyed in detail, although it has been considered; but it is so long and costly as to indicate quite clearly that no further survey is necessary to rule it out also. It would involve 65 miles of new construction, and would increase the distance between Gisborne and Wairoa by at least 16 miles.

F. W. Furkert.

19th September, 1924.

APPENDIX C.

ANNUAL REPORT ON BUILDINGS BY THE GOVERNMENT ARCHITECT.

The Government Architect to the Hon. Minister of Public Works.

Sir,—

I have the honour to submit the following report on the activities of the Architectural Branch of the Department for the year ended 30th June, 1924.

During the period plans and sketches were prepared for buildings of a total estimated value of £507,995, of which works of a total value of £219,995 were carried out.

A large amount of minor alterations and repairs to offices and other buildings occupied by various Government Departments, and the usual maintenance work, has been carried out in all districts. A considerable quantity of furniture and fittings has been manufactured in the Public Works workshops and supplied to various Departments.

In common with the building trade generally, the Department has from time to time experienced difficulty in obtaining prompt delivery of seasoned and satisfactory timber and bricks, particularly in the Wellington District, where the brickmaking plant at Wi Tako Prison has proved of great service in supplying local wants, but no serious delays in completion of works have occurred.

Builders have tendered freely for Government works, and costs generally show a slightly downward tendency, while it is satisfactory to note that workmanship is gradually returning to pre-war standard.

During the year this branch undertook the architectural service in connection with secondary-school buildings throughout the Dominion, and this, together with the strong forward movement in connection with mental hospitals, has called for sustained and enthusiastic service by the staff, the personnel of which will require to be augmented in the near future; and I desire to place on record my appreciation of the loyal and efficient manner in which all have responded to the demands made upon them.

The following is a schedule of the works carried out :—

Government Houses.

Auckland and Wellington.—General repairs and maintenance as required.

Departmental Buildings.

Maintenance and general upkeep of buildings, including renovations, repairs, fittings, &c., to departmental buildings in larger towns.

Post-offices, etc.

Whangarei District.—Additions, repairs, &c., were carried out to eighteen post-offices. An additional room was built at Ohaeawai, and a motor-garage and benzine-store erected at Whangarei.

Auckland District.—General repairs, renovations, and alterations have been carried out to fifty-six post-offices; new post-offices have been erected, and fittings supplied, at Ohinewai, Onewhero, Pukemiro, Waharoa, Waimauku, Waitoa, and Silverdale; extensive additions have been made at Pukekohe; and a new shed for lineman erected at Papakura.

Taumarunui District.—Renovations have been carried out to six post-offices; a new post-office erected at Kopaki; and additions made to Ohura and Piopio Post-offices.

Tauranga District.—Repairs and painting were carried out at Whakarewarewa; additions at Matata, Mokai, Taneatua, Te Puke, and Rotorua; and a new post-office erected at Ngongotaha.

Gisborne District.—Alterations and additions to Tokomaru Bay Post-office were completed; a new garage and benzine-store erected at Opotiki, and water-supply installed. Renovations were carried out to six post-offices.

Stratford District.—Renovations and repairs were carried out to twenty-three post-offices; extensive additions and alterations were done at New Plymouth, Inglewood, Hawera, Wanganui, and Hunterville; a new lineman's cottage was erected at Awakino; large new post-offices in brick completed at Stratford and Patea; and a new post-office is in course of erection at Ohingaiti.

Napier District.—Renovations and repairs were carried out to ten post-offices.

Wellington District.—The new Automatic-telephone Exchange, Stout Street, Wellington, is also nearing completion. The building consists of three stories and basement in brick and reinforced concrete, with a steel frame. The wiring for light and power is being carried out by the Department. A large brick motor-garage, store, repair-shop, &c., have been erected on the post-office site at Palmerston North. New post-offices in wood have been erected at Pongaroa and Tinui, and the large brick post-office at Dannevirke was completed in December. Electric wiring for the latter was carried out by the Department, and furniture and fittings supplied. Extensive additions and alterations were carried out to several post-offices, and renovations and repairs to a large number of post-offices in the district.

Nelson District.—Renovations and repairs were carried out to seven post-offices, and additions and alterations completed at Motueka.

Canterbury District.—Renovations and repairs carried out to six post-offices; alterations, &c., to six offices; and a new post-office, in wood, erected at Orari.

Greymouth District.—Renovations and repairs carried out to fifteen post-offices; Otira Post-office was removed to a new site and renovated.

Otago District.—Renovations and repairs were carried out to twenty-five post-offices; the new Automatic-telephone Exchange completed at Dunedin; and new post-offices erected at Hyde and Middlemarch.

Southland District.—Renovations and repairs were carried out to eleven post-offices, and petrol-stores erected at Gore and Queenstown.

Courthouses, etc.

A new Courthouse has been erected at Matamata, and alterations, renovations, and repairs carried out to about fifty Courthouses throughout the Dominion.

Police-stations and Gaols.

Whangarei District.—Renovations and repairs were carried out to six police-stations, and a new building erected at Rawene.

Auckland District.—At Mount Eden Gaol further accommodation for female prisoners has been provided, and two new cottages erected. Various additions were made to buildings, &c. Additional cell accommodation was provided at Hamilton; a new police-station erected at Devonport; and various materials supplied at Waikeria Reformatory for works carried out by prisoners.

Taumarunui District.—A new residence for Officer in Charge was erected at Hautu Prison Farm; a new sawmill at Waikune Prison Camp, and necessary machinery and plant installed. Renovations were carried out to four police-stations.

Tauranga District.—Renovations and repairs were carried out to four police-stations.

Gisborne District.—A new police residence and lockup at Nuhaka, and additional buildings at Ruatorea, in course of erection. Renovations were carried out to Gisborne Gaol and to four police-stations.

Stratford District.—Additions were made to police-stations at Wanganui, St. John's, and Patea; and repairs and renovations carried out to ten police-stations.

Napier District.—Renovations and repairs were carried out to seven police-stations. Materials were supplied to Napier Prison, and electric lighting installed.

Wellington District.—A new police residence and office in brick is being erected at Foxton, and is nearing completion. Additions and alterations are being carried out to the Women's Reformatory, Point Halswell, consisting of an administrative block in brick and twenty-four wooden cells. The work is being done by prison labour under the supervision of this Department, and is nearing completion. Extensive alterations and repairs have been carried out to police-stations at Featherston, Masterton, Martinborough, and Tinui, and minor repairs and renovations to several others.

Nelson District.—Repairs, &c., were carried out to five police-stations; a new brick building at Port Nelson is in the course of erection.

Christchurch District.—New station and quarters were erected at St. Albans, and renovations and repairs carried out to four stations.

Greymouth District.—Repairs and renovations were carried out to sixteen police-stations.

Otago District.—Repairs and renovations were carried out to eleven police-stations, and a new residence was erected at Clyde.

Southland District.—Repairs and renovations were carried out to six stations, and to the Borstal Institute, Invercargill; water-supply laid on at Nightcaps; roading carried out, and stables, slaughterhouse, &c., erected at Estuary Farm, Invercargill.

Mental Hospitals.

Avondale.—Additions to kitchen have been completed; alterations to lavatories and basement completed and fittings supplied; electric light is being installed; extensive painting and renovations and repairs have been completed.

Tokanui.—New administration block, stores, and female admission block are all in course of erection; additional ventilation has been provided under floors of male and female wards, and a large quantity of material has been supplied.

Porirua.—The usual maintenance works were carried out as required.

Nelson.—Electric light has been installed throughout all buildings; billiard-room has been extensively altered, and other works carried out; furniture and fittings have been supplied; new drive and road constructed. Repairs were made to the dam at Stoke, and a tender has been accepted for a closed villa in brick.

Sunnyside.—New quarters for male attendants are in the course of erection. General maintenance works have been carried out.

Hokitika.—The new kitchen and dining-room building has been painted, and all necessary furniture and fittings supplied. Existing buildings have been connected up with the new drainage, and electric light installed. The old Nurses' Home has been removed to a new site, and fitted up as an isolation ward. Urinals have been erected at C and D wards. Unit No. 1 of the new scheme is almost completed. Furniture and fittings are being made in the hospital workshops. The attendants' quarters have been moved to a new site, and are being renovated. The Medical Superintendent's house and the night nurses' cottage are in course of erection.

Seacliff.—No new buildings have been erected, but a large amount of general maintenance work has been carried out; new bathrooms and lavatories have been provided, and new female airing-courts laid out.

EDUCATION.

Whangarei District.—Renovations and repairs were carried out to twelve Native schools; the school at Whakarapa was removed and re-erected, and extensive additions made to the school at Ahipara.

Tauranga District.—Renovations and repairs were carried out to six Native schools; additions were made to the school at Poroporo; and school residence was removed to Owhataiti and repaired.

Gisborne District.—A Native school is in course of erection at Whakawhitira. Renovations were carried out to four schools.

Stratford District.—Repairs were carried out to the Native school at Karioi.

Napier District.—Repairs were carried out to the Greenmeadows Receiving-home.

Wellington District.—Extensive repairs and renovations were carried out at the Wellington Boys' College, and a portable class-room provided at the Girls' College Hostel.

Nelson District.—Electric light was installed at Special School for Girls, Richmond; latrines were built for Nelson Girls' College.

Southland District.—Good progress is being made with the Southland Boys' High School, the brick-work being practically completed; painting and plastering is proceeding, and the heating service is being installed.

PUBLIC HEALTH DEPARTMENT.

Auckland District.—Fittings have been supplied for the new St. Helens Hospital, Auckland, and electric elevator installed, and extensive alterations carried out; a new roadway has been formed, and fencing completed.

Rotorua.—Alterations were effected and fittings supplied.

Pukeora Sanatorium.—Considerable additions were made, and a new cottage erected for the house-manager.

Wellington.—A cottage for the house-manager was erected at Otaki Sanatorium.

Invercargill.—A nursery was erected at St. Helens Hospital.

General maintenance and repairs were carried out to buildings as required.

GENERAL.

Various minor works, alterations, repairs, &c., were carried out in a large number of offices for different Departments, including Defence, Public Trust, Marine, Tourist, Valuation, Agriculture, Customs, Electoral, Internal Affairs, Government Life, and Mines; also to Ministerial residences.

A large quantity of furniture and fittings was made, and supplied to various offices.

JOHN T. MAIR, A.R.I.B.A.,
Government Architect.

APPENDIX D.

ANNUAL REPORT OF THE CHIEF ELECTRICAL ENGINEER.

The Chief Electrical Engineer to the Hon. the Minister of Public Works.

Sir,—

I beg to report on the position of the development of electric power in the Dominion for the past year as follows:—

GOVERNMENT SCHEMES IN OPERATION.

Lake Coleridge Electric-power Supply.

The year under review and ending 31st March, 1924, is the ninth year of operation of this plant, and it is satisfactory to note that the plant has again shown a profit after paying all expenses. Analyses of the results of operation of the scheme will be found in Tables A, B, and C, whilst in Table D is shown a record of the connected load. The growth of load to date is shown in attached Figure 1.

Financial Results.—The capital outlay at the close of the year was £892,801, as against £848,033 at the beginning of the year, representing an increase of £44,768. Details of capital expenditure are shown in Table B. The total revenue for the year was £78,508, being £703 in excess of all charges, including interest at 5·4 per cent., depreciation at 2 per cent., but not including sinking fund. The profit on the year's operation has reduced the accumulated deficiency on the Profit and Loss Account from £23,876 to £23,173. Table A gives particulars of financial results of operation and load records.

The power-house maximum output reached 10,800 kw., an increase of 15 per cent. on the previous year. Units output from the power-house were 50,614,955, as against 44,008,106 for the preceding year, showing an increase of 15 per cent. The annual load factor was 53 per cent., or practically the same as that for last year.

The total costs per unit generated are 0·382d., or 0·03d. greater than the previous year's costs. The increase is accounted for by interest on additional capital outlay and increased depreciation. Operating costs are greater by £1,506, represented chiefly by increased maintenance on transmission and distribution lines. Particulars of operating costs are found in Table C.

Connected Load.—The total connected load at the end of the year was 62,495 kw., representing an increase of over 24 per cent. on that of the year previous. Details of connected load will be found in Table D. The maximum demand on the power-house was 10,800 kw., showing a diversity factor of 5·8.

Interruptions, Christchurch Lines.—During the year there were eight interruptions to service exceeding one minute's duration, the total amount of these being 5 hours 59½ minutes. The longest period of interruption was 5 hours 25 minutes, occurring on Monday, 10th December, at 9.43 p.m., due to insulator failures on both transmission-lines simultaneously. The weather at the time was misty and wet, following immediately on a long dry spell, and the cause of failure can only be assumed to be due to an accumulation of dirt on the insulators. The Tramway Board's standby plant was called on to maintain a temporary service until repairs were effected. In addition to the above there were fifteen interruptions of a momentary nature, due mainly to defective insulators, or to bark, or magpies fouling the lines. The insulators replaced during interruptions totalled thirteen.

Timaru Transmission-line.—The Point-Ashburton section of this line was put into service in August, and the Ashburton-Timaru section in February. There have been a total of forty-six interruptions to service on this line, other than those prearranged for necessary completion of work. Twenty-two of these interruptions were due to trees, bark, wires, or magpies fouling the lines; nine were due to insulator troubles, three to operation, and nineteen to causes unknown. A great deal of trouble has been experienced on the lines by malicious throwing of wires on the power-lines, and also to breaking of insulators by rifle-fire; but, as the culprits in at least one case were dealt with, these troubles should be reduced to a minimum in the future. Steps have been taken to deal effectively with the excessive number of interruptions, and a decided improvement is looked for.

During the year No. 6 unit, 3,000 kw., was put into service, and this enabled the plant to operate without overload throughout the year. After being a few months in service this machine developed a fault which resulted in a rather serious burn-out. As spare plant was available no serious inconvenience was experienced during the few weeks in which repairs were being made. No trouble was experienced with the water-supply, and the lake was maintained at high level throughout the year.

The installation of No. 6 generator brought the station up to 12,000 kw. capacity, the limit of the present tunnel and headworks. Two new banks of transformers, each consisting of three units of 4,000 K.V.A., with one spare unit, were installed at the power-house early in the year, and the two displaced banks, each three units of 1,500 kw. each, were transferred to Timaru and to Addington.

With the completion of Ashburton Substation, supply at 11,000 volts was given to Ashburton Power Board in August. Timaru Substation building was completed and a temporary supply at 11,000 volts was given to Timaru Borough in December, pending the erection of the necessary 66,000/11,000-volt transformers and switching equipment. This work was completed and supply at 66,000 volts was given in February. A duplicate 11,000-volt line from Hororata to Darfield has been erected to supply the Railway Department's signalling service on the Midland Railway, and also the Malvern Power Board.

Supply was given to the Railway Department at 3,300 volts at the beginning of December. An 11,000-volt line was erected from the Point Switching-station to Mr. T. A. Phillips's residence, Windwhistle, and livened up in February. The mileage of the Department's 11,000-volt feeders has been increased during the year from 90 to 99 miles.

A contract was let in February for extensions to Addington Substation building, and good progress has been made by the contractors. The extensions should be completed during the year, and will provide the necessary accommodation for a third bank of transformers, synchronous condenser, and additional switching equipment required. When this work is completed the capacity of Addington Substation will be increased to 13,500 K.V.A.

Tenders were called on the 23rd March for one 6,000 K.V.A. synchronous condenser for Addington. This machine will replace the existing 1,500 K.V.A. condenser, which will be transferred to Timaru Substation.

The outdoor oil circuit-breakers for use at the Point Switching-station have come to hand, and will be installed during the coming year.

Supply was given to the Ashburton Power Board in August, and to the South Canterbury Power Board in December. The latter Board was formed during the year, and will control the whole of South Canterbury south of the Rangitata River, including Timaru Borough. A Power Board has been formed, to include the counties of Malvern, Selwyn, and Tawera, under the name of "The Malvern Electric Power Board," and steps are being taken to raise the necessary loan for reticulation purposes. The Springs-Ellesmere Power Board area has been increased to include Paparua County, and arrangements are being made by the Board for the purchase of the Department's reticulation in that county.

For the purpose of overhaul and inspection of the tunnel, pipe-lines, and machinery, the plant was shut down on Sunday, 23rd December, between 6 a.m. and 5 p.m., the result of the inspection being quite satisfactory.

Transmission System.—The Point-Ashburton section of the Timaru transmission-line was put into service in August, and in December the section Ashburton–Timaru was livened up at 11,000 volts to enable a temporary supply to be given to Timaru Borough. This section was finally put into service at 66,000 volts in February.

The overhaul and reconstruction of the three transmission-lines to Christchurch was completed at the beginning of the year. Two of these lines are constructed with 19/13 S.W.G. copper cables, and are at present used for supplying Christchurch. The other line (north) is constructed partly with aluminium and partly with copper, and will be brought into permanent service when the extensions to Addington Substation are completed. Steps, however, have been taken to enable this line to be used in case of emergency in the meantime.

Lake Coleridge Duplication.—The work in connection with the duplication of the plant is well in hand. A co-operative contract was let on the 26th January to Messrs. J. Beban and party for construction of the tunnel, and by the close of the financial year good progress had been made; the necessary adit and 82 ft. of the actual tunnel were driven at the surge-chamber end, and work on the shafts at centre of tunnel and intake was commenced. The intake works are being carried out by the Department, and will consist of a tunnel driven out under the lake and terminating in a concrete-lined steel cylinder beyond the area affected by shingle. Satisfactory progress has been made with the excavations for the surge-chamber, power-house building, and pipe-lines. Specifications have been drafted for the pipe-lines, power-house building, and switch-gear, and tenders were called in January for two 7,500 kw. turbines and generators.

The new tunnel will be sufficiently large to deal with all the water required for the complete station output of 27,000 kw., should this be required. Provision is being made for the installation of a third pipe-line and 7,500 kw. set, to act as a standby.

Waikato Electric-power Supply.

Capital Outlay and Financial Results.—The capital outlay at the end of the year was £474,817, as compared with £395,022 at the end of last year, an increase of £79,795. This is analysed in Table B herewith. Of this outlay, about £80,000 represents assets not yet in operation, this being almost entirely due to expenditure on additions to Horahora.

The year ended with a profit, after paying interest, working-expenses, and depreciation (but not sinking fund), of £15,826. This is sufficient to pay off the accumulated sinking-fund arrears and the sinking fund for the year ended, amounting in all to £12,718, and leaves a surplus of £3,108, which, together with £386 from last year, makes an accumulated surplus of £3,494.

The revenue for the year increased from £41,818 to £59,924, an increase of £18,106, or 43 per cent.

Table A gives the financial results of operation and operating figures, and the revenue from different classes of consumers is shown in the following statement:—

Revenue from—	1922. £	1923. £	1924. £
Large mining companies	19,547	20,177	24,635
Power Boards	4,310	14,728	26,007
Hamilton Borough	1,391	2,911	4,621
Other wholesale consumers	1,675	2,565	3,281
Miscellaneous	1,374	1,437	1,380
	£28,207	£41,818	£59,924

It is very satisfactory to note that this result as shown by the above table is due principally to the large increase in revenue from the Power Boards. The sum of their maximum loads has increased from 1,051 kw. (1,400 horse-power) in 1922 to 1,845 kw. (2,460 horse-power) in 1923, and to 3,038 kw. (4,050 horse-power) in 1924.

It is worthy of note that this increase in load of the Power Boards, combined with the increase of other consumers' load also, has caused an increase of only 500 kw. in the maximum load on the power-house. The growth of load from date of purchase is shown in attached Figure 2.

For the present year it is estimated that the mining load and revenue will drop considerably, and the increase in revenue from the Power Boards will be practically equal to this, so that the total revenue will be almost the same. Expenses will be slightly higher, so that the net revenue will be a little lower.

As regards future prospects outside the original area of supply, supply is intended to be given to the Auckland and Franklin Power Boards and to Rotorua. The work for this should be completed before the end of the coming financial year, but it will have little effect on the financial position.

Extensions during the Year and Future Extensions.

(*a.*) Waihou Substation was put into operation in September, 1923, supplying power to the Thames Valley Power Board, in the Te Aroha - Morrinsville district. The 50,000-volt line connecting Horahora to Arapuni was completed, and is supplying power to Arapuni at 11,000 volts. No additional large consumers were supplied during the year.

The total system supplied from Horahora (on the 31st March, 1924) consisted of 86 miles of 50,000-volt lines, and 38 miles of 11,000-volt lines belonging to the Department, and 334 miles of 11,000-volt lines, 444 miles of 3,300-volt lines, and 371·5 miles of low-tension lines belonging to the Power Boards.

The connected load has increased from 19,565 kw. to 25,123 kw. during the year, an increase of 5,558 kw., or 28 per cent.; but the increase in power-house maximum load has been only 500 kw. The diversity has increased from 2·84 to 3·4, but is still lower than is usually found, owing to the low diversity of the two large mining companies.

(*b.*) *Extensions at Horahora.*—The additions to the headworks and generating station to accommodate two additional 2,000 kw. units have been in progress all the year, and one of the additional units should be ready by November, 1924, and the other by February, 1925.

(*c.*) *Additional Transmission-lines.* — The 110,000-volt line to Auckland is under construction. Difficulties have been experienced in making a final survey of the route which would be satisfactory from the point of view of possible interference with the Post and Telegraph lines, and difficulty has been met with in construction, owing to the wet nature of a considerable portion of the country. The opportunity was made use of during the dry weather to erect the poles on the worst portion of the route, south of Mercer. This line is to be completed by January, 1925. 50,000-volt lines to Rotorua (Ngongotaha) and to Waitomo (Hangatiki) are being surveyed, and should be completed in the coming summer.

(*d.*) *Substations.*—Plans have been prepared and material ordered for the Auckland Substation at Penrose, and the preliminary work for substations for Rotorua and Waitomo is in hand.

Operation.

(*a.*) *Headworks and Power-house.*—The maximum load of 7,400 kw.—*i.e.*, an overload of 1,100 kw., or 18 per cent. on the plant capacity of 6,300 kw.—was carried without serious difficulty, although it was necessary at times to ask the Grand Junction Company to run their steam plant for power-factor correction, and to arrange for the Waihi Company to reduce their load slightly. In addition, the Grand Junction plant was called on for emergency or overhaul purposes on seven occasions during the year, for a total time of 75 hours, during which 42,400 units were supplied by steam power with a maximum load of about 1,000 kw., in addition to the company's own load at these times. Of this time, 20 hours was for line overhaul. As for last year, this co-operation between the two plants was of great value.

This is the first year in which it has not been considered necessary to shut the power-house down completely for some alteration or examination. During the year considerable sums were spent out of the maintenance fund on temporary improvements to the weir to enable more water to be got into the race, and for renewals on the turbines, now ten years old, to put them into good operating condition.

The power-house operated under overload almost daily throughout the year, and credit is due to the Superintendent and staff for maintaining and improving it under these conditions.

(*b.*) *50,000-volt Transmission-line, Horahora–Waikino.*—There were fourteen accidental stoppages on this line, for a total time of 46 hours 44 minutes. One of these was for 44 hours 34 minutes, this being due to a mechanical defect on a tower on the Mountain section, combined with telephone trouble. Wind and heavy rain made it difficult to locate the trouble. The other interruptions were of short duration, the longest being for 33 minutes. The standby supply minimized inconvenience to consumers. There were also seven prearranged interruptions, for a total time of 24 hours 42 minutes.

Two insulators (pin type) were replaced during the year. Orders have been placed and arrangements made to replace several of the towers on the Mountain section which show signs of deterioration.

(*c.*) *50,000-volt Transmission-line, Horahora–Hamilton.*—There were twenty-eight accidental stoppages on this line, for a total time of 7 hours 12 minutes, including one of 5 hours 2 minutes; also two prearranged interruptions, for a total time of 1 hour 7 minutes. Most of these accidental interruptions were only momentary, and the cause of them has been removed.

One insulator (pin type) was replaced.

(*d.*) *11,000-volt Lines.*—No insulators have been replaced on these, and the accidental interruptions have been only momentary.

Waikaremoana Power Plant.

A small plant has been installed by the Department at Waikaremoana for the supply to Wairoa Borough Council, and in anticipation of our requiring power for construction purposes on the main scheme of development. This plant has been leased to the Wairoa Power Board, and has been operated by them during the year. The results have been very satisfactory in supplying the needs of the Wairoa district and in building up a load in that district in anticipation of a larger development. The plant has a capacity of 700 kw., and the maximum load reached during the year was 555 kw.

The financial results, considering the plant simply as an operating-station, are not very satisfactory, but, as the plant is really an advance portion of the larger scheme of development at Waikaremoana, the capital investment is considerably greater than would have been necessary if the scheme had been put in purely for its present purpose of supplying power to the Wairoa Power Board. The capital outlay is £77,148. Capital charges (interest and depreciation) amounted to £5,574, and the revenue to £2,100, giving a loss of £3,474 for the year.

GOVERNMENT SCHEMES UNDER CONSTRUCTION.

Mangahao Electric-power Supply.

Construction work on the tunnels, dams, pipe-lines, and power-house building have been carried well on to completion during the year, as more particularly described in the report of the Engineer-in-Chief. Close attention has been paid to the excavation of foundations of the dams, and modifications made to designs as occasion arose to meet the particular conditions disclosed during construction. Some delay was experienced in the completion of the power-house building, so that we were unable to commence the erection of the power-house plant until February of this year, and then work was carried on under difficulties owing to the restricted space available due to the necessity of completing building operations at the same time. Nevertheless satisfactory progress has been made with the erection of all sections of the plant, and it is anticipated that two of the main units of the plant (12,000 K.V.A.) will be ready for operation by the end of October, 1924.

A large amount of work has been done on the erection of the transmission-lines radiating from Shannon to Wellington, Wanganui, and Napier. About 200 miles of transmission pole-line, and 160 miles of telephone-line, were erected during the year. Some delay was experienced in the delivery of the steel towers for the rough cross-country sections between Paekakariki and Wellington, between Ashhurst and Woodville, and in the Ruamahunga Gorge. The Paekakariki–Wellington section has now been completed, and the others are in hand. About 30 miles of tracks have been formed to give access to various sections of the lines, and over six hundred gates erected to facilitate patrol on the cross-country sections.

A contract has been let for the erection of the main substation building at Khandallah to supply Wellington, but progress has not been satisfactory, and the installation of plant at this point has been held up somewhat accordingly. The building is now almost complete, and the erection of the plant is well in hand. It is anticipated that we shall be able to supply power from this substation early in December, 1924.

Contracts have been let for other substation buildings at Bunnythorpe, Masterton, Mangamaire, Dannevirke, and Waipukurau. The plant for these substations is now coming to hand, and erection will commence shortly. It is anticipated that power will be available at Bunnythorpe in January, 1925, and at the other substations at successive intervals of about one month thereafter. Surveys for extensions from Marton to Wanganui, and from Waipukurau to Napier, are in hand, and most of the material for these lines and substations has been ordered.

Most of the Power Boards which are to take power from Mangahao are well forward with their reticulation work, and will be in a position to provide a substantial load as soon as power is available at their respective substations. Practically the whole of the available power from Mangahao has now been definitely allocated, and guarantees of revenue have been received from the Wellington City Corporation and the various Power Boards. The guaranteed revenue is equivalent to the full output of the power-station in five years, but there are indications that the load that will be developed will necessitate the provision of additional power even before that date.

Arapuni Electric-power Plant.

In anticipation of a contract being let for this work, considerable progress has been made on access roads and bridges, and on preparation of a village-site. These works are more particularly described in the report of the Engineer-in-Chief. During the year plans and specifications were prepared and tenders invited for the construction of the first instalment of the main plant, to consist of three units each of 15,000 k.w. capacity. In response to the invitation of tenders, several British firms sent out expert engineers to investigate the proposals on the ground and to submit tenders. Three complete tenders were received for Section 1 (dam and headworks), and four complete, and several partial tenders for Section 2 (power-house building and plant). Owing to the complexity of the work, particularly Section 2, the tenders received were very bulky documents, and a large amount of work was involved in analysing and comparing the different proposals. The successful tenderer in each case was Sir W. G. Armstrong, Whitworth, and Co. (Limited), at a total price for the two sections of £1,170,891. In view of discussion and criticism of this scheme which has taken place from time to time, it is satisfying to know that the various experts who investigated it in connection with these tenders were unanimous as to the natural advantages of the site. It is also satisfying to know that they could suggest no improvements on the Department's design of the scheme, and that the tender finally accepted was so close (within less than 1 per cent.) to the Department's estimate of the cost of the work.

Electric-power Boards.

It is gratifying to note the interest that is being taken in Power Board business throughout the country, and the substantial progress made by the various Boards during the year. The attached coloured map shows the various Power Boards at present constituted.

The total area covered is 57,876 square miles, or 55 per cent. of the total area of the Dominion. The total population concerned is 679,748, or 53 per cent. of the total population of the Dominion; and the unimproved value of the land included in the electric-power districts and outer areas is £202,359,574, or 63 per cent. of the total unimproved value of the Dominion. Considerably more than one-half of the Dominion is thus covered.

So far, many of the Boards have been engaged solely on preparatory and construction work and have not begun their all-important function of supplying power. It is felt that the early completion of the Department's hydro-electric generating-station at Mangahao, and the extensions which are in hand at Lake Coleridge and at Horahora, will make an extra amount of bulk power available which will greatly stimulate the Boards' activities.

The Boards already formed are carrying out their functions energetically. Eight Boards—viz., Thames Valley, Cambridge, Central, Te Awamutu, Banks Peninsula, Springs-Ellesmere, Ashburton, and South Canterbury—have carried out fairly complete reticulation of their areas, and are distributing power taken in bulk from the Public Works Department's hydro-electric-power plants at Horahora and Lake Coleridge. The Auckland Board has taken over the city steam-power station, and is providing for extensions both of plant and mains. It has also entered into a contract to take the whole of its power, with a minimum of 15,000 kw., from the Government when the Arapuni Station is completed, which is estimated to be in 1928. Six—viz., Southland, Wairarapa, Taranaki, Manawatu-Oroua, Horowhenua, and Tararua—while pushing on with their reticulation in anticipation of a general supply of hydro-electric power, are giving a partial supply from smaller stations in the meanwhile. Wairoa is taking power in bulk from the Department's station at Lake Waikaremoana, and supplies the borough and a few consumers in the neighbourhood. Two—viz., Opunake and Teviot—have small local water-power stations in operation. Seven others—viz., Dannevirke, Rangitikei, Hutt Valley, Central Hawke's Bay, Malvern, Waitaki, and Otago—are arranging to take power in bulk from the Government hydro-electric sources, and are preparing their systems of reticulation with this end in view. The Buller District, though constituted, has not yet elected a Board. The other ten—viz., Westland, Reefton, Grey, Otago Central, Wairere, Hobson, Kaipara, Marlborough, Poverty Bay, and Tauranga—are making special arrangements in each case which have not yet been finalized.

In addition to the thirty-six districts already formed, steps are being taken to form districts in Hawke's Bay, Hokianga, and Waitomo, including large areas in each case.

Table L herewith gives details of the dates of construction, the area, population, and rateable value included in each of the thirty-six power districts already formed, also the amounts of the loans already authorized, and the voting on each poll taken. The total amount of the loans authorized by the twenty-five districts which have already taken their polls is £7,941,000. The population of the inner areas concerned is 521,802, so that the loans authorized amount to £15·2 per head of population, as compared with £13·5 last year. The unimproved valuation of the inner areas is £153,383,640, so that the loans authorized amount to 5·2 per cent. of the unimproved rateable value of the lands pledged as security for the loans, which is practically the same as the figure for last year. The voting at the twenty-five polls amounted to 28,975 to 2,589—*i.e.*, a majority of 92 per cent. In one case (Te Awamutu District) the poll was unanimous, and in the Taranaki poll, in which the opposition was the strongest, the majority was still 77 per cent.

Table M herewith shows the capital expenditure incurred by each Board up to the end of the financial year, the revenue and expenditure, and the amount of rates struck and collected. The total capital outlay by the twenty-five Boards which have started construction is £3,212,296, but a great part of this is on works not yet in service. The gross revenue from the sale of electricity by the nine Boards which had commenced supply was £332,467, of which 65 per cent. was received by the Auckland Board. The general result is a profit over the whole business of the Power Boards of £4,534. A substantial portion of the interest on lines still under construction was charged to capital, so that the total amount raised by rating in order to cover the initial losses of those Boards not yet in active operation was only £9,319. With many of the schemes in the very early stages of supply this result is quite satisfactory. The rating for the next few years will have to be substantially heavier unless provision is made to enable Power Boards to carry forward losses in early stages of their operations, to be paid out of the profits which can be anticipated after the first few years, as the Department has done in connection with Lake Coleridge and Horahora. But, even so, such losses in the early stages do not indicate any want of security in the business as a whole, but are inherent in the starting of any concern depending to such an extent on a large initial capital outlay to earn a revenue which takes time to develop.

During last year seven of the Boards struck a general rate, which was only collected in five cases; and ten of the Boards struck special rates for the security for loans, only one of which had to be collected.

Several of the Boards are passing through a critical stage owing to the high cost and high interest rates ruling in 1921 when they started construction work, and to the fact that they have undertaken the construction of many lines without requiring the guarantees from consumers authorized by clause 7 (*d*) of the regulations. But costs and rates of interest are now substantially lower, and the other Boards are profiting by such experiences, and much better results will be attained by the Power Boards generally in future as the result of the experience of these earlier districts.

Local Electric-supply Systems.

Including the Government plants, there are now fifty-eight public electric-power stations in the Dominion, as detailed in Tables O and P herewith.

One new gas station started operation during the year—viz., Waipukurau (80 kw.); and four gas stations (Ashburton, Timaru, Winton, Ngaruawahia), and two water-power stations (Akaroa and Te Aroha) were closed down and supplied in bulk from existing hydro-electric stations.

Extensions were made during the year at Lake Coleridge (3,000 kw., water-power), Wellington (5,000 kw., steam), and Auckland (5,000 kw., steam). The changes during the coming year will also be in the direction of increasing the large stations and closing down the small ones, giving greater economy in operation.

The total installed capacity has increased during the year by 8,365 kw., or 14·5 per cent. (from 57,589 kw. to 65,954 kw), while the sum of the maximum loads has decreased by 390 kw., or less than 1 per cent. (from 54,502 kw. to 54,112 kw.). This is due to the concentration of the peak load into a lesser number of stations.

The proportion of installed plant is now as follows :—

	Stations.	Kilowatts.	Proportion per Cent.
Water-power	30	30,392	46·1
Steam-power	8	30,085	45·6
Gas-power	18	4,621	7·0
Oil-power	2	856	1·3
	58	65,954	100·0

This increase in the proportion of steam-power is due to the addition of units in the Auckland and Wellington stations, pending completion of the Government hydro-electric stations. Next year the proportion of water-power will be considerably increased.

The number of consumers supplied has increased from 106,790 to 124,705, an increase of 17,915, or 17 per cent., for the year. The units per consumer were 1,394, as compared with 1,280 last year.

The total population included in the various areas of electric-power supply is 824,030, or over 61 per cent. of the total population of the Dominion; so that the ideal of a supply being available to every home in the Dominion is well on the way to realization.

The maximum demand per head of population in the areas supplied is 0·066 kw., practically one-half of the allocation of 0·15 kw., or 0·2 h.p. per head of population, which is the basis of the design of the Government schemes. The units sold per head of population supplied were 211, as compared with 178 last year.

The total length of distributing-line is 4,878 route-miles, as compared with 3,758 last year, an increase of 1,120 miles, or 30 per cent. The number of consumers per route-mile is 25·6, as compared with 28·4 last year, the reduction being due to the large mileage of new lines erected during the year to which the full number of services are not yet connected.

The power-demand per route-mile of line is now 11 kw., the sales 35,648 units, and the revenue £292. These are substantially smaller than last year, for the same reason, but are still remunerative returns over the whole business.

The revenue per kilowatt of output of all stations was £26·3, as compared with £24·2 last year. The water-power stations show a revenue of £23·1 per kilowatt, steam stations of £30·9 per kilowatt, and gas stations of £32·8 per kilowatt. These are valuable figures for use in forecasting the revenue from systems of various descriptions. The water-power systems include the largest proportion of large consumers, and the gas-engine stations the largest proportion of small consumers.

Out of the eighty-three distributing authorities, sixty showed a profit for the year amounting to £170,939, and twenty-three showed a loss amounting to £26,213. The general result is a net profit for the whole Dominion of £144,726 after paying working-costs (£715,441) and capital charges (£563,218) at the rate of 7·2 per cent. on the total capital outlay of £7,822,034. This shows a net profit of 1·85 per cent., as compared with 1·7 per cent. last year. The business on the whole is thus a thoroughly sound and remunerative one, as well as supplying a public necessity to 61 per cent. of the population of the Dominion.

Electric-power Supply of New Zealand for the year ended 31st March, 1924.

—	Water.	Steam.	Gas.	Oil.	Total.
Number of stations	30	8	18	2	58
Average capacity (kilowatts)	1,013	3,761	257	428	1,137
Number of consumers	71,397	40,144	9,995	3,169	124,705
Installed capacity (kilowatts), (main plant only)	30,392	30,085	4,621	856	65,954
Maximum load (kilowatts)	32,949	17,522	2,949	692	54,112
Units generated	152,302,799	56,312,793	6,658,394	1,535,445	216,809,431
Annual load-factor (per cent.)	52·8	36·7	25·8	25·3	45·7
Units sold	120,617,414	46,712,494	5,272,399	1,292,985	173,895,292
Total capital outlay*	£4,985,857	£2,162,342	£594,720	£79,115	£7,822,034
Total capital per kilowatt installed* ..	£164	£72	£129	£92	£119
Total annual working-costs	£315,231	£317,156	£69,249	£13,805	£715,441
Total annual working-cost per unit sold ..	0·63d.	1·63d.	3·15d.	2·56d.	0·99d.
Total annual working-cost per kilowatt, maximum load	£9·6	£18·1	£23·5	£19·9	£13·2
Total annual capital charges	£350,651	£183,075	£23,429	£6,063	£563,218
Total annual capital charges per unit sold	0·70d.	0·94d.	1·07d.	1·12d.	0·78d.
Total annual capital charges per kilowatt, maximum load	£10·6	£10·4	£7·9	£8·8	£10·4
Total annual capital charges, percentage of capital outlay	7·03	8·47	3·94	7·66	7·20
Total annual costs	£665,882	£500,231	£92,678	£19,868	£1,278,659
Total annual costs per unit sold ..	1·33d.	2·57d.	4·22d.	3·69d.	1·77d.
Total annual cost per kilowatt, maximum load	£20·2	£28·5	£31·4	£28·7	£23·6
Total annual revenue	£760,587	£541,225	£96,605	£24,968	£1,423,385
Total annual revenue per unit sold ..	1·51d.	2·78d.	4·40d.	4·63d.	1·96d.
Total annual revenue per kilowatt, maximum load	£23·1	£30·9	£32·8	£36·1	£26·3
Net profit	£94,705	£40,994	£3,927	£5,100	£144,726

* Includes distribution.

Daily Load Curves.

The question of the daily load curve and the ratio of the average load to the maximum load or the load-factor is an important one in determining the selling-price of electric power. Each station must ascertain its own load-factor and determine its selling policy accordingly. As a general guide the daily load curves of sixteen of the larger stations of the Dominion have, by the kind co-operation of the engineers to these places, again been obtained for two days of the current year—viz., Friday, 14th March (representing equinoctial conditions), and Friday, 27th June (representing midwinter conditions). Friday has been selected as the late-shopping night in most places, thus representing the most extreme conditions of loading. These sixteen stations have an installed capacity of 63,271 kw., or 96 per cent. of the total installed capacity of the Dominion, so that the resultant curves may be taken to represent quite accurately the shape of the load curve of the combined output of the whole Dominion. Water-power and fuel stations are proportionately represented, including all the large stations of each type, and the diagram includes not only the total output, but the water-power and fuel-power outputs separately. The summation curves are plotted in Fig. 3, and the results are as follows :—

Summer and Winter Typical Loads

(Sixteen Power-stations).

—	Installed.	Maximum Load.	Units.	Daily Load-factor.
March 14th, 1924—	Kilowatts.	Kilowatts.		
Water-power	29,225	26,809	506,024	78·64
Fuel-power	34,046	16,535	231,769	58·40
Totals	63,271	42,537*	737,793	72·27
June 27th, 1924—				
Water-power	29,225	26,651	475,144	74·28
Fuel-power	34,046	22,718	301,351	55·27
Totals	63,271	49,124*	776,495	65·86

* Combined maximum.

These are daily load-factors. The annual load-factors are, of course, substantially lower, being 52·8 per cent. for water-power, 36·7 per cent. for steam-power, and 45·7 per cent. for the whole output of the Dominion.

Registration of Electric Wiremen.

This matter has now been under consideration for several years, and a draft Bill dealing with the registration of wiremen has been prepared in collaboration with the supply authorities. With the increasing amount of electrical work that is going on all over the Dominion, it is felt that some standard of construction, with adequate inspection, is necessary, so that as far as possible the same standard of work will be carried out in all parts. At present wiremen are licensed by various electric-supply authorities to do work in their own areas, and in accordance with their own particular sets of rules. The result is that a man who is licensed to do electrical-wiring work in one town may have to pass a fresh examination and obtain a new license before being allowed to work in another district. The draft Bill which has been prepared, provided for a controlling body on which will be representatives of the Government, the electric-supply authorities, the electrical contractors, the fire underwriters, and the wiremen, who will have authority to issue regulations in respect to wiring-work, and to arrange or conduct examinations, and issue licenses to wiremen which shall hold good all over the Dominion. It is proposed that the expenses of this Board and cost of examinations, &c., shall be carried temporarily by the Government Electric Supply Account until it reaches some predetermined amount, when it shall be divided *pro rata* amongst the various electric-supply authorities.

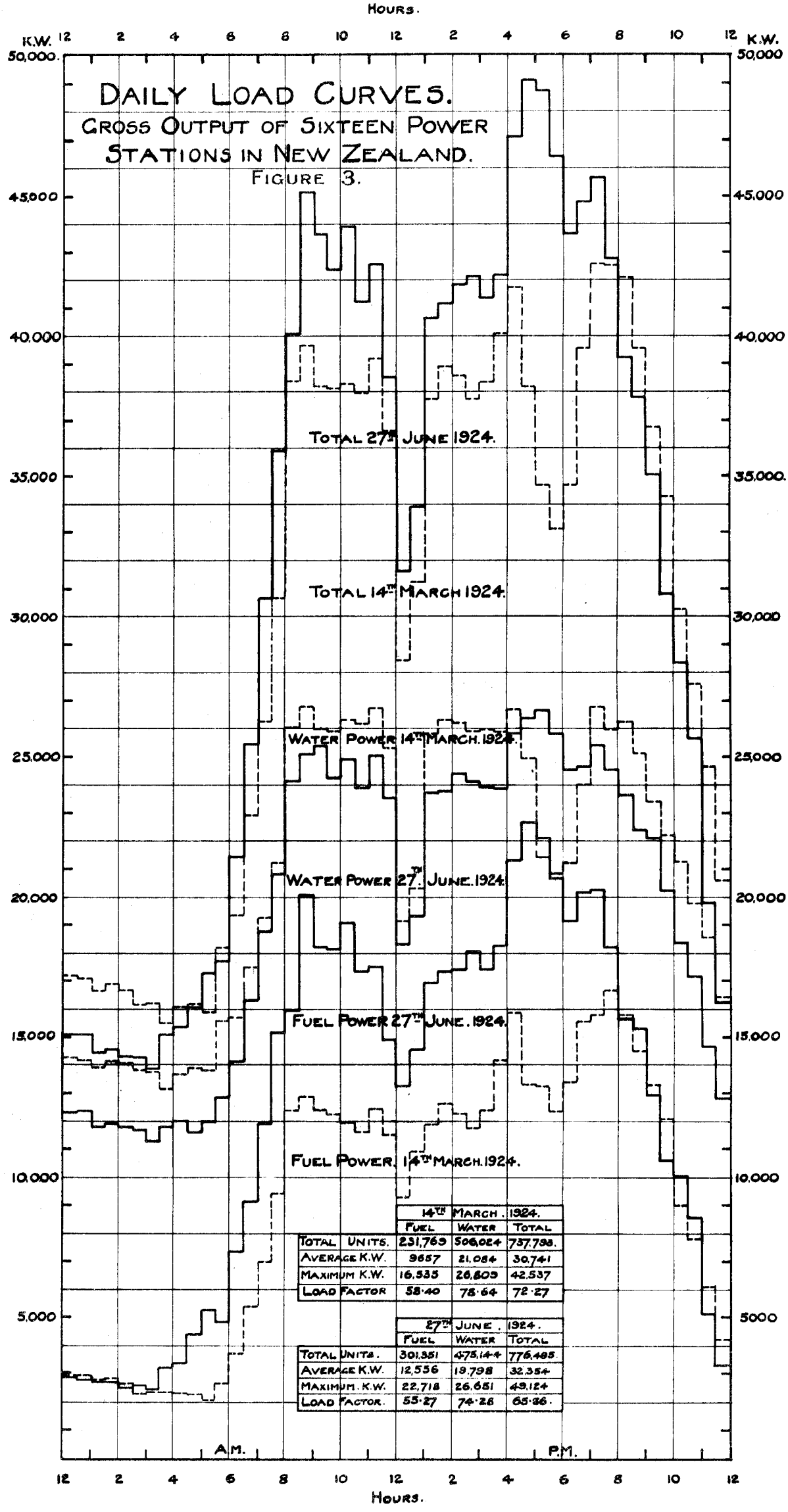
World Power Conference.

A comprehensive paper on the electric-power supply of New Zealand was prepared during the year for presentation at the World Power Conference held in London in August. This paper was to have been read at the conference by the late Chief Electrical Engineer, Mr. Lawrence Birks, B.Sc., M.Inst.C.E., M.I.E.E., &c.

Mr. Birks left New Zealand in April to attend this conference, and generally to study electrical development abroad, but unfortunately was compelled by illness to return from Australia to New Zealand, where he died on the 25th July.

During his absence and since his death the work of the branch has been carried on by the undersigned, who takes this opportunity of expressing his appreciation of the loyal and efficient manner in which all members of the staff have co-operated in carrying through the extra work that has been occasioned through being short-handed during the present important period of development.

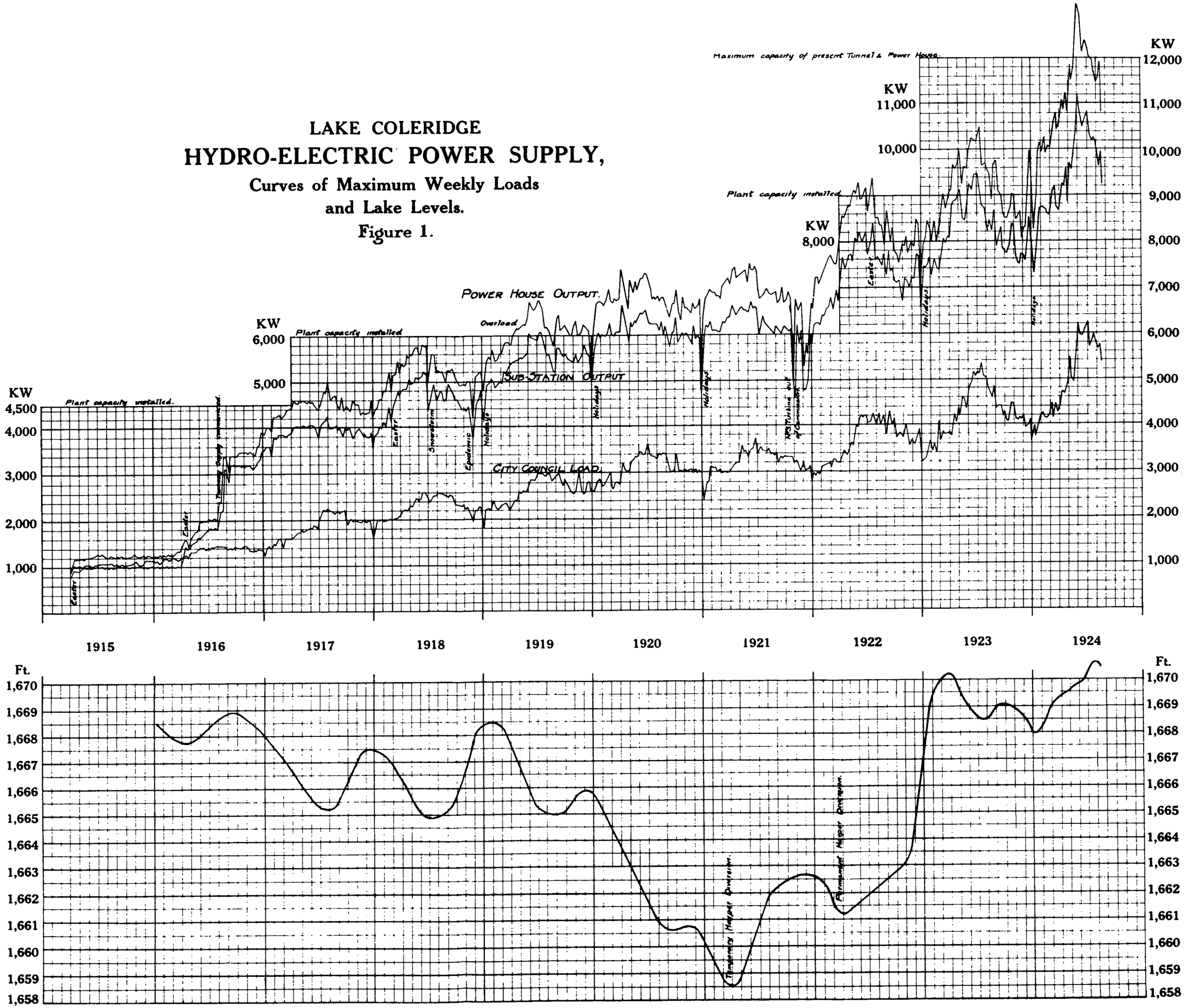
F. T. M. Kissel, B.Sc., A.M.Inst.C.E., A.M.I.E.E.,
Chief Electrical Engineer.



14TH MARCH. 1924.			
	FUEL	WATER	TOTAL
TOTAL UNITS.	231,769	506,024	737,793.
AVERAGE K.W.	9657	21,084	30,741
MAXIMUM K.W.	16,535	26,809	42,537
LOAD FACTOR	58·40	78·64	72·27

27TH JUNE. 1924.			
	FUEL	WATER	TOTAL
TOTAL UNITS.	301,351	475,144	776,495.
AVERAGE K.W.	12,556	19,798	32,354
MAXIMUM. K.W.	22,718	26,651	49,124
LOAD FACTOR.	55·27	74·28	65·86.

LAKE COLERIDGE
HYDRO-ELECTRIC POWER SUPPLY,
Curves of Maximum Weekly Loads and Lake Levels.
Figure 1.



WAIKATO
HYDRO-ELECTRIC POWER SUPPLY,
Curve of Maximum Weekly Load.
Figure 2.

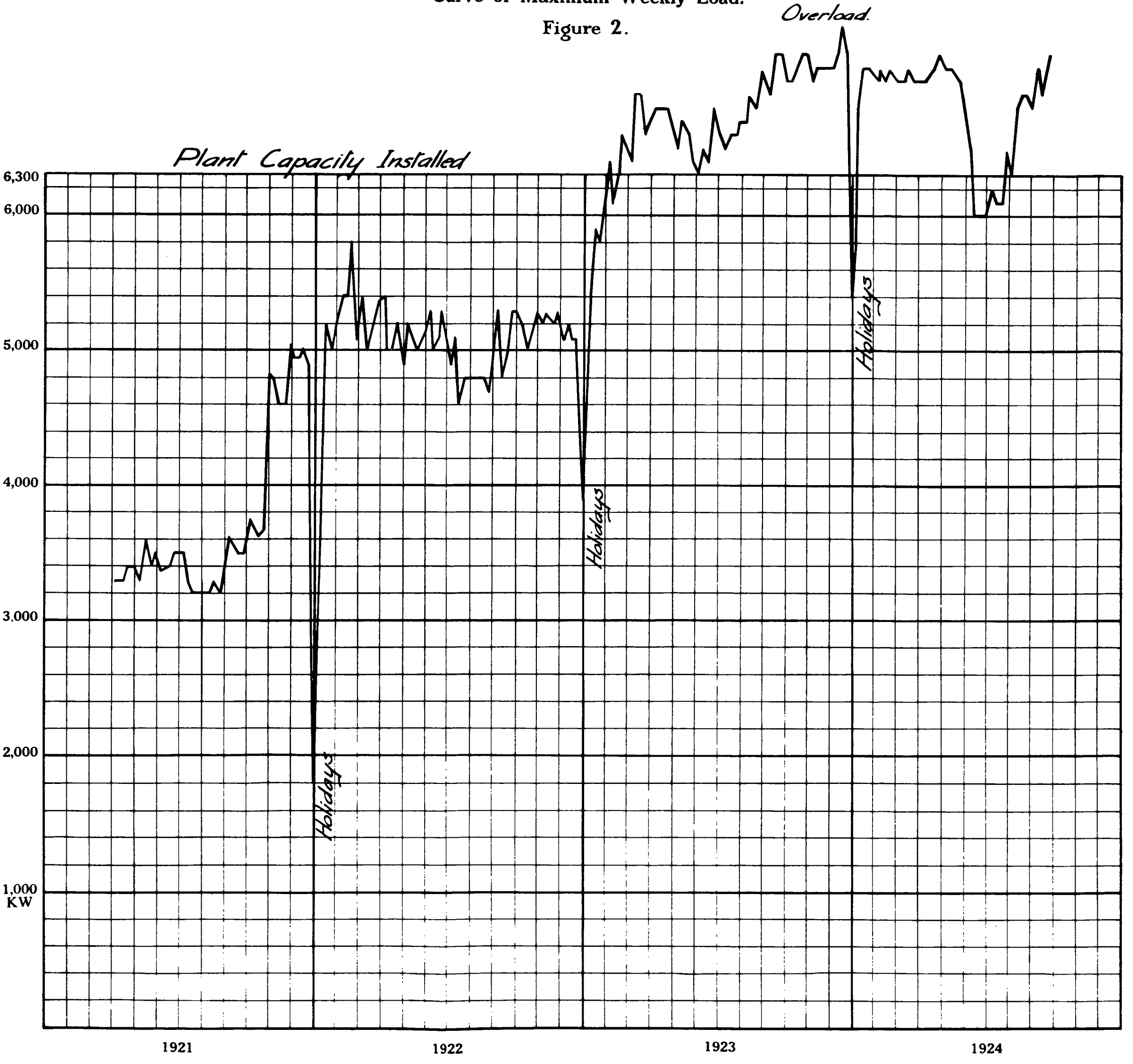


TABLE A.—LAKE COLERIDGE ELECTRIC-POWER SUPPLY.—RESULTS OF OPERATION.

—	Sixth Year, March, 1921.	Seventh Year, March, 1922.	Eighth Year, March, 1923.	Ninth Year, March, 1924.
	£	£	£	£
Capital outlay	499,957	671,608	848,033	892,801
Costs—				
Working-costs	21,341	25,911	19,271	20,777
Interest, 5·4 per cent.	18,639	20,981	35,275	44,444
Depreciation, 2 per cent.	7,946	8,424	9,307	12,584
Total costs	47,926	55,316	63,853	77,805
Accumulated Depreciation Fund	44,751	54,537	61,275	72,594
Accumulated deficiency	30,674	29,175	23,876	23,172
Revenue—				
City Council	17,700	18,890	21,641	26,055
Tramways	7,835	7,957	8,909	9,189
Wholesale consumers	22,339	26,019	34,344	39,280
Retail consumers	1,785	1,880	2,118	2,289
Miscellaneous	1,714	2,068	2,141	1,695
Total revenue	51,373	56,814	69,153	78,508
Maximum load (kilowatts)—				
Power-house	7,412	7,600	9,390	10,800
Substations	6,712	6,720	8,420	9,490
City Council	3,601	3,750	4,290	5,344
Tramways	1,840	2,120	2,480	2,740
Average load (kilowatts)—				
Power-house	4,147	4,453	5,024	5,722
Substations	3,719	3,875	4,528	5,158
City Council	1,697	1,760	2,006	2,438
Tramways	727	702	842	870
Units output—				
Power-house	36,545,169	38,419,102	44,008,106	50,614,955
Fed to village and Murchison's—Losses	235,589	427,921	556,446	1,837,069
Fed to transmission-lines	36,309,580	37,929,750	43,451,660	48,777,886
Substations (various)	32,588,320	33,947,100	39,665,420	45,778,007
Units sold—				
City Council	14,700,000	15,419,100	17,575,610	21,664,830
Tramways	6,379,717	6,499,258	7,360,035	7,623,900
Wholesale consumers and local bodies	10,051,734	10,746,697	12,449,239	14,198,034
Retail consumers	270,900	278,879	176,743	305,608
Total units sold	31,402,351	32,943,934	37,561,627	43,792,372
Losses—				
Transmission-line losses	3,728,190	3,982,650	3,786,240	2,999,879
Percentage	10·27	10·5	8·72	6·15
Distribution losses	1,185,969	1,003,166	1,977,256	1,985,635
Percentage	3·64	3·0	5·2	4·3
Average load-factor (per cent.)—				
Power-house	61·4	62·9	53·5	53·0
Substation	60·5	62·0	53·6	54·3
City	53·8	53·6	47·0	45·6
Working-costs—				
Per kilowatt (power-house maximum)	£2·87	£3·40	£2·05	£1·92
Per kilowatt (substation maximum)	£3·17	£3·85	£2·29	£2·19
Per unit generated	0·140d.	0·161d.	0·106d.	0·102d.
Per unit sold	0·150d.	0·188d.	0·123d.	0·113d.
Capital charges—				
Per kilowatt (power-house maximum)	£3·58	£3·87	£4·74	£5·28
Per kilowatt (substation maximum)	£3·96	£4·37	£5·29	£6·00
Per unit generated	0·174d.	0·184d.	0·246d.	0·280d.
Per unit sold	0·203d.	0·214d.	0·284d.	0·313d.
Total cost—				
Per kilowatt (power-house maximum)	£6·46	£7·27	£6·80	£7·20
Per kilowatt (substation maximum)	£7·14	£8·23	£7·58	£8·20
Per unit generated	0·314d.	0·350d.	0·352d.	0·382d.
Per unit sold	0·366d.	0·403d.	0·408d.	0·426d.
Revenue—				
Per kilowatt (power-house maximum)	£6·93	£7·47	£7·36	£7·27
Per kilowatt (substation maximum)	£7·65	£8·45	£8·21	£8·27
Per unit generated	0·337d.	0·354d.	0·382d.	0·386d.
Per unit sold	0·392d.	0·414d.	0·441d.	0·430d.
Per unit sold (city)	0·288d.	0·295d.	0·295d.	0·288d.
Per unit sold (trams)	0·294d.	0·293d.	0·290d.	0·289d.
Per unit sold (wholesale consumers)	0·533d.	0·585d.	0·662d.	0·664d.
Per unit sold (retail consumers)	1·58d.	1·61d.	2·88d.	1·80d.

TABLE B.—LAKE COLERIDGE ELECTRIC-POWER SUPPLY.—ANALYSIS OF CAPITAL OUTLAY.

Item.	Capital Outlay.		Expenditure during Year.
	31st March, 1923.	31st March, 1924.	
	£	£	£
Land, roading and fencing	17,393	17,537	144
Harper diversion	21,413	21,432	19
Tunnel and headworks	154,065	154,486	421
Second tunnel	..	10,333	10,333
Power-house and machinery	125,596	120,975	−4,621
Staff village	14,560	14,709	149
Transmission-lines	251,790	259,694	7,904
Addington substation	41,405	44,640	3,235
Primary distribution	56,090	57,910	1,820
Secondary distribution	47,954	72,460	24,506
Service transformers and meters	16,683	9,329	−7,354
Vehicles and loose tools	18,694	18,384	−310
Telephone-lines	1,903	1,903	..
Office furniture	249	250	1
Surveys, preliminary expenses, &c.	50,442	55,935	5,493
Interest during construction	29,796	32,824	3,028
Totals	848,033	892,801	44,768

TABLE C.—LAKE COLERIDGE ELECTRIC-POWER SUPPLY.—OPERATING OR WORKING COSTS.

Expenditure.	1923.		1924.	
	Cost.	Per Unit sold.	Cost.	Per Unit sold.
	£	d.	£	d.
Harper diversion—Maintenance ..	568	0·003	683	0·003
Generation	5,796	0·037	5,774	0·032
Transmission line	1,243	0·008	1,523	0·008
Main distribution station	2,164	0·014	2,106	0·011
H.T. distribution	2,166	0·014	2,852	0·016
L.T. distribution	1,596	0·010	2,026	0·011
Standby plant	1,368	0·009	1,421	0·008
Management and general expenses ..	4,370	0·028	4,392	0·024
Totals	19,271	0·123	20,777	0·113

TABLE D.—LAKE COLERIDGE ELECTRIC-POWER SUPPLY.—CONNECTED LOAD IN KILOWATTS AT 31ST MARCH, 1924.

—	Light.	Heat.	Power.	Total.
Local Bodies.				
Ashburton Power Board	513	477	355	1,345
Banks Peninsula Power Board ..	281	505	248	1,034
Eyre County Council	35	59	85	179
Halswell County Council	57	80	70	207
Heathcote County Council	262	542	95	899
Kaiapoi Borough Council	112	161	59	332
Kowai County Council	70	127	39	236
Lyttelton Borough Council	187	180	392	759
Lyttelton Pumping Station	1	..	115	116
Paparua County Council	139	166	44	349
Rangiora County Council	87	121	211	419
Rangiora Borough Council	166	98	154	418
Riccarton Borough Council	406	658	208	1,272
Springs Ellesmere Power Board ..	305	365	172	842
Sumner Borough Council	201	263	97	561
Tai Tapu Dairy Company	71	113	234	418
Timaru Borough Council	1,184	182	750	2,116
Waimairi (Hillmorten)	10	18	2	30
Power-station and substation ..	38	193	129	360
Direct Wholesale Consumers.				
Christchurch Tramway Board ..	85	..	6,575	6,660
Freezing-works (4)	148	29	2,253	2,430
Flour-mills (5)	5	6	303	314
Dairy factories (1)	3	..	56	59
Quarries (1)	1	..	46	47
Tanneries, &c. (6)	36	7	809	852
Seed-cleaning (4)	5	2	179	186
Brickyard (1)	..	..	91	91
Railway workshop (1)	31	..	210	241
Harbour Board (1)	55	..	660	715
Institutions (6)	130	255	164	549
Soapworks (1)	3	..	35	38
Steelworks (1)	3	1,200	26	1,229
Glueworks (1)	3	..	102	105
Sawmill (1)	..	1	22	23
Woollen-mill (2)	9	..	82	91
Aviation School (1)	5	10	6	21
Twine-mill (1)	2	1	119	122
Railway-stations (2)	66	9	58	133
Chemical-works (1)	..	..	196	196
Racing club (1)	19	12	26	57
Electrical-vehicle-charging set (1) ..	..	1	15	16
Railway Department Electrical-signalling	..	..	..	35
Christchurch City Council	..	..	..	36,393
Totals	4,734	5,841	15,492	62,495

Power-house maximum, 10,800 kw. Diversity factor, 5·8.

TABLE E.—LAKE COLERIDGE ELECTRIC-POWER SUPPLY: GROSS FINANCIAL RESULTS OF DISTRIBUTION OF ENERGY FOR YEAR ENDED 31ST MARCH, 1924.

Distributing Authority.	Number of Consumers.	Capital Outlay.	Revenue.				Expenditure.						Balance (Profit).
			Consumers.	Rates.	Trading Account.	Other Sources.	Paid for Electricity.	Maintenance.	Interest.	Depreciation.	Sinking Fund.	Other Expenditure.	
		£	£	£	£	£	£	£	£	£	£	£	£
Public Works Department ..	543	892,801	35,474*	..	..	1,694	..	20,778	44,443	12,584	..	..	703
Ashburton Power Board ..	1,022	78,261	6,964	..	..	45	1,215	4,617	†	†	†	..	1,177
Banks Peninsula Power Board ..	785	89,568	7,594	2,237	50	20	1,489	2,772	4,057	..	832	..	751
Christchurch City Council ..	20,089	480,437	120,839*	..	985	426	23,942‡	26,181	19,330	28,733	..	289	23,775
Eyre County Council	120	5,570	1,344	..	..	..	617	122	273	..	50	..	282
Halswell County Council ..	170	6,116	1,426	..	..	5	664	201	263	..	50	..	253
Heathcote County Council ..	763	18,641	4,745	..	..	202	2,319	1,146	424	..	494	..	564
Kaiapoi Borough Council ..	427	4,500	2,368	..	..	..	1,110	624	236	214	45	..	139
Kowai County Council	210	15,681	1,098	..	..	47	232	188	713	..	..	..	12
Lyttelton Borough Council ..	388	5,000	3,266	..	..	..	975	1,171	235	..	100	19§	766
Rangiora Borough Council ..	336	8,156	2,344	..	17	..	644	473	345	265	75	75	484
Rangiora County Council ..	336	22,403	3,137	..	..	..	1,303	227	704	..	255	500	148
Riccarton Borough Council ..	866	10,718	3,951	..	..	1,069	1,260	1,625	305	85	..	..	1,745
Springs-Ellesmere Power Board ..	637	58,686	4,917	2,503	..	..	1,037	2,365	2,558	..	150	..	1,310
Sumner Borough Council ..	652	10,198	3,272	..	..	..	878	819	448	194	81	..	852
Tai Tapu Dairy Company ..	183	8,476	2,811	..	370	..	1,304	933	284	582	..	..	78
Waimairi County Council ..	2,029	45,008	13,706	..	..	..	P.W. 183 C.C. 2,167	4,559	2,080	..	1,341	..	3,376
Totals	29,556	1,760,220	219,256	4,740	1,422	3,508	41,339	68,801	76,698	42,657	3,473	883	36,415

* After deducting amount of sales to other distributing bodies, totalling £41,340 to Public Works Department and £2,167 to Christchurch City Council. † Included in capital expenditure.
‡ After deducting £2,167, amount paid by other distributing body. § Loss on Trading Account.

Gross profit of the Lake Coleridge system, £36,415.

TABLE F.—WAIKATO ELECTRIC-POWER SUPPLY.—RESULTS OF OPERATION.

—	First Year, March, 1921.	Second Year, March, 1922.	Third Year, March, 1923.	Fourth Year, March, 1924.
Capital outlay..	£ 249,499	£ 353,808	£ 395,022	£ 474,817
Costs—				
Working costs	6,452	7,986	9,721	12,474
Interest	10,675	13,187	19,208	21,231
Depreciation, 2 per cent.	3,960	4,512	6,620	10,393
Total costs	21,087	25,685	35,549	44,098
Revenue—				
Cambridge Electric-power Board	..	541	1,837	2,319
Central Electric-power Board	..	353	2,216	4,436
Te Awamutu Electric-power Board	..	508	2,119	3,196
Thames Valley Electric-power Board	..	2,908	8,556	16,056
Hamilton Borough Council	..	1,391	2,911	4,621
Waihi Gold-mining Company	13,698	13,748	15,927	15,305
Waihi Grand Junction Gold Company	782	5,709	4,250	9,330
New Zealand Railways, Frankton	..	..	450	1,590
Other consumers	238	1,675	2,115	1,691
Miscellaneous (rents, &c.)	86	1,374	1,437	1,380
Total revenue	14,804	28,207	41,818	59,924
Profit (P.) or loss (L.)	(L.) 6,282	(P.) 2,522	(P.) 6,269	(P.) 15,826
Accumulated deficiency	8,404	5,882	..	..
Accumulated surplus	..	..	386	3,494
Accumulated Depreciation Fund..	5,653	10,210	16,605	24,832
Accumulated Sinking Fund	..	..	..	12,718
Maximum load (kilowatts)—				
Power-house, for year	3,500	5,800	6,900	7,400
Power-house, average weekly	2,675	4,080	5,382	6,852
Units output—				
Power-house total	16,729,050	25,659,550	33,732,150	45,077,150
Substations total	..	..	30,435,036	40,614,013
Units sold—				
Cambridge Electric-power Board	Included in "other consumers"	"other consumers" below	519,450	780,370
Central Electric-power Board			657,000	1,320,827
Te Awamutu Electric-power Board			622,040	887,570
Thames Valley Electric-power Board			3,776,065	7,019,366
Hamilton Borough Council			860,000	1,500,818
Waihi Gold-mining Company	14,477,387	15,383,006	19,116,114	18,776,851
Waihi Grand Junction Company	738,613	5,449,870	4,079,700	8,957,300
New Zealand Railways, Frankton	..	..	..	247,613
Other consumers	160,000	2,260,719	400,000	424,139
Total units sold	15,376,000	23,093,595	30,030,369	39,914,854
Losses—				
Transmission losses	..	..	3,297,114	4,463,137
Percentage	..	..	9·8	9·9
Distribution losses	1,338,450	2,565,955	3,701,781	5,162,296
Percentage	8·0	10·0	11·0	11·3
Load-factor—				
Power-house annual (per cent.)	54·5	50·5	55·8	69·6
Power-house, average weekly (per cent.)	71·0	71·3	71·2	75·3
Working-costs—				
Per kilowatt—power-house maximum (annual)	£1·84	£1·38	£1·41	£1·69
Per kilowatt—power-house maximum (average weekly) ..	£2·38	£1·95	£1·81	£1·82
Per unit generated	0·093d.	0·075d.	0·069d.	0·067d.
Per unit sold	0·100d.	0·083d.	0·078d.	0·075d.
Capital costs—				
Per kilowatt—power-house maximum (annual)	£4·18	£3·06	£3·76	£4·28
Per kilowatt—power-house maximum (average weekly) ..	£5·47	£4·34	£4·80	£4·62
Per unit generated	0·210d.	0·166d.	0·184d.	0·168d.
Per unit sold	0·228d.	0·184d.	0·206d.	0·194d.
Total costs—				
Per kilowatt—power-house maximum (annual)	£6·02	£4·43	£5·15	£5·96
Per kilowatt—power-house maximum (average weekly) ..	£7·85	£6·29	£6·61	£6·44
Per unit generated	0·303d.	0·240d.	0·253d.	0·235d.
Per unit sold	0·327d.	0·267d.	0·284d.	0·277d.
Revenue—				
Per kilowatt—power-house maximum (annual)	£4·23	£4·83	£6·07	£8·10
Per kilowatt—power-house maximum (average weekly) ..	£5·53	£6·91	£7·77	£8·73
Per unit generated	0·212d.	0·264d.	0·298d.	0·319d.
Per unit sold	0·229d.	0·293d.	0·334d.	0·360d.
Per kilowatt maximum—				
Cambridge Electric-power Board	..	£5·817	£10·038	£9·911
Central Electric-power Board	..	£5·883	£8·446	£9·165
Te Awamutu Electric-power Board	..	£5·708	£10·188	£9·455
Thames Valley Electric-power Board—				
Horahora	..	£3·220	£9·145	..
Waikino	..	£3·809	£6·410	..
Waihou	..	..	..	..
Average	..	£3·595	£7·166	£8·093

TABLE F.—WAIKATO ELECTRIC-POWER SUPPLY.—RESULTS OF OPERATION—*continued.*

—	First Year, March, 1921.	Second Year, March, 1922.	Third Year, March, 1923.	Fourth Year, March, 1924.
Revenue—*continued.*				
Per kilowatt maximum—*continued.*	£	£	£	£
Hamilton Borough Council	..	£5·724	£8·031	£9·316
Waihi Gold-mining Company	£4·892	£4·124	£5·210	£5·347
Per unit sold—				
Cambridge Electric-power Board	..	..	0·849d.	0·712d.
Central Electric-power Board	..	..	0·810d.	0·806d.
Te Awamutu Electric-power Board	..	..	0·818d.	0·865d.
Thames Valley Electric-power Board—				
Horahora	..	..	0·683d.	0·630d.
Waikino	..	..	0·489d.	0·557d.
Waihou	..	..	..	0·436d.
Average	..	..	0·544d.	0·547d.
Hamilton Borough Council	..	..	0·812d.	0·739d.
Waihi Gold-mining Company	0·227d.	0·214d.	0·199d.	0·196d.

TABLE G.—WAIKATO ELECTRIC-POWER SUPPLY.—ANALYSIS OF CAPITAL OUTLAY.

Item.	Capital Outlay.		Expenditure during Year.
	31st March, 1923.	31st March, 1924.	
	£	£	£
Land, roading, and fencing at Horahora	3,125	3,208	83
Headworks	88,666	134,842	46,131
Generating-station, transformers, and machinery ..	72,390	97,588	25,198
Staff village, Horahora	10,320	11,054	728
Transmission-lines	112,258	113,245	987
Distribution-lines	705	705	..
Main substations	40,189	41,123	934
Distribution substations	7,395	7,414	19
Vehicles and loose construction equipment ..	7,859	8,418	559
Land, stores, and railway-siding, Ruakura ..	11,342	11,342	..
Staff residences, Ruakura	3,521	3,521	..
Office furniture, Hamilton	440	494	54
Surveys, supervision, and preliminary expenses ..	15,604	17,639	2,035
Interest during construction	21,208	24,224	3,016
Totals	395,022	474,817	79,744

TABLE H.—WAIKATO ELECTRIC-POWER SUPPLY.—OPERATING OR WORKING COSTS.

Expenditure.	1923.		1924.	
	Cost.	Per Unit sold.	Cost.	Per Unit sold.
	£	d.	£	d.
Generation	3,859	0·031	5,583	0·034
Transmission	1,480	0·012	2,495	0·015
Main substations	1,016	0·008	1,805	0·011
H.T. distribution	245	0·002	265	0·002
Management and general	3,031	0·024	2,238	0·013
Miscellaneous and stand-by expenses ..	90	..	88	..
Totals	9,721	0·077	12,474	0·075

TABLE J.—WAIKATO ELECTRIC-POWER SUPPLY.—CONNECTED LOAD IN KILOWATTS (31ST MARCH, 1924).

—	Light.	Heat.	Power.	Total.
Waihi Gold-mining Company ..	164	100	4,646	4,910
Waihi Grand Junction Gold Company	38	38	2,452	2,528
Cambridge Co-operative Dairy Company	2	1	184	187
New Zealand Co-operative Dairy Company, Frankton	16	5	769	790
State Farm, Ruakura	10	1	5	16
New Zealand Railways, Frankton ..	57	27	667	751
Cambridge Electric-power Board ..	404	684	454	1,542
Central Electric-power Board ..	511	781	843	2,135
Te Awamutu Electric-power Board ..	301	511	639	1,451
Thames Valley Electric-power Board ..	1,275	2,397	4,135	7,807
Hamilton Borough Council	1,317	577	929	2,823
Public Works Department, Horahora ..	6	77	30	113
Public Works Department, Arapuni ..	1	10	3	14
Public Works Department, Hamilton ..	4	10	42	56
Totals	4,106	5,219	15,798	25,123

Power-house maximum load, 7,400 kw. Diversity factor = 3·4.

TABLE K.—WAIKATO ELECTRIC-POWER SUPPLY.—GROSS FINANCIAL RESULTS OF DISTRIBUTION OF ENERGY FOR THE YEAR ENDED 31ST MARCH, 1924.

Distributing Authority.	Number of Consumers.	Capital Outlay.	Revenue.				Expenditure.						Balance.	
			Consumers.	Rates.	Trading Account.	Other Sources.	Paid for Electricity.	Maintenance.	Interest.	Depreciation.	Sinking Fund.	Other Expenditure.	Profit.	Loss.
		£	£	£	£	£	£	£	£	£	£	£	£	£
Public Works Department ..	11	474,817	26,494*	..	165	1,214	88	12,386	21,231	10,393	12,718	..	3,108	..
Cambridge Power Board ..	729	87,529	8,087	..	9	120	2,319	2,447	4,495	..	750	..	..	1,795
Central Power Board ..	1,479	146,961	17,845	..	..	126	4,436	3,456	8,444	..	1,500	..	135	..
Hamilton Borough Council ..	2,115	48,989	22,478	..	19	26	4,621	5,702	3,349	..	3,827	..	5,024	..
Te Aroha Borough Council ..	497	16,227	4,947	..	..	359	1,422	1,183	709	320	55	..	1,617	..
Te Awamutu Power Board ..	856	126,187	10,913	2,121	32	326	3,196	5,005	8,631	..	1,200	..	..	4,640
Thames Valley Power Board	2,653	417,265	40,970*	..	8,216	163	14,634†	4,821	17,625	..	1,000	135	11,134	..
Totals	8,340	1,317,975	131,734	2,121	8,441	2,334	30,716	35,000	64,484	10,713	21,050	135	21,018	6,435

* After deducting amount of sales to other distributing bodies, totalling £30,628 to Public Works Department and £1,422 to Thames Valley Power Board. † After deducting £1,422, amount paid by other distributing body.

Gross profit of the Waikato system, £27,301.

TABLE L.—ELECTRIC-POWER BOARDS OF NEW ZEALAND AS CONSTITUTED ON 31ST MARCH, 1924.

Name of Electric-power District.	Proclamation constituting District gazetted.	Number of Members on Board.	Approximate Area of District (Square Miles).		Population.		Value of Rateable Property (Unimproved).		Amount of Loan authorized.	Voting for Loan Poll.	
			Inner Area.	Outer Area.	Inner Area.	Outer Area.	Inner Area.	Outer Area.		For.	Against.
							£	£	£		
Southland	19/11/19	12	7,798	3,059	65,450	9	14,163,952	137,513	1,500,000	6,516	415
Thames Valley	8/1/20	12	2,304	..	30,475	..	7,550,000	..	700,000	1,503	28
Te Awamutu	8/1/20	10	261	25	8,000	500	1,559,588	108,921	120,000	359	..
Cambridge	8/1/20	8	137	..	6,000	..	1,841,209	..	112,000	474	71
Banks Peninsula	8/1/20	7	387	..	3,935	..	5,086,935	..	100,000	331	23
Wairarapa	25/3/20	9	302	1,694	17,500	1,752	3,913,232	5,457,271	260,000	1,704	225
Central	8/7/20	8	440	..	11,000	..	3,958,424	..	200,000	515	19
Springs-Ellesmere	8/7/20	11	715	..	10,927	5,895	6,566,696	..	60,000	330	24
Teviot	22/7/20	7	76	..	1,800	..	169,137	..	35,000	191	27
Wairoa	29/7/20	10	1,354	..	4,368	..	2,660,292	..	100,000	504	31
Dannevirke	11/8/21	10	568	105	11,648	433	4,177,743	488,970	175,000	651	93
Opunake	18/8/21	7	122	117	2,744	500	716,111	200,000	70,000	170	20
Ashburton	17/11/21	12	1,193	1,349	16,691	533	9,346,863	700,181	296,500	1,590	96
Manawatu-Oroua	1/12/21	12	1,301	..	38,500	..	13,955,493	..	500,000	1,144	96
Horowhenua	1/12/21	9	630	..	11,795	..	3,403,255	..	260,000	973	26
Wanganui-Rangitikei	1/12/21	12	1,648	972	41,364	650	6,568,540	1,408,210	375,000	1,315	214
Tararua	23/3/22	10	700	565	8,485	1,781	2,912,346	1,147,113	200,000	714	83
Auckland	1/4/22	12	295	..	145,870	..	43,469,650	..	1,722,500	4,179	288
Taranaki	19/5/22	7	218	1,419	10,190	12,000	2,865,396	3,109,336	350,000	635	190
Hutt Valley	6/7/22	9	471	..	23,422	..	2,656,299	..	200,000	1,431	137
Central Hawke's Bay	19/10/22	9	1,226	..	8,980	..	6,653,485	..	150,000	543	41
South Canterbury	26/10/22	12	1,673	3,429	35,618	6,000	12,946,839	2,536,815	..	..	..
Grey	26/10/22	9	640	810	10,000	2,000	514,694	100,000	80,000	630	134
Malvern	28/6/23	6	308	1,833	3,920	1,500	2,433,080	1,458,588	40,000	326	22
Waitaki	9/8/23	9	420	2,780	18,134	653	4,358,230	255,558	135,000	1,286	124
Otago	18/10/23	6	676	1,605	10,604	13,478	1,882,990	2,813,458	200,000	961	162
Westland	28/10/20	9	750	..	3,272	..	196,268	..			
Reefton	30/6/21	5	24	..	1,850	..	64,476	..			
Buller	11/5/22	5	1,987	..	9,197	..	696,374	..			
Otago Central	26/10/22	7	27	2,657	1,500	2,989	52,313	982,621			
Wairere	18/1/23	7	147	260	1,500	1,000	392,434	480,000			
Hobson	29/3/23	8	778	..	7,017	..	1,389,487	..	Poll not yet taken.		
Tauranga	14/6/23	7	636	3	4,656	3,106	964,553	267,547			
Kaipara	18/10/23	6	49	..	1,600	..	327,635	..			
Marlborough	25/10/23	8	3,198	..	13,637	..	5,901,609	..			
Poverty Bay	20/12/23	11	1,735	..	23,320	..	4,391,844	..			
Totals	..	..	35,194	22,682	624,969	54,779	180,707,472	21,652,102	7,941,000	28,975	2,589

TABLE M.—ELECTRIC-POWER BOARDS.—RETURNS FOR YEAR ENDED 31ST MARCH, 1924.

Board.	Main Supply commenced.	Capital Outlay.	Revenue.		Expenditure.			Profit.	Loss	General Rate.		Special Rates.		Valuation Basis.
			Sale of Electricity. (Gross.)	Sale of Materials. (Profit.)	Capital Charges.	Power.	General.			Levied.	Collected.	Levied.	Collected.	
		£	£	£	£	£	£	£	£	d.	£	d.	£	
Ashburton	1923	78,261	7,009	..	..	4,098	1,734	1,177	..	..	..	0·55	Nil	Capital.
Auckland	1908	1,183,140	215,364	217	110,022	..	100,756	4,803	..	..	..	0·157	Nil	Capital.
Banks Peninsula ..	1922	89,568	7,614	50	4,889	1,489	2,772	..	1,486	0·9	2,237	..	..	Capital
Cambridge	1921	87,529	7,797	419	5,245	2,319	2,448	..	1,796	..	..	0·5	Nil	Capital.
Central	1921	146,961	17,971	..	9,943	4,436	3,457	135	..	..	..	..	..	..
Central Hawke's Bay	..	664	..	..	..	..	..	..	..	..	..	0·4	Nil	Unimproved.
Dannevirke ..	..	30,947	..	..	..	..	..	..	..	..	..	1·03	Nil	Unimproved.
Grey	..	..	..	..	..	..	..	..	..	..	..	1·10	Nil	Capital.
Hobson	..	..	..	..	..	..	..	..	..	0·10	562	..	..	Unimproved.
Horowhenua ..	..	76,238	..	..	..	..	..	..	..	..	..	..	..	Capital.
Hutt Valley ..	..	36,426	..	..	..	..	..	..	..	..	..	..	..	Unimproved.
Manawatu-Oroua ..	..	123,200	..	90	..	..	..	90	..	..	..	0·75	Nil	Unimproved.
Opunake	1923	60,795	1,297	841	573	..	700	865	..	0·25	28	..	..	Capital.
Otago Central ..	..	353	..	..	..	..	..	..	..	..	..	..	..	Capital.
Reefton	..	176	..	..	..	..	147	..	147	..	..	..	..	Capital.
South Canterbury ..	..	..	..	..	..	..	..	..	..	0·03	11	..	..	Capital.
Southland	..	426,801	6,534	359	..	5,310	1,070	513	..	..	..	..	..	Unimproved.
Springs-Ellesmere ..	1922	58,686	4,917	..	2,708	1,037	2,365	..	1,193	..	..	0·16	2,503	Capital.
Taranaki	..	40,718	..	..	..	..	1,054	..	1,054	..	1,873*	..	..	Capital.
Tararua	..	24,480	3,331	92	1,236	2,365	366	..	544	1·25	Nil	1·25	Nil	Unimproved.
Te Awamutu ..	1921	126,187	11,240	32	9,831	3,204	4,997	..	6,760	0·14	2,105	..	..	Capital.
Teviot	..	27,193	..	..	..	..	..	..	..	..	..	4·00	Nil	Unimproved.
Thames Valley ..	1921	417,265	42,555	8,216	18,760	16,096	4,781	11,134	..	..	..	..	..	..
Wairarapa	..	132,539	529	258	..	..	418	369	..	..	..	..	..	Capital.
Wairoa	1923	42,242	6,309	166	2,350	2,100	3,075	..	1,050	..	..	..	..	Capital.
Waitaki	..	..	..	..	..	..	522	..	522	0·04	Nil	..	..	Capital.
Wanganui-Rangitikei	..	1,927	..	..	..	..	..	..	..	..	..	..	..	Capital.
Totals ..	..	3,212,296	332,467	10,740	165,557	42,454	130,662	19,086	14,552	..	6,816	..	2,503	..

* Arrears.

Buller, Kaipara, Malvern, Tauranga, Otago, Poverty Bay, Waitomo, Wairere, and Westland Boards not yet in operation.

Table O.—Electric-supply Stations of New Zealand at 31st March, 1924.

(G = gas; O = oil; S = steam; W = water.)

Station.	Ownership.	Supply commenced.	Population supplied.	Number of Consumers.	Capacity, in Kilowatts.			Connected Load (Kilowatts).	Diversity Factor.	Units.				Annual Load-factor Percentage.	System of Supply.	Supply Voltage.	Route-miles of Lines.	Static Head, in Feet.
					Main Plant.	Standby Plant.	Maximum Load.			Generated or purchased.	Sold.	Non-productive.	Percentage Non-productive.					
Steam Stations.																		
1. Auckland (lighting) ..	Power Board ..	1908	145,870	16,342	20,260	..	7,650	..	..	26,337,490	21,230,903	5,106,587	19·4	39·3	D.C./A.C.	460/400/230	200	..
2. Wellington (lighting)	City	1888	100,000	17,000	3,500	..	4,310	..	..	10,500,280	8,231,812	2,268,468	21·6	27·8	A.C./S.P.	105	195	..
,, (tramways)		1904	..	513	4,000	..	3,900	..	..	14,136,149	12,653,789	1,482,360	10·5	41·5	D.C.	550	..	..
3. Invercargill ..	Borough ..	1913	26,000	3,036	1,450	525	1,050	5,432	5·3	3,879,810	3,413,049	466,761	12·0	42·2	A.C.	400/230	108	..
4. Gisborne	Borough ..	1912	13,126	2,420	650	..	530	3,199	6·0	1,298,942	1,049,107	249,835	19·3	28·0	D.C.	440/220	33	..
5. Huntly	Town Board ..	1916	2,500	378	225	..	46	460	10·0	80,574	66,073	14,501	18·0	20·0	D.C.	460/230	7	..
6. Bluff	Borough ..	1903	1,600	295	Bulk	..	30	..	..	65,508	55,622	9,886	15·1	24·9	D.C.	440/220	7	..
7. Kaitangata	Borough ..	1917	1,768	160	Bulk	..	6	..	..	14,040	12,139	1,901	13·6	26·8	A.C.	230	8	..
Totals	..	..	290,864	40,144	30,085	525	17,522	..	..	56,312,793	46,712,494	9,600,299	17·0	36·7	..	..	558	..
Gas Stations.																		
1. Wanganui	Borough ..	1908	17,500	1,100	1,650	..	950	2,893	3·0	2,152,390	1,627,640	524,750	24·4	25·9	A.C.	400/230	54	..
2. Napier	Borough ..	1913	13,600	2,509	830	..	778	3,845	4·9	2,083,695	1,778,279	305,416	14·6	30·5	D.C.	460/230	30	..
3. Devonport	Borough ..	1915	9,300	1,348	400	..	256	1,857	7·3	596,340	451,119	145,221	24·4	26·6	D.C.	460/230	20	..
4. Feilding	Borough ..	1914	5,000	1,142	310	..	185	1,029	5·6	527,414	395,035	132,379	25·1	32·5	A.C./S.P.	230	26	..
5. Te Kuiti	Borough ..	1913	2,325	540	170	..	130	525	4·1	260,507	211,744	48,763	18·7	22·9	D.C.	460/230	11	..
6. Pukekohe	Borough ..	1917	2,200	448	220	..	86	393	4·6	189,446	138,704	50,742	26·7	25·2	A.C.	400/230	15	..
7. Waipukurau† ..	Borough ..	1923	2,000	342	80	..	70	389	5·6	79,725	68,817	10,908	13·8	15·6	A.C.	400/230	11	..
8. Opotiki	Private ..	1914	1,100	288	99	..	65	116	1·8	87,430	72,859	14,571	16·7	15·3	D.C.	460/230	11	..
9. Picton	Borough ..	1917	1,400	300	65	..	64	363	5·7	186,836	168,153	18,683	10·0	33·3	D.C.	460/230	10	279
10. Pahiatua	Power Board* ..	1918	1,360	277	107	..	57	250	4·3	70,179	58,008	12,171	17·3	13·9	D.C.	460/230	10	..
11. Waitara	Borough ..	1907	1,500	314	85	..	55	160	2·9	81,700	56,316	25,384	31·0	16·9	D.C.	460/230	9	..
12. Tamaki West ..	Road Board ..	1922	2,000	270	150	..	52	226	4·3	69,017	64,382	4,635	6·7	15·1	A.C.	400/230	11	..
13. Waiuku	Company ..	1918	3,000	176	200	30 (G.)	44	268	6·1	48,295	38,636	9,659	20·0	12·6	A.C.	400/230	8	..
14. Motueka	Borough ..	1921	1,490	207	52	..	42	94	2·4	48,824	31,504	17,320	35·4	13·3	A.C.	400/230	10	..
15. Martinborough ..	Town Board ..	1914	964	246	77	..	40	100	2·5	73,372	38,127	35,245	48·1	20·9	D.C.	230	8	..
16. Eketahuna	Power Board* ..	1909	874	221	62	..	33	157	4·7	37,531	31,276	6,255	16·7	12·8	D.C.	230	7	..
17. Bull's	Town Board ..	1915	505	156	27	..	22	97	4·5	23,643	18,363	5,280	22·3	12·6	D.C.	230	5	..
18. Kaikoura	County ..	1922	600	111	37	..	20	76	3 8	42,050	23,437	18,613	44·2	24·0	A.C.	400/230	4	..
Totals	..	..	66,718	9,995	4,621	30	2,949	12,838	4·4	6,658,394	5,272,399	1,385,995	20·8	25·8	..	..	260	..
Oil Stations.																		
1. Hastings	Borough ..	1912	10,000	2,294	576	..	487	2,968	6·1	1,096,920	998,100	98,820	9·1	25·8	D.C./A.C.	460/400/230	31	..
2. Stratford	Borough ..	1898	9,000	875	280	..	205	1,120	5·5	438,525	294,885	143,640	32·7	24·4	A.C./S.P.	250/110	25	27
Totals	..	..	19,000	3,169	856	..	692	4,088	5·9	1,535,445	1,292,985	242,460	15·8	25·3	..	..	56	..
Hydro Stations.																		
1. Coleridge	P.W. Dept. ..	1915	203,000	543	12,000	1,500 (S.)	10,800	61,462	5·7	48,777,886	43,792,372	4,985,514	10·2	51·5	A.C.	400/230	376	480
Christchurch ..	City Council ..	1904	(94,500)	20,089	Bulk	750 (S.)	(5,640)	(36,393)	6·5	(21,696,610)	18,979,956	2,716,654	12·5	44·0	A.C.	400/230	291	..
Timaru†	Borough ..	1908	(14,500)	1,720	Bulk	475 (GS)	(450)	(2,116)	4·7	1,338,720	1,038,140	300,580	22·4	34·1	D.C./A.C.	460/400/230	52	..
Waimairi	County ..	1916	(11,000)	2,029	Bulk	..	(270)	(3,177)	11·8	(1,228,191)	982,553	245,638	20·0	51·9	A.C.	400/230	120	..
Ashburton‡ ..	Power Board ..	1908	(17,224)	1,022	Bulk	321 (GO)	(240)	(1,345)	5·6	(529,687)	374,650	155,037	29·3	25·2	D.C./A.C.	460/400/230	97	..
Banks Peninsula ..	Power Board ..	1920	(4,000)	785	Bulk	30 (W.)	(199)	(1,034)	5·5	(582,851)	275,539	307,312	52·7	33·5	A.C.	400/230	185	310
Rangiora	County ..	1918	(3,150)	336	Bulk	..	(199)	(419)	2·1	(391,151)	312,921*	78,230*	20·0	22·5	A.C	400/230	48	..
Riccarton	Borough ..	1916	(4,140)	866	Bulk	..	(195)	(1,272)	6·5	(400,490)	363,457	37,033	9·2	23·4	A.C.	400/230	18	..
Heathcote ..	County ..	1914	(4,000)	763	Bulk	..	(170)	(899)	5·3	(774,820)	746,079*	28,741*	20·0	52·0	A.C.	400/230	26	..
Tai Tapu	Company ..	1915	(5,600)	183	Bulk	..	(160)	(418)	2·6	(465,895)	372,716*	93,179*	20·0	33·3	A.C.	400/230	37	..
Springs-Ellesmere ..	Power Board ..	1921	(10,927)	637	Bulk	..	(116)	(842)	7·3	(304,266)	205,438	98,828	32·5	30·0	A.C.	400/230	139	..

* Borough plants taken over by Power Board. † Return for ten months only.

TABLE O (*continued*).—ELECTRIC-SUPPLY STATIONS OF NEW ZEALAND AT 31ST MARCH, 1924.

(G = gas; O = oil; S = steam; W = water.)

Station.	Ownership.	Supply commenced.	Population supplied.	Number of Consumers.	Capacity in Kilowatts.			Connected Load (Kilowatts).	Diversity Factor.	Units.				Annual Load-factor percentage.	System of Supply.	Supply Voltage.	Route-miles of Lines.	Static Head, in Feet.
					Main Plant.	Standby Plant.	Maximum Load.			Generated or purchased.	Sold.	Non-productive.	Percentage Non-productive.					
Hydro Stations—continued.																		
Sumner	Borough ..	1915	(3,250)	652	Bulk	..	(106)	(561)	5·3	(400,890)	320,712*	80,178*	20·0	39·5	A.C.	400/230	17	..
Kaiapoi	Borough ..	1917	(1,800)	427	Bulk	..	(111)	(332)	3·0	(419,050)	335,240*	83,810*	20·0	43·1	A.C.	400/230	20	..
Lyttelton ..	Borough ..	1917	(3,840)	388	Bulk	..	(103)	(759)	7·4	(359,300)	338,283	21,017	5·9	39·8	A.C.	400/230	9	..
Eyre	County ..	1920	(1,020)	120	Bulk	..	(92)	(179)	1·9	(206,354)	165,083*	41,271*	20·0	25·3	A.C.	400/230	20	..
Halswell	County ..	1919	(1,800)	170	Bulk	..	(85)*	(207)	2·4	(172,086)*	137,669*	34,417*	20·0	23·1	A.C.	400/230	22	..
Rangiora	Borough ..	1919	(2,000)	336	Bulk	..	(71)	(418)	5·9	(193,090)	141,450	51,540	26·7	30·9	A.C.	400/230	11	..
Kowia	County ..	1923	(2,080)	210	Bulk	..	(33)	(236)	7·1	(81,540)	54,144	27,396	33·5	28 2	A.C.	400/230	45	..
2. Horahora	P.W. Dept. ..	1913	72,200	11	6,300	1,500 (G.)	7,400	25,920	3·5	45,119,550	39,914,854	5,204,696	11·5	69·7	A.C.	11,000	125	27
Thames Valley ..	Power Board ..	1921	(30,000)	2,653	Bulk	..	(1,951)	(7,807)	4·0	(7,019,366)	5,615,493	1,403,873	20·0	41·1	A.C.	400/230	441	..
Hamilton ..	Borough ..	1913	(14,000)	2,115	Bulk	..	(496)	(2,823)	5·7	(1,500,818)	1,230,112	270,706	18·0	34·5	A.C.	400/230	51	..
Central	Power Board ..	1921	(11,000)	1,479	Bulk	..	(484)	(2,135)	4·4	(1,320,827)	906,067	414,760	31·4	31·1	A.C.	400/230	270	..
Te Awamutu ..	Power Board ..	1920	(8,500)	856	Bulk	..	(330)	(1,451)	4·4	(800,080)	574,964	225,116	28·2	27·6	A.C.	400/230	255	..
Cambridge ..	Power Board ..	1921	(6,000)	729	Bulk	..	(218)	(1,542)	7·1	(780,370)	639,904	140,466	18·0	40·8	A.C.	400/230	115	..
Te Aroha ..	Borough ..	1906	(2,200)	497	Bulk	150 (W.)	(148)	(797)	5·4	(289,046)	272,104	16,942	5·9	22·3	A.C.	400/230	15	560
3. Dunedin (Waipori) ..	City	1907	75,000	14,000	6,000	860 (O)	7,360	22,813	3·1	30,154,599	21,721,942	8,432,657	26·8	46·7	A.C.	400/230	367	700
4. Wairua	Company ..	1916	6,100	30	2,000	..	2,200	..	..	10,110,780	8,447,197	1,663,583	16·4	52·6	A.C.	400/230	31	130
Whangarei ..	Borough ..	1915	(5,400)	1,305	Bulk	..	222	1,769	8·0	(743,590)	612,092	131,498	17·7	38·2	A.C.	400/230	44	..
5. New Plymouth ..	Borough ..	1906	26,000	4,456	800	..	880	4,674	5·3	4,030,114	2,396,289	1,633,825	40·5	52·3	A.C.	400/230	194	120
6. Tauranga	Borough ..	1915	4,300	866	800	..	709	2,263	3·2	3,623,924	2,990,802	633,122	17·5	58·0	A.C.	400/230	68	110
Te Puke	Town Board ..	1921	875	179	Bulk	..	(42)	(265)	6·4	(123,000)	104,677	18,323	14·9	33·5	A.C.	400/230	9	..
7. Waikaremoana ..	Power Board ..	1923	4,368	66	700	..	558	1,271	2·3	1,334,627	1,066,295	268,332	20·1	27·3	A.C.	400/230	33	680
Wairoa	Borough ..	1913	(2,100)	437	Bulk	..	(122)	(619)	7·9	(266,735)	226,725	40,010	15·0	38·9	A.C.	400/230	12	..
8. Hawera	Company ..	1903	5,750	2,006	625	135 (O.)	499	2,041	4·1	883,822	775,815	108,007	12·2	20·2	A.C.	400/230	68	57
9. Hokitika (Kaneiri)‖ ..	Company ..	1908	2,500	317	700	150 (S.)	480	860	1·8	1,851,840	1,347,300	504,540	27·2	44·1	A.C.	400/230	18	250
10. Oamaru	Borough ..	1918	8,500	1,177	270	..	254	1,683	6·6	718,038	599,798	118,240	16·5	32·3	A.C.	400/230	30	250
11. Rotorua	Government ..	1901	3,886	968	200	20 (O.)	200	1,284	6·4	759,219	515,751	243,468	30·1	43·3	A.C.	200/115	28	14
12. Taihape	Borough ..	1912	2,009	446	175	..	157	639	4·1	328,011	297,131	30,880	9·4	23·8	D.C.	460/230	8	30
13. Gore	Borough ..	1905	3,740	853	240	..	150	750	5·0	499,465	454,060	45,405	9·1	37·9	A.C.	400/230	33	23
14. Thames	Borough ..	1914	5,000	915	100	105 (O.)	150	1,019	6·8	474,312	383,918	90,394	19·1	36·1	D.C./A.C.	460/400/230	19	130
15. Whakatane	Borough ..	1922	1,800	250	240	..	130	305	2·4	343,000	279,200	63,800	18·6	30·1	A.C.	400/230	30	276
16. Havelock North ..	Town Board ..	1915	1,500	250	176	..	90	..	..	290,265*	232,212	58,053*	20·0	36·8*	A.C.	400/230	17	50
17. Inglewood	Borough ..	1905	1,300	394	120	..	89	772	8·7	209,540	190,491	19,049	9·1	26·8	A.C.	400/230	10	38
18. Ohakune	Borough ..	1914	1,560	256	120	30 (G.)	77	450*	5·8*	98,906	89,706	9,200	9·3	14·7	A.C.	400/230	9	42
19. Brightwater	Company ..	1911	4,000	420	100	40 (G.)	70	250	3·6	70,000	62,666	7,334	10·4	11·4	A.C.	400/230	30	11
20. Murchison	County ..	1922	420	97	100	..	70	114	1·6	122,200	65,159	57,041	46·6	19·9	A.C.	400/230	14	105
21. Patea	Borough ..	1901	1,700	270	135	..	66	155	2·4	160,882	126,343	34,539	21·5	27·8	A.C./S.P.	100	13	78
22. Reefton	Company ..	1887	1,400	216	86	..	65	..	..	201,600*	161,300*	40,300*	20·0	25·3	D.C.	230	8	27
23. Kaponga	Town Board ..	1916	800	312	140	..	56	215	3·8	94,863	90,415	4,448	4·7	19·3	A.C./D.C.	400/230	37	48
24. Raetihi	Borough ..	1917	4,500	420	50	50 (W.)	55	529	9·5	158,919	144,482	14,437	9·1	32·8	A.C.	400/230	19	350
25. Mataura	Borough ..	1913	1,280	237	75	..	48*	..	..	57,589	48,342	9,247	16·0	13·7*	A.C.	440/220 S.P.	25	23
26. Mangaweka ..	Town Board ..	1913	350	106	40	28 (O.)	30	190	6·4	345,370	22,250	323,120§	..	13·1	A.C.	400/230	7	37
27. Winton	Borough ..	1914	800	178	Bulk	..	30*	115	3·8*	34,801	29,643	5,158	14·8	13·2*	A.C.	400/230	4	..
28. Havelock South ..	Town Board ..	1918	300	50	20	..	19*	..	..	29,800*	23,840*	5,960*	20·0	17·0	D.C.	460/230	2	270
29. Waverley	Town Board ..	1916	650	170	40	..	18	105	5·9	32,577	29,616	2,961	9·1	20·6	A.C.	400/230	6	60
30. Fairlie	County ..	1922	1,860	134	40	..	17	99	6·0	47,580	42,060	5,520	11·6	32·9	A.C.	400/230	6	66
Totals	..	..	447,448	71,397	30,392	6,144	32,949	131,747	4·0	152,302,799	120,617,414¶	31,685,385	20·8	52·8	..	..	4,004	..

* Assessed from incomplete returns. † Bulk supply temporary at 11,000 volts from December, 1923, and permanent at 66,000 volts from February, 1924, and pumping. ‡ Bulk supply from August, 1923. § Includes units used for town street-lights ‖ Return for nine months only. ¶ Units retailed.

NOTE.—Figures in parentheses not included in totals.

Table P.—Summary of Returns of Operating Results for the Year ended 31st March, 1924.

Station.	Capital Outlay at 31st March, 1924.	Gross Revenue (not including Rates).	Working-expenses.*	Capital Charges.	Total Annual Costs.	Net Results.		Average Revenue.		Working-costs.		Capital Charges.		Total Costs.		Retail Selling-rates.		
						Profit.	Loss.	Per Unit sold.	Per Kw. of Max.	Per Unit sold.	Per Kw. of Max.	Per Unit sold.	Per Kw. of Max.	Per Unit sold.	Per Kw. of Max.	Lighting.	Heating.	Power.
Steam Stations.	£	£	£	£	£	£	£	d.	£	d.	£	d.	£	d.	£	s. d.	s. d.	s. d.
1. Auckland (lighting) ..	1,183,140	215,581	100,756	110,022*a*	210,778	4,803	..	2·36	27·4	1·14	13·1	1·24	14·4	2·38	27·5	0 6	0 4	0 2¼
2. Wellington (lighting) ..	544,073	150,191	96,471	40,852*a*	137,323	12,868	..	4·23	33·6	2·81	22·4	1·19	9·5	4·00	31·9	0 6	0 2	0 3½
,, (tramways)	220,035	111,006	81,664	20,518*a*	102,182	8,824	..	2·10	28·5	1·55	20·9	0·39	5·3	1·94	26·2	..	..	0 3½
3. Invercargill	143,528	35,501	17,952	8,461*b*	26,413	9,088	..	2·44	33·0	1·26	17·1	0·59	8·1	1·85	25·2	0 6¼	0 2¾	0 2¾
4. Gisborne	56,930	23,071	15,049	2,445*b*	17,494	5,577	..	5·21	42·9	3·45	28·4	0·56	4·6	4·01	33·0	0 8	0 4½	0 3½
5. Huntly	8,575	2,846	2,961	536*b*	3,497	..	651	8·04	48·0	10·75	64·3	1·95	11·7	12·70	76·0	0 9	0 5	0 5
6. Bluff	4,589	2,574	2,001	241*c*	2,242	332	..	11·10	82·8	8·61	66·6	1·04	8·0	9·65	74·6	0 7½	0 4	0 4
7. Kaitangata	1,472	455	302	..	302	153	..	9·00	75·8	6·00	50·3	..	..	6·00	50·3	0 9	..	..
Totals	2,162,342	541,225	317,156	183,075	500,231	41,645	651	2·78	30·9	1·63	18·1	0·94	10·4	2·57	28·5	..	..	.. ½
Gas Stations.																		
1. Wanganui	216,721	17,613	15,639	..	15,639	1,974	..	2·72	18·1	2·31	16·4	..	..	2·31	16·4	0 8	0 4	0 3¼
2. Napier	93,705	28,572	15,086	7,119*a*	22,205	6,367	..	3·77	35·9	2·04	19·4	0·96	9·2	3·00	28·6	0 6½	..	0 3½
3. Devonport	42,822	9,490	6,784	2,927*b*	9,711	..	221	4·31	33·1	3·45	5·3	1·55	11·4	5·00	16·7	0 6	0 3	0 3
4. Feilding	41,385	9,712	5,168	3,592*d*	8,760	952	..	5·72	50·9	3·13	27·9	2·18	19·4	5·31	47·3	0 11	0 4	0 4
5. Te Kuiti	16,196	5,335	3,817	894*b*	4,711	624	..	5·86	39·8	4·32	29·3	1·01	6·9	5·33	36·2	0 10	0 2	0 4
6. Pukekohe	35,322	3,736	3,289	1,996*b*	5,285	..	1,549	5·81	39·0	5·68	38·2	3·46	23·2	9·14	61·4	0 8	0 4	0 4
7. Waipukurau*f* ..	13,488	1,679	2,132	945*b*	3,077	..	1,398	4·81	19·7	7·45	30·5	3·30	13·5	10·75	44·0	0 10	0 4	0 3
8. Opotiki	6,692	2,876	2,639	237*c*	2,876	..	..	8·73	40·8	8·69	40·7	0·78	3·6	9·47	44·3	0 10	0 5	0 5
9. Picton	10,301	2,003	1,951	200*c*	2,151	..	148	2·79	30·6	3·08	30·5	0·29	3·1	3·37	33·6	Flat rates.		
10. Pahiatua*e*	15,382	2,210	1,582	1,038*b*	2,620	..	410	8·95	37·6	6·65	27·6	4·29	18·0	10·94	45·6	0 10	0 5	0 4
11. Waitara	9,168	2,055	1,381	500*b*	1,881	174	..	8·75	36·7	5·84	25·1	2·13	9·1	7·97	34·2	0 10	..	0 4
12. Tamaki West ..	19,506	1,969	1,512	631*b*	2,143	..	174	6.85	35·4	5·63	29.2	2·36	12·1	7·99	41·3	0 8	0 5	0 5
13. Waiuku	26,046	1,482	1,809	428*c*	2,237	..	755	7·70	28·4	11·46	41·3	2·66	9·8	14·12	51·1	0 8	0 4	0 4
14. Motueka	14,095	1,590	1,395	964*b*	2,359	..	769	11·00	34·4	10·62	33.2	7 34	22·9	17·96	56·1	0 10	..	..
15. Martinborough ..	11,228	2,201	1,614	506*b*	2,120	81	..	10·30	41·2	10·16	40·3	3·18	12·7	13·34	53·0	0 10	0 5	0 5
16. Eketahuna*e*	7,685	1,619	1,144	505*b*	1,649	..	30	10·25	39·8	8·76	34·3	3·87	15·2	12·63	49·5	0 10	0 7	0 7
17. Bull's	6,000	1,268	818	390*b*	1,208	60	..	14·45	51·5	10·79	38·1	5·11	18·2	15·90	56·3	1 3	0 9	0 9
18. Kaikoura	8,978	1,195	1,489	557*b*	2,046	..	851	11·92	58·1	15·26	24·5	5·71	27·9	20·97	52·4	1 0	..	0 6
Totals	594,720	96,605	69,249	23,429	92,678	10,232	6,305	4·40	32·8	3·15	23·5	1·07	7·9	4·22	31·4	..	..	..
Oil Stations.																		
1. Hastings	53,163	17,618	8,821	3,303*a*	12,124	5,494	..	4·24	36·2	2·13	18·1	0·79	6·8	2·92	24·9	0 8	0 4	0 3
2. Stratford	25,952	7,350	4,984	2,760*a*	7,744	..	394	5·98	35·8	4·05	24·3	2·25	13·5	6·30	37·8	0 8	0 4	0 5
Totals	79,115	24,968	13,805	6,063	19,868	5,494	394	4·63	36·1	2·56	19·9	1·12	8·8	3·69	28·7	..	..	..
Hydro Stations.																		
1. Coleridge	892,801	78,508	20,778	57,027*a*	77,805	703	..	0·42	7·1	0·11	1·9	0·31	5·3	0·42	7·2	..	..	..
Christchurch (C.C.) ..	480,437	124,417	52,290	48,352*a*	100,642	23,775	..	1·57	21·8	0·66	9·3	0·61	8·6	1·27	17·9	0 6	0 3	0 1½
Timaru	82,091	21,051	11,979	6,163*b*	18,142	2,909	..	4·68	45·1	2·77	26·6	1·42	13·7	4·19	40·3	0 8	0 4	0 4
Waimairi	45,008	13,706	6,909	3,421*b*	10,330	3,376	..	3·35	50·8	1·69	25·6	0·84	12·7	2·53	38·3	0 6	0 3	0 3
Ashburton ..	78,261	7,009	5,832	..	5,832	1,177	..	4·47	29·0	3·73	24·2	..	..	3·73	24·2	0 8	0 3	0 3
Banks Peninsula ..	89,568	7,664	4,261	4,889*b*	9,150	..	1,486	6·61	38·2	3·71	21·4	4·26	24·6	7·97	46·0	0 8	0 3	0 3
Rangiora (County) ..	22,403	3,137	1,530	1,459*e*	2,989	148	..	2·41	15·8	1·17	7·7	1·12	7·3	2·29	15·0	0 8	0 8	0 2
Riccarton	10,718	5,021	2,886	390*a*	3,276	1,745	..	2·61	20·2	1·90	14·8	0·26	2·0	2·16	16·8	0 5	0 1½	0 3
Heathcote	18,641	4,947	3,465	919*b*	4,384	563	..	1·52‡	27·9	1·11‡	20·5	0·29‡	5·4	1·40‡	25·9	0 6	0 1½	0 3
Tai Tapu	8,476	3,181	2,237	866*a*	3,103	78	..	1·86	17·6	1·44	13·9	0·56	5·3	2·00	19·2	Flat rates.		

* Includes wages, fuel, and maintenance. *a* Includes interest, depreciation, and sinking fund. *b* Includes interest and sinking funds only. *c* Includes interest only. *d* Includes interest, sinking funds, and reserve funds. *e* Borough plants taken over by Power Board. *f* Return for ten months only.

TABLE P (*continued*).—SUMMARY OF RETURNS OF OPERATING RESULTS FOR THE YEAR ENDED 31ST MARCH, 1924.

Station.	Capital Outlay at 31st March, 1924.	Gross Revenue (not including Rates).	Working-expenses.*	Capital Charges.	Total Annual Costs.	Net Results.		Average Revenue.		Working-costs.		Capital Charges.		Total Costs.		Retail Selling-rates.		
						Profit.	Loss.	Per Unit sold.	Per Kw. of Max.	Per Unit sold.	Per Kw. of Max.	Per Unit sold.	Per Kw. of Max.	Per Unit sold.	Per Kw. of Max.	Lighting.	Heating.	Power.
Hydro Stations—continued.	£	£	£	£	£	£	£	d.	£	d.	£	d.	£	d.	£	s. d.	s. d.	s. d.
Springs-Ellesmere ..	58,686	4,917	3,402	2,708*b*	6,110	..	1,193	5·74	42·4	3·98	29·3	3·16	23·4	7·14	52·7	0 7	0 3	0 3
Sumner	10,198	3,272	1,696	723*c*	2,419	853	..	2·44	28·2	1·27	14·6	0·54	6·2	1·81	20·8	0 6	0 1	0 1
Kaiapoi	4,500	2,368	1,734	495*c*	2,229	139	..	1·70	21·3	1·24	15·6	0·35	4·5	1·59	20·1	Flat rates.		
Lyttelton	5,000	4,316	3,225	335*b*	3,560	756	..	2·32	31·6	1·53	20·9	0·80	3·3	2·33	24·2	0 6	0 1½	0 3
Eyre	5,570	1,344	739	323*b*	1,062	282	..	1·95	14·6	1·07	8·1	0·47	3·5	1·54	11·6	Flat rates.		
Halswell	6,116	1,431	865	313*b*	1,178	253	..	2·49	16·8	1·51	10·1	0·55	3·7	2·06	13·8	Flat rates.		
Rangiora (Borough)..	8,156	2,361	1,117	760*c*	1,877	484	..	3·98	33·0	1·89	15·7	1·29	10·7	3·18	26·4	0 6	0 3	0 3
Kowai	15,681	1,145	421	712*d*	1,133	12	..	4·87	33·3	1·86	12·7	3·16	21·6	5·02	34·3	0 8	0 3	0 3
2. Horahora	474,817	59,924	12,474	31,624*a*	44,098	15,826	..	0·35	7·9	0·07	1·7	0·19	4·3	0·26	6·0	..	..	..
Thames Valley ..	417,265	50,770	20,877	18,760*b*	39,637	11,133	..	1·81	21·7	7·58	10·8	0·80	9·6	8·38	20·4	0 8	0 3	0 3
Hamilton	48,989	22,523	10,323	7,176*b*	17,499	5,024	..	4·40	45·3	2·02	20·8	1·40	14·5	3·42	35·3	0 7½	0 2½	0 2½
Central	146,961	17,971	7,892	9,944*b*	17,836	135	..	4·52	35·2	2·10	16·3	2·63	20·5	4·73	36·8	0 9	0 1½	0 3
Te Awamutu ..	126,187	11,272	8,200	9,831*b*	18,031	..	6,759	4·35	31·6	3·42	24·8	4·10	29·8	7·52	54·6	0 8	0 2	0 3
Cambridge.. ..	87,529	8,216	4,766	5,245*b*	10,011	..	1,795	2·92	35·7	1·78	21·8	1·94	24·0	3·72	45·8	0 9	0 3	0 3
Te Aroha	16,227	5,307	2,606	1,084*c*	3,690	1,617	..	4·25	32·5	2·29	17·6	0·96	7·3	3·25	24·9	0 7	0 3	0 3
3. Dunedin (Waipori) ..	774,501	120,888	46,347	62,739*c*	109,086	11,802	..	1·31	16·2	0·51	6·3	0·07	8·5	0·58	14·8	0 5	0 2	0 2
4. Wairua	87,539	11,258	5,715	7,300*f*	13,015	..	1,757	0·32	5·1	0·19	2·6	2·08	3·3	2·27	5·9	0 5	0 2·7	0 2·7
Whangarei.. ..	31,716	9,973	4,294	1,398*e*	5,692	4,281	..	3·58	41·2	1·68	19·3	0·55	6·3	2·23	25·6	0 5½	0 2	0 2
5. New Plymouth ..	301,793	31,564	8,528	26,711*c*	35,239	..	3,675	2·95	33·5	0·86	9·8	2·68	30·3	3·54	40·1	0 7	0 2	0 2
6. Tauranga	86,909	11,204	3,822	4,197*b*	8,019	3,185	..	0·83	14·6	0·31	5·4	0·34	5·9	0·65	11·3	0 7	0 1½	0 2
Te Puke	9,535	1,814	746	966*c*	1,712	102	..	4·15	43·3	1·70	17·8	2·22	23·1	3·92	40·9	0 10	0 3½	0 2
7. Waikaremoana ..	42,242	6,475	5,175	2,350*b*	7,525	..	1,050	1·42	11·3	1·16	9·2	0·53	4·2	1·69	13·4	0 9	0 3	0 3
Wairoa	12,853	3,896	1,892	1,418*b*	3,310	586	..	3·98	48·4	2·00	24·3	1·50	18·2	3·50	22·5	0 7	0 3	0 3
8. Hawera	77,941	21,753	6,684	7,342*c*	14,026	7,727	..	5·74	30·7	2·07	13·1	2·27	14·7	4·34	27·8	0 7·2	0 2·7	0 3·6
9. Hokitika (Kanieri) *g* ..	31,958	4,352	2,784	1,449*f*	4,233	119	..	0·76	8·8	0·50	5·8	0·26	3·0	0·76	8·8	0 6	0 1½	0 3
10. Oamaru	44,459	10,486	4,766	2,458*b*	7,224	3,262	..	4·17	41·0	1·91	18·8	0·98	9·7	2·89	28·5	0 9	0 3	0 3
11. Rotorua	49,911	8,861	3,850	4,492*c*	8,342	519	..	3·94	42·3	1·75	19·2	2·09	22·5	3·84	41·7	0 6	0 3	0 3
12. Taihape	13,387	4,556	3,372	740*b*	4,112	444	..	3·65	24·8	2·72	21·5	0·60	4·7	3·32	26·2	0 8	0 1½	0 2
13. Gore	26,704	8,276	4,657	1,637*b*	6,294	1,982	..	3·66	46·2	2·65	31·1	0·87	10·9	3·52	42·0	0 7	..	0 3
14. Thames	28,465	7,285	3,876	1,268*b*	5,144	2,141	..	4·01	42·9	2·42	25·8	0·80	8·5	3·22	34·3	0 10	0 3	0 3
15. Whakatane	47,454	3,649	1,268	1,269*b*	2,537	1,112	..	2·23	20·0	1·09	9·7	1·09	9·8	2·18	19·5	0 4	0 3	0 3
16. Havelock North ..	23,047	3,666	1,271	1,722*b*	2,993	673	..	3·78	40·7	1·31	14·1	1·78	19·2	3·09	33·3	0 7	0 4	0 4
17. Inglewood	11,312	3,388	2,350	510*b*	2,860	528	..	3·23	28·8	2·97	26·4	0·64	5·7	3·61	32·1	0 6	0 2	0 2
18. Ohakune	10,094	2,325	1,090	502*b*	1,592	733	..	5·82	28·3	2·91	14·2	1·34	6·5	4·25	20·7	0 9	0 3	0 4
19. Brightwater	17,310	2,204	1,412	1,300*a*	2,712	..	508	7·84	29·3	5·41	20·2	4·99	18·6	10·40	38·8	0 9	0 4	0 4
20. Murchison	13,300	1,354	343	834*b*	1,177	177	..	4·95	19·4	1·26	4·9	3·08	11·9	4·34	16·8	0 10	0 3	0 3
21. Patea	9,018	2,170	1,454	412*b*	1,866	304	..	3·86	30·8	2·76	22·0	0·78	6·3	3·54	28·3	0 9	0 6	0 3·6
22. Reefton	5,947	2,981	1,984	313*f*	2,297	684	..	4·38	45·2	2·95	31·6	0·46	4·8	3·41	36·4	Flat rates.		
23. Kaponga	16,342	2,115	1,199	581*b*	1,780	335	..	5·34	36·0	3·19	21·4	1·55	10·3	4·74	31·7	0 9	0 4	0 4
24. Raetihi	19,951	3,211	627	1,110*b*	1,737	1,474	..	5·03	54·7	1·04	11·3	1·84	20·0	2·88	31·3	0 8	0 3	0 3
25. Mataura	4,379	1,173	1,009	120	1,129	44	..	5·09	20·5	5·00	20·2	0·59	2·5	5·59	22·7	0 6	0 2½	0 2½
26. Mangaweka	4,784	577	511	358*b*	869	..	292	6·14	19·2	5·50	17·2	3·86	12·1	9·36	29·3	1 0	0 6	..
27. Winton	4,582	975	754	473*c*	1,227	..	252	7·11	32·5	6·10	25·1	3·83	15·8	9·93	40·9	0 7	..	0 4
28. Havelock South ..	2,160	288	296	88*d*	384	..	96	2·89	15·2	3·36	17·6	0·88	4·6	4·24	22·2	Flat rates.		
29. Waverley	5,364	970	524	291*b*	815	155	..	7·01	48·1	4·24	29·1	2·36	16·2	6·60	45·3	0 10	0 6	..
30. Fairlie	10,614	1,122	127	784*b*	911	211	..	6·20	65·6	0·72	7·7	4·50	47·6	5·22	55·3	0 9	0 4½	0 4½
Totals	4,985,857	760,587	315,231	350,651	665,882	113,568	18,863	1·51	23·1	0·63	9·6	0·70	10·6	1·33	20·2	..	..	..

* Includes wages, fuel, and maintenance.

a Includes interest and depreciation only. *b*. Includes interest and sinking funds only. *c*. Includes interest, depreciation, and sinking fund. *d*. Includes interest only.
e. Includes interest, sinking funds and reserve funds. *f*. Includes depreciation only. *g*. Return for nine months only.

TABLE Q.—AVAILABLE WATER-POWER IN NEW ZEALAND: SCHEMES OF 1,000 HORSE-POWER AND OVER.

Source of Power.	Position of Power-house.	Available Flow: Cubic Feet per Second.	Available Head.	Average Power on 50-per-cent. Load Factor.		Nearest City, Port, or Deep Water.	Distance.
			Ft.	H.p.	Kw.		Miles.
NORTH ISLAND.							
North Auckland District—							
Wairua Falls	Wairua Falls	150*	130	3,200	2,400	Whangarei	18
Omapere	Utakura Stream	11*	550	1,000	750	..	..
South Auckland District—							
Kaituna	Kaituna River	500†	784	65,000	50,000	Tauranga	25
						Auckland	125
Wairoa River	Wairoa	420*	80	5,600	4,200	Tauranga	20
Waikato River	Aratiatia Rapids	4,400†	170	136,000	100,000	Auckland	154
Waikato River	Orakeikorako Rapids	4,400†	35	14,000	10,000	Auckland	148
Waikato River	Aniwhaniwha Falls	4,400†	80	32,000	24,000	Auckland	142
Waikato River	Atiamuri Rapids	4,400†	25	10,000	7,500	Auckland	139
Waikato River	Arapuni Gorge	5,300†	165	163,000	120,000	Auckland	105
Waikato River	Horahora Rapids	5,300†	27	13,000	10,000	Auckland	97
Pokaiwhenua River	Horahora Rapids	165*	170	4,600	3,400	Auckland	97
Marakopa Falls	Marakopa	90	420	3,100	2,300	Te Kuiti	27
Wairere Falls	Wairere Falls	160*	60	1,600	1,200	Te Kuiti	22
Hawke's Bay District—							
Waikaremoana	Upper Waikaretaheke	530†	1,100	97,000	75,000	Gisborne	50
Waikaremoana	Lower Waikaretaheke	530†	360	32,000	24,000	Napier	60
Te Reinga Falls	Te Reinga Falls	124	125	1,300	1,000	Gisborne	35
Waikohu River	Waikohu	45†	847	6,000	4,500	Gisborne	28
Wanganui District—							
Mangawhero River	Raukawa Falls	125	90	1,000	750	Wanganui	45
Mangawhero River	Wanganui River	125	680	7,100	6,950	Wanganui	24
Rangitikei River	Makohine	1,500†	300	75,000	56,000	Wanganui	48
Wangaehu River	Wangaehu River	260	70	1,500	1,100	Wanganui	25
Karioi	Karioi	300*	180	8,800	6,600	Wanganui	60
Taranaki District—							
Waitara River	Waitara River	400	140	4,600	3,600	New Plymouth	12
Waiwakaiho	Waiwakaiho	150†	250	6,200	4,800	New Plymouth	4
Manganui River	Waitara River	415†	340	26,000	19,400	New Plymouth	25
Wellington District—							
Mangahao River	Shannon	160†	895	24,000	18,000	Wellington	65
Makuri River	Makuri Gorge	100*	384	6,400	4,800	Pahiatua	20
Waiohine	Woodside	120*	120	2,400	1,800	Masterton	15
Hutt River	Mangaroa	200†	330	11,000	8,300	Wellington	24
Tauherenikau	Featherston	150*	440	11,000	8,300	Wairarapa	..
Kourarau	Kourarau	20	755	2,680	2,000	Masterton	12
Totals—North Island	..	..	..	776,080	582,650		
SOUTH ISLAND.							
Marlborough District—							
Clarence	Ericaburn	640	158	8,300	6,300	Blenheim	45
Waihopai River	Waihopai Gorge	130*	96	2,000	1,500	Blenheim	28
Nelson and Buller District—							
Boulder Lake	Aorere River	50*	2,600	22,000	16,000	Golden Bay	10
Rotoiti Lake	Buller River	200†	600	20,000	15,000	Nelson	50
Rotoroa Lake	Gowan River	900†	400	60,000	45,000	Nelson	60
Inangahua River	Blackwater River	78	125	8,000	6,000	Westport	20
Four-mile Creek	Four-mile Creek	24*	450	2,000	1,500	Westport	4
Westland District—							
Lake Brunner	Stillwater	1,750	200	29,000	22,000	Greymouth	10
Kumara Water-race	Kumara	87	330	2,400	1,800	Greymouth	12
Otira River	Otira	40	700	2,300	1,700	Greymouth	52
Rolleston River	Otira	36	700	2,000	1,500	Greymouth	52
Kanieri Lake	Kanieri River	100	330	2,800	2,100	Hokitika	12
Toaroha River	Toaroha River	150	760	10,000	7,500	Hokitika	17
Whitcombe River	Hokitika River	250	800	16,000	12,000	Hokitika	20
Kakapotahi River	Kakapotahi River	100	580	4,800	3,600	Hokitika	26
Wanganui River	Hende's Ferry	830	580	40,000	30,000	Hokitika	36
Wataroa River	Wataroa	1,360	700	80,000	60,000	Hokitika	48
Canterbury District—							
Clarence River	Jollie's Pass	200	1,160	20,000	15,000	Christchurch	90
Clarence River	Conway River	1,150	1,050	100,000	75,000	Christchurch	90
Waiau-ua River	Culverden	1,600	200	27,000	20,000	Christchurch	75
Waimakariri River	Gorge Bridge	1,000*	90	15,000	11,000	Christchurch	30
Waimakariri River	Otarama	1,000*	150	30,150	22,500	Christchurch	42
Lake Coleridge	Rakaia River	100†	480	8,000	6,000	Christchurch	65
Acheron River	Rakaia River	50†	480	4,000	3,000	Christchurch	65
Harper River	Rakaia River	320†	480	25,000	18,000	Christchurch	65
Wilberforce River	Rakaia River	1,100	480	44,000	33,000	Christchurch	65

* Signifies daily storage available to utilize 50-per-cent. load-factor. † Signifies seasonal storage made available.

TABLE Q.—AVAILABLE WATER-POWER IN NEW ZEALAND—*continued.*

Source of Power.	Position of Power-house.	Available Flow: Cubic Feet per Second.	Available Head.	Average Power on 50-per-cent. Load Factor.		Nearest City, Port, or Deep Water.	Distance.
Canterbury District—continued.			Ft.	H. p.	Kw.		Miles.
Rakaia River	Gorge Bridge ..	2,600	30	6,500	4,800	Christchurch ..	50
Lake Heron	Rakaia River ..	300	200	5,000	3,750	Christchurch ..	88
Opihi River	Opihi Gorge ..	200	400	6,700	5,000	Timaru ..	30
Pukaki Lake	Pukaki	5,000†	460	50,000	37,000	Timaru ..	85
Tekapo Lake	Fairlie	5,100†	900	400,000	300,000	Timaru ..	40
Ohau Lake	Waitaki River ..	5,000†	300	125,000	90,000	Timaru ..	85
Otago and Southland District—							
Ahuriri River	Waitaki River ..	600	200	10,000	7,500	Oamaru ..	62
Waitaki River	Waitaki River ..	15,000	30	37,000	28,000	Oamaru ..	60
Waipori Falls	Waipori River ..	230†	700	26,800	20,000	Dunedin ..	30
Lee Stream	Outram	15*	750	1,800	1,300	Dunedin ..	18
Deep Stream	Taieri River ..	110	900	8,400	6,300	Dunedin ..	20
Taieri River	Deep Stream ..	700	220	12,000	9,000	Dunedin ..	44
Talla Burn	Clutha River ..	30	890	2,200	1,600	Dunedin ..	60
Teviot River	Roxburgh ..	100†	1,900	30,000	21,000	Dunedin ..	90
Manuherika River ..	Chatto Creek ..	200	350	5,800	4,400	Dunedin ..	127
Hawea Lake	Wanaka Lake ..	2,500†	205	80,000	60,000	Dunedin ..	170
Shotover	Wakatipu Lake ..	500	250	10,000	7,500	Invercargill ..	112
Lake Hall	Doubtful Sound ..	220	2,625	48,000	36,000	On seaboard ..	..
Lake Cecil	Lake Te Anau ..	200	900	15,000	11,200	On seaboard ..	..
Lake Hilda	Lake Te Anau ..	550	1,190	55,000	41,080	On seaboard ..	..
Lake Te Anau	George Sound ..	12,630	694	1,600.000	1,200,000	On seaboard ..	..
Lake Manapouri	Smith Sound ..	8,400†	600	840,000	630,000	On seaboard ..	..
Bowen Falls	Milford Sound ..	700	600	35,000	25,000	On seaboard ..	..
Lake Monowai	Waiau River ..	500†	160	16,000	12,000	Invercargill ..	60
Lake Hauroto	Tewaewae Bay ..	2,300	514	100,000	75,000	Invercargill ..	51
Totals—South Island	..	..	..	4,110,950	3,074,430		

* Signifies daily storage available to utilize 50-per-cent. load-factor. † Signifies seasonal storage made available.

APPENDIX E.

REPORT ON MODERN HIGHWAY CONSTRUCTION AND MAINTENANCE.

By A. TYNDALL, A.M.Inst.C.E., Assoc.M.Am.Soc.C.E.

INTRODUCTION.

This report is in the nature of a record of observations made, data collected, and opinions formed during twelve months' study of the construction and maintenance of rural highways abroad. The subject of street-construction in cities is not intended to be covered.

I had the opportunity of inspecting roads in the following countries: England, Scotland, France, Belgium, Holland, Switzerland, Italy, United States, Canada, Mexico, Hawaii, and Panama.

New Zealand's problems are very similar to those being faced in the more thinly populated of the United States of America. Although many millions of pounds have been spent on road-construction in the United States in recent years, it should be realized that the country claims only 374,000 miles of "good roads" out of a total mileage of about 2,800,000. The "good roads" comprise all the surfaced mileage, including at least 170,000 miles gravelled. It would appear, therefore, that New Zealand, with 23,000 miles surfaced out of a total of 59,000 miles, is well to the fore amongst the newer countries as regards the proportion of surfaced mileage (40 per cent. in New Zealand as against 13·4 per cent. in United States of America.)

The problem ahead is not so much to extend the system of surfaced roads as to bring up to a standard commensurate with the traffic the main thoroughfares of the Dominion, and also to learn to maintain the roads we have already built.

Formation and Drainage.

The outstanding features of road-formation in the older countries as compared with ordinary rural-road construction in New Zealand are the flatter batters, the large and well-formed water-tables, and the considerably wider shoulders provided to support the gravel metal, concrete, or other pavement; and before expensive surfacings are laid in New Zealand, in addition to providing better alignment and curvature on the highways, practical consideration must be given to the improvements mentioned above. It should be realized that these improvements are of a much more permanent nature than the most expensive and most scientifically constructed pavements. No sinking fund is required to cover the cost of their replacement, and upon them depends the success of the expensive forms of urfacing which follow.

Large and well-formed water-tables can probably be maintained just as cheaply as small inefficien water-tables, on account of their adaption to the use of machinery; and, in addition, the tendency abroad seems to be to make the inside slope so flat that the ditch can be safely used by vehicles in case of emergency. In England particularly, where the road reserve is narrow, coarse metal is often rolled in practically to the lowest point of the water-table. In California there are now being constructed concrete shoulders 2 ft. 6 in. wide, extending from the edge of the pavement proper to within 6 in. of the lowest point in the water-table. Concrete shoulders or kerbs, and sometimes channels, are even considered for rural water-bound macadam roads in England, and wherever these are found their value is most apparent. The provision of good earth or gravel shoulders alongside modern smooth pavements is of considerable assistance in dealing with horse traffic. Water-tables, however, are not very effective in improving the bearing-power of a subgrade unless placed below the limit of capillary rise of moisture in the particular soil forming the subgrade.

Widths.

The latest standard set for the width of English main roads by the Ministry for Transport is 10 ft. per line of traffic. This is greater than is usually provided in most places. Some American authorities specify 12 ft., 18 ft., 24 ft., and 30 ft., for one, two, three, and four lines of traffic respectively. 16 ft. is generally regarded in England as being sufficient for two streams at moderate speeds, and 20 ft. for two streams at high speeds.

The Bureau of Public Roads, U.S.A., considers 18 ft. to be the minimum satisfactory width for hard surfacing on any main country road, as this width allows a continuous line of cars to pass a large lorry with reasonable clearance. If there are many lorries going in both directions a width of 20 ft. is specified.

On narrow mountain-roads there should be frequent points where extra widths of formation are provided for runoffs and turnarounds.

Curvature and Increase of Widths.

A motor-vehicle in traversing a curve takes up a strip of pavement greater in width than when it is travelling on a straight: hence it is only reasonab e that pavements should be widened at curves. An English authority gives the following table for suggested increases in width for curves of different radii:—

Radius at Centre-line.	Exact Extra Width for one Vehicle.	Suggested Extra Width to allow for turning with Two Lines of Traffic.
Feet.	Feet.	Feet.
25	4·70	12
50	2·50	8
75	1·65	6
100	1·30	5
125	1·00	4
150	0·80	3
200	0·50	3

It will be seen that the figures are appreciably large for curvatures which we are often compelled to adopt in New Zealand.

The use of transition curves, spiral and parabolic, is common in America, particularly for concrete roads.

Visibility.

The question of curvature is bound up with that of visibility. A visibility of less than 100 ft. may be considered dangerous.

For a speed of twenty-five miles per hour a range of vision of 250 ft. to 300 ft. is desirable. An Indian formula is as follows:—

$$(\text{Speed in miles per hour})^2 = 2 \times (\text{Limit of view in feet}).$$

Thus at 20 m.p.h. a view of 200 ft. is necessary.

On many curves in the U.S.A. benches have been cut in the batters about 4 ft. above formation level to increase the range of vision.

Superelevation.

Another feature which affects the safety of the traveller, and also the wearing-qualities of the pavement on curves, is the superelevation of the roadway. If the ordinary camber is used the traffic tends to cut in on the inside of the turn to obtain the assistance of the banking effect of the camber, and one-half of the road takes most of the traffic.

Superelevation is now more or less standardized in most of the States in the U.S.A. The following tabulation shows recent practice :—

State.	Pitch of Fully Superelevated Section.		Transition Section and Rate.
	Pitch per Foot of Width.	Radius (in Feet).	
California mountain roads	¾ in.	Up to 75	Length, 30 ft. (15 ft. on curve and 15 ft. on tangent).
	⅜ in.	100 to 150	
	⅛ in.	225 to 300	
Indiana ..	½ in.	All curves	Length, 100 ft. Full superelevation at principal curve.
Michigan	1 in.	66 to 150	Length, 100 ft. (75 ft. before principal curve to 25 ft. past, to reach full superelevation).
	¾ in.	150 to 300	
	⅝ in.	300 to 450	
	½ in.	450 to 700	
New Jersey ..	⅓ in.	All curves	Length, 100 ft. Full superelevation at principal curve.
New York	1 in.	Up to 300	Length of transition varying from 85 ft. to 35 ft. before principal curve.
	¾ in.	800 to 1,500	
	½ in.	1,500 to 2,500	
Ohio ..	½ in. to ⅛ in.	190 to 1,400 5,000	Length, 100 ft. (from 50 ft. before to 50 ft. past principal curve).
Pennsylvania ..	½ in.	50 to 300	Spiral transition on inside curve according to special table.
Washington	⅝ in. to 0·22 in.	190 5,000	Same as Ohio.
West Virginia	¾ in.	75	Length, 75 ft. (one-third superelevation at principal curve and two-thirds at 25 ft. past principal curve).
	0·3 in.	400	

The following formula is sometimes used for arriving at superelevation :—

$$\text{Superelevation in inches per foot width of roadway} = \left(\tfrac{1}{2} + \frac{75}{\text{Radius of curve in feet}}\right).$$

An American formula for concrete roads is—

$$E = \cdot 067 \frac{S^2}{R}$$

where E = slope in feet per foot of width, S = speed in miles per hour, R = radius of curve in feet.

Where there is horse traffic on concrete roads the superelevation should not exceed 1 in. per foot of width of roadway. In laying out pavements the transition from camber to full superelevation should be complete at the commencement of the curve.

Oiled Earth Roads.

There are a number of earth and sand roads in the United States which have simply been given two coats of asphaltic base petroleum or petroleum residuum, and have successfully carried heavy traffic. Where the ground seems to be more or less of a gravelly nature the oiled road has proved particularly successful as a cheap expedient. This is probably due to the fact that such soils have excellent natural drainage.

The roadway is first shaped, dampened, and rolled with a 10-ton roller until the surface is unyielding. The surface is then loosened and pulverized with a cultivator and harrow to a depth of 4 in., and again watered to make it roll satisfactorily. All stones over 3 in. in diameter are removed or broken up. After further rolling with the 10-ton roller minor depressions are filled up, and the road again dampened, and finished off with a 5-ton roller. Oil at a temperature of between 300° and 400° F. is applied with pressure distributing-sprays at a rate of ⅝ U.S. gallon per square yard, and left for at least twelve hours, when a layer of ¾ in. to ½ in. screenings sufficient to absorb all the surplus oil is evenly spread. A second coating of oil at the rate of ⅜ U.S. gallon per square yard is then applied, and after a further lapse of twelve hours a layer of somewhat finer screenings is spread, any surplus stone being raked or swept off. The surface is then given a final rolling until it is uniformly smooth. Any sticky places are to be treated with further screenings, as necessary.

This type of treatment is quite commonly used for the first surface on new roads in suburban subdivisions in California. It deals effectively with the dust problem, and is very suitable to a dry climate.

Culverts.

The following excerpt from the 1923 annual report of the Chief of the Bureau of Public Roads in the United States, with regard to experiments on the smaller and more common forms of pipe culverts, is interesting :—

"The results with concrete, vitrified clay, and corrugated-metal pipe culverts, 30 ft. long, with straight end-wall entrances, and varying in diameter from 12 in. to 30 in., show that a 12 in. vitrified-clay-pipe culvert with bevelled lips up-stream will carry about 65 per cent., an 18 in. clay-pipe culvert about 50 per cent., a 24 in. clay pipe culvert about 40 per cent., and a 30 in. clay-pipe culvert about 30 per cent. more water than corrugated-metal-pipe culverts of similar sizes; while a 12 in. concrete pipe with bevelled lip end up-stream will carry about 49 per cent., a 24 in. concrete pipe about 36 per cent., and a 30 in. concrete pipe about 32 per cent. more water than corrugated-metal pipes of the respective sizes.

"By merely rounding the entrance to a 24 in. vitrified-clay-pipe culvert the capacity may be increased approximately 13 per cent. over that obtained in a square entrance. By increasing the area of the cross-section of the outlet end of an 18 in. vitrified-clay-pipe culvert so that the area is about double and the angle of divergence about 10°, the discharge of the culvert, when the outlet is submerged, may be increased 40 per cent. over that obtained in the same culvert having a uniform bore throughout.

"The utilization of the data obtained in culvert design enables an engineer to increase the carrying-capacity of culverts 40 to 50 per cent. over former standard practice with a comparatively small increase in cost."

Subgrade.

A pavement depends upon the subgrade for support, and this support is exceedingly non-uniform in character. The supporting-power of a subgrade depends on the type of soil, its capillarity, the proximity of the ground-water, the amount of sustained rainfall, and the extent of freezing and thawing.

In the construction of modern pavements more and more attention is being given to the preparation of the subgrade. The statement is often made that the drainage and preparation of the foundation have more effect on the life of a pavement than the traffic. Altogether too little care has been used in the preparation of the subgrades in the past in New Zealand. It is just as important to have a smooth uniform surface true to cross-section on the subgrade as it is to have it on the pavement. It is much cheaper to fill up minor depressions with suitable earth than to allow an extra thickness of metal, concrete, or other surfacing to compensate for those depressions. The extreme importance with which the preparation of the subgrade is regarded in America can be gathered most satisfactorily by referring to the extract from the latest specification of the California Highway Commission, forming Enclosure A to this report.

Gravel Roads.

Gravel for many years will be our most important and cheapest roadmaking material. While it is only fit for taking light loads, nevertheless a good gravel road from the point of view of the motorist is better than a good macadam road. Careful study of the behaviour of gravelled roads is therefore warranted, and improved methods of construction can and should be evolved. The following points show the direction in which improvements are being made in America :—

(1.) The gravel should be passed through a crusher, particularly if there are numbers of fragments over 3 in. in diameter.

(2.) The gravel should be laid in two courses, the lower course consisting of material passing a screen with circular openings of not more than 2 in. (preferably 1½ in.) retained on a screen having openings of 1 in. or ⅞ in. diameter; the upper course consisting of all material passing the smaller screen.

(3.) No single course should be greater in depth than 5 in.

(4.) During and for some time after construction the road should be constantly dragged, and if necessary dampened.

(5.) The use of light rollers is advisable.

Water-bound Macadam.

This type of pavement is too well known to warrant a detailed description. There are certain features of accepted good practice, however, which could be observed more frequently to great advantage in this country: for example—

(1.) The better preparation of the subgrade as regards shape, drainage, and consolidation.

(2.) The segregation of the stone into three sizes, for the bottom course, top course, and binder.

(3.) The greater use of water in binding the road-surface, and the more frequent use of rollers.

(4.) More attention to the provision of lateral support for the surfacing.

With regard to No. 4, the use of any form of kerb is generally prohibitive in cost, but a good substitute can be constructed at moderate cost by treating the outer 12 in. on each side of the macadam with bitumen applied by the penetration method, using 1 U.S. gallon per square yard on the base course, and the same amount per square yard on the upper course. This method is particularly suitable when it is intended to treat the surface of the water-bound road.

Tar or Bitumen Surfacing.

Tar or bituminous surfacing may be applied to an old road-surface in good condition, or to a new surface after it has been rolled, consolidated, and dried. Some engineers consider that the tar or bitumen should not be applied until the road has been under traffic for some time, but by others it is regarded as the better practice to keep the traffic off the road until after the tar or bitumen has been applied. In the latter method penetration to some small extent is obtained, so that a road thus surfaced really is an intermediate type between the bituminous macadam road and the road which has been surfaced after having carried traffic for some months.

As regards the preparation of the road-surface, there are three important points which must be observed to obtain successful results :—

(1.) The road must be properly shaped and consolidated and free from ruts, pot-holes, or bumps. Feather-edged patches should be avoided. If the surface is very rough the road should be lightly scarified and sufficient material added to restore the shape. The road should then be thoroughly rolled, and traffic allowed to season the new surface for some weeks before the bituminous material is applied.

(2.) The road-surface must be as clean as possible and free from dust. A very good method is to sweep the road with a mechanical sweeper and follow up with a thorough hand-sweeping. A further precaution is to flush the surface with water, using a pressure flushing-tank or a hose. This is an excellent idea, and, provided the surface is allowed to dry out thoroughly, practically guarantees adhesion of the bituminous material.

(3.) The road-surface must be perfectly dry before the application of any hot tar or bituminous material. The objection to the flushing process is now apparent, as considerable time must elapse between the flushing and the application of the tar or bitumen to enable the surface to dry. It is claimed that for cold treatments there may be a certain amount of moisture present.

Tar or bitumen may be used to surface water-bound macadam and gravel roads. One coat or two coats may be applied. Some further details will be found under the heading of "Bituminous Materials."

Using tar for a first treatment and bitumen for the second treatment produces splendid results. The same class of bitumen or asphaltic oil is often used for both coats, and sometimes two different classes are used. The same remark applies to the use of refined tar.

If a thin bitumen or refined tar is used it should be heated to a temperature of 200° to 250° F. If a 90 to 120 penetration bitumen is used, it should be heated to a temperature of 300° to 350°. Care must be taken not to exceed these temperatures, as thereby the life of the material may be destroyed. Bitumen should not be applied when the open-air temperature is below 60° F.

The first application will vary in amount according to the nature of the surface, but should be about $\frac{1}{3}$ gallon per square yard. The minimum and maximum limits should be $\frac{1}{10}$ and $\frac{1}{2}$ gallon per square yard respectively.

The bitumen should preferably be applied with a pressure distributor, but hand-pouring and gravity spraying may also be used provided the material is well broomed into the road-surface to guarantee equal distribution. If the bitumen is not equally distributed the final surface will not be of uniform hardness, and waves will form. A bitumen surfacing is more apt to wave than a tar surfacing.

The first application of bitumen is covered with a thin coating of dustless broken stone or clean gravel. The Bureau of Public Roads specifies that not less than 85 per cent. of the broken stone shall pass a $\frac{1}{2}$ in. screen and not less than 85 per cent. shall be retained on a $\frac{1}{4}$ in. screen. If pea gravel is used it should range between $\frac{3}{8}$ in. and $\frac{1}{8}$ in. in size. Over 1 cubic yard of stone will seldom be required for each 20 gallons of bitumen. Considerable allowance must be made for waste, however, if the stone is dumped at intervals on the roadside.

The stone must be spread as evenly as possible, and should be just sufficient to absorb the bitumen, otherwise the particles will not be sufficiently coated to adhere to the road-surface. If spreading is done by hand-shovel a long side swing should be used. It is far better to apply too little stone at first than too much.

After the surface has been rolled or beaten in with traffic, loose chips should be swept off and a second application of bitumen made. This may range from $\frac{1}{10}$ to $\frac{1}{5}$ of a gallon per square yard. Another light layer of $\frac{1}{4}$ in. of chips, coarse sand, or pea gravel is then spread, and either rolled or allowed to be ironed out by traffic. In the case of tar surfacing it is considered good practice to make the second application two or three months after the first.

The following method has been used successfully in surfacing good gravel roads in America :—

"After the gravel road has had traffic sufficient to form a hard crust, the surface should be swept or water-flushed until it is practically free from loose particles or foreign matter. The bitumen should then be applied in two courses, in the same manner as for water-bound macadam. Gravel should be used for covering-material, and it should be clean, sharp, and well graded from 1 in. down to sand. The sand passing a No. 30 sieve should not exceed 30 per cent. A roller should be used on this covering to make sure the larger pebbles are securely bedded, after which the road should be opened to traffic. All breaks which develop in the surface during a period of from three to five months after the road is opened to traffic should be repaired at once by a maintenance gang equipped with a heating-kettle and pouring-pots, and at the end of this period the surface should be scarified for a depth of from 1 in. to $1\frac{1}{2}$ in. By then disk-harrowing the scarified material, reducing it to a mealy condition, the bitumen content will be distributed uniformly throughout the depth scarified. Dress

this material with the grader and roll it thoroughly. Follow the rolling immediately with an application of ½ U.S. gallon per square yard of bitumen, cover as before with gravel, and roll, and the road is ready for traffic."

Such a road is said to be able to carry up to eight hundred vehicles per day.

Bituminous Macadam.

A bituminous macadam pavement is one having a wearing-course of macadam with the interstices filled by penetration methods with a bituminous binder. It is not durable enough for heavy traffic, but stands up well under moderate loads. Advocates of bituminous concrete, and salesmen, are often heard disparaging this form of pavement, but nevertheless it holds a definite place in modern road-construction, chiefly on account of its low initial cost and the small amount of equipment required to lay it.

It must be remembered that the functions of the bituminous material in bituminous macadam and bituminous or asphaltic concrete are not quite analogous, although the adhesive quality of the material is the essential quality in both cases. In the case of asphaltic concrete the bitumen filler and aggregate go to make a dense mixture, which when rolled in place forms a structure capable of taking loads, but in the absence of the bitumen the mixture would not take loads without lateral displacement of the material. In the case of bituminous macadam, before the application of bitumen the structure is capable of taking loads without lateral displacement, on account of the interlocking action of the mineral aggregate. Under this method a dense pavement is not possible, neither is it looked for, as the function of the bitumen and chips is to provide a matrix which will waterproof the surface of the pavement, and will not be sucked out by rubber-tired traffic in the way the binding constituents of an ordinary macadam road are sucked out.

A bitumen of higher penetration is required for a bituminous-macadam road than for a bituminous-concrete road. The consistency must be such that when in a melted condition it is fluid enough under proper working-conditions to flow freely and coat the coarse stone aggregate with a thin film. When cooled to summer temperatures it must be stiff enough not to flow; when still further cooled to winter conditions it must remain plastic enough to contract without cracking. This question will be dealt with more fully under the heading of "Bituminous Materials."

The stone used should be sufficiently hard and tough to withstand thorough rolling without crushing, as if crushing takes place proper penetration of the bitumen cannot be attained. Should a comparatively soft stone be the only kind available, a larger-sized coarse aggregate should be used to mitigate somewhat the effect of the further crushing under the rolling. With stone of good quality the size used should be from 1 in. to 1½ in. The stone is spread on a water-bound-macadam foundation to such a depth that when compacted the layer will be from 2 in. to 3 in. thick. The course is then rolled. As the chief reliance is placed upon the interlocking action of the stone to obtain stability, rolling must be done until full compression has been obtained and all lateral movement has ceased before the bituminous binder is applied. The importance of adequate rolling cannot be emphasized too much, as a large number of failures—or, at least, very undesirable features—in the finished pavement can only be assigned to insufficient rolling before applying the binder. Unless the coarse stone is rigidly keyed together to prevent lateral displacement the following application of bituminous material will have the effect of surrounding the stone with a lubricant which under summer conditions and under traffic favours the readjustment and constant displacement of the stone aggregate. This will produce ruts and other depressions, and corresponding ridges, over large parts of the road-surface, which will not only make travel unpleasant but will also be destructive to vehicles. The condition of such a pavement becomes worse and worse in time as vehicular impact increases and the depressions increase in depth and the ridges in height.

Compacting of the bottom course being completed, hot bituminous material at the rate of about 1⅓ imperial gallons per square yard is then uniformly applied under pressure, in such quantity so as not merely to cover the surface but also to flow into the voids between the stone fragments.

The surface voids in the course are next filled by spreading and rolling in a thin layer of chips. No bituminous material should be applied unless the entire depth of coarse stone is thoroughly dry and the air temperature in the shade is over 50° F.

After sweeping off all unabsorbed chips a further application of bituminous material is made in an amount just sufficient to provide a thin coating of tar or asphalt, which is immediately covered with stone chips and rolled. This second application is usually at the rate of about ½ gallon to the square yard.

It is of the utmost importance that all stone, coarse and fine, should be reasonably clean and free from dust in order that it may be thoroughly coated with the bituminous binder. If necessary the stone should be flushed with water, but it must be thoroughly dry before the application of bitumen.

If too much bitumen is used in the seal coat an independent mat will form, which in time will develop corrugations.

In adopting American specifications, the difference between the United States gallon and the imperial gallon should always be borne in mind. It may mean the difference between success and failure.

Bituminous or Asphaltic Concrete.

There are a number of forms of bituminous paving which can be classified under the above heading. The essential difference between the various forms is chiefly in the grading and quantity of the coarser aggregate. Asphaltic concrete is really a sheet asphalt mixture with the addition of a percentage of aggregate varying from 1 in. to ¼ in.

The well-known Topeka mix is an asphaltic concrete, but the original specification is now modified to give a better grading of the proportions of the finer constituents. Two modified Topeka mixes are shown in the following :—

	No. 1. Per Cent.	No. 2. Per Cent.
Asphalt cement	7 to 11	7 to 9
Passing ½ in. and retained on ¼ in. mesh	5 to 10	5 to 10
Passing ¼ in. and retained on 10-mesh	11 to 25	12 to 22
Passing 10-mesh and retained on 40-mesh	7 to 25	12 to 20
Passing 40-mesh and retained on 80-mesh	11 to 36	18 to 26
Passing 80-mesh and retained on 200-mesh	10 to 25	12 to 20
Passing 200-mesh	5 to 11	9 to 14

Asphaltic concrete holds a midway place between bituminous macadam on the one side and sheet asphalt on the other.

In Denver I inspected a number of asphaltic-concrete pavements which were put down on old water-bound-macadam roads. A 1½ in. wearing-course on top of a 1½ in. binder course only was used. The binder course was mixed in the proportion of 50 lb. of asphalt-cement to 250 lb. of sand and 750 lb. of smelter-slag (maximum size 1 in.). The surface course was mixed in the proportion of 80 lb. of asphalt-cement to 85 lb. of limestone dust, 535 lb. of sand, and 300 lb. of slag (maximum size ⅝ in.). The cost was only 4s. 6d. per square yard, and, with the exception of minor cracks, the pavements seemed to be standing up well to the traffic.

In the Topeka type of surfacing the coarse aggregate constitutes barely one-third of the mass of the pavement. It is claimed that this amount is not entirely sufficient to place the stones in close-enough contact to prevent displacement, hence in many cases the coarse aggregate has been increased both in size and amount, so that more dependence could be placed on the interlocking action of the stones.

As an indication of the great attention given to the details of construction of asphaltic concrete pavements by the American engineers, an extract from one of the very latest specifications for a 1½ in. wearing-course on a 3½ in. base is attached to this report (see Enclosure B).

Mastic Asphalt.

I did not see any mastic asphalt being laid in America, but inspected a number of plants working in England. Mastic asphalt is composed primarily of similar ingredients to those found in compressed-rock asphalt, with the addition of a suitable percentage of bitumen to bring the mixture to such a consistency that it can be floated by hand with wooden trowels. It is usually applied in a 2 in. layer on a concrete foundation not less than 6 in. in thickness, but it may also be laid on a good macadam foundation. The mastic mixture is prepared in 6-ton horizontal portable boilers, which are fitted with paddles, driven usually by portable engines. The mastic is first prepared in blocks, which are melted and mixed with small screenings on the job.

A standard mastic asphalt for work in England has the following composition :—

	As manufactured in Block Form and despatched from the Depot. Per Cent.	As mixed and laid on the Job after the Addition of Screenings. Per Cent.
Bitumen	16·4	10·8
Passing 200-mesh screen	43·2	22·1
Passing 100-mesh screen	9·2	7·0
Passing 80-mesh screen	2.0	2·8
Passing 50-mesh screen	10·8	5·6
Passing 40-mesh screen	4·5	2·6
Passing 30-mesh screen	6·8	2·3
Passing 20-mesh screen	4·7	3·7
Passing 10-mesh screen	2·4	5·5
Retained on 10-mesh screen	nil	37·6

Concrete Roads.

In speaking of concrete roads care should be taken in defining accurately what is meant by the term. There is no doubt as to the classification of an unprotected concrete surfacing, but concrete may be used for the construction of a base to support a wearing-course of 1½ in. sheet asphalt. Such a pavement is not called a concrete road in the United States. Yet those roads which consist of a layer of concrete with a ⅜ in. protective coat of bitumen and screenings are classed as concrete roads.

It is almost universally agreed that concrete as a base for sheet asphalt, wood blocks, &c., is unrivalled, but opinions differ quite widely as to its place in the scale of wearing-surfaces. While the sheet-asphalt wearing-surface on a concrete base constitutes the most popular city pavement in the United States to-day, the unprotected concrete pavement is the most popular surfacing for the more important rural highways. Many exhaustive tests have been carried out on unprotected concrete roads, and in spite of a certain amount of prejudice engendered by the fairly frequent failures of the light 4 in. low-strength original Californian roads, the popularity of the pavement has increased enormously throughout the United States, and nowhere more than in California itself. Even in Britain a continually increased mileage every year is being laid down.

The greatest drawback of bituminous surfaced roads has always been the difficulty of preventing wave-formation, and it is the freedom from such troubles that has had much to do with the great increase in popularity of the concrete pavement.

The principal advantages of concrete pavements are as follows :—

(1.) As far as can be judged, they are durable under ordinary suburban and rural traffic conditions :

(2.) They present a smooth, even surface, which offers very little resistance to traffic :

(3.) They are practically dustless, and may be easily cleaned :

(4.) They may be maintained at comparatively small cost :

(5.) They may be made to serve as a base for some other type of surface when resurfacing becomes necessary.

The principal disadvantages are :—

(1.) They are somewhat noisy under steel-tired traffic :

(2.) They are subject to cracking, and wherever a crack develops it must be given frequent attention in order to prevent deterioration of the pavement :

(3.) On account of the sharp line of separation between the pavement and the shoulders, and the marked difference in hardness, an abrupt and dangerous depression is sometimes formed at the edge of the pavement, which reduces the effective width of roadway :

(4.) The difficulty of reinstatement after any disturbance of the road has taken place (this objection applies more particularly to city work).

Most of the secrets of the success of a concrete road centre around the care bestowed upon the selection, proportioning, mixing, and laying of the various materials. The cement should be regularly tested. Sand should come up to the usual specifications for concrete-work, except that much more attention should be paid to the grading of the particles. The Bureau of Public Roads recommends the following grading :—

	Per Cent.
Passing ¼ in. screen	100
Passing ¼ in screen and retained on No. 10 sieve	5 to 25
Passing No. 10 and retained on No. 50 sieve	5 to 90
Passing No. 100 sieve, not more than	10
Weight removed by elutriation test, not more than	3

The coarse aggregate of stone should be clean, and have a French coefficient of wear of at least 7. If gravel it should not show a greater loss than 12 per cent. under the abrasion test. Attention should also be paid to the grading of the coarse aggregate, the object being to obtain as dense a mixture as possible. The Bureau of Public Roads recommends the following grading for the coarse aggregate :—

	Per Cent.
Passing 2 in. screen	100
Passing 2 in. and retained on 1 in. screen	25 to 60
Passing ¼ in. screen, not more than	10

The method of proportioning by voids is used in England. In America Fuller's method is much used. In practice it is generally not feasible to follow strictly any of the theories in the proportioning of the materials, as conditions vary so frequently. A set of tables compiled from experiments by Professor Abrams is generally used on the job in the United States. They give a large number of satisfactory combinations of variously graded coarse and fine aggregates.

The most up-to-date methods of laying and curing concrete roads in America can be gathered most satisfactorily by perusing the extract from a 1924 specification, forming Enclosure C to this report.

The two chief sets of tests carried out in recent years on concrete pavements were the Bates tests and the Pittsburg tests. It is very significant that the designs evolved as being the most economical from both these tests are practically identical. These designs are being widely adopted through the United States as standards. The main features are : (1) The pavement is 6 in. thick except for 2 ft. from each edge, where the thickness gradually increases until at the edge it is 9 in. ; (2) a longitudinal centre joint with deformed bars acting as dowels on pavements 18 ft. or over in width. With inferior foundations and more than the average rural traffic the pavement-thickness is, of course, increased. When an intensity of heavy lorry traffic of 150 per day is anticipated 8 in. is regarded as the minimum thickness. A crown of 2 in. in an 18 ft. pavement is used.

A peculiar feature of a concrete pavement was disclosed by the above tests. It was found that the slab curled upwards at the edges during the night. This means that it is possible for water to get access to the subgrade. It was also observed that the early-morning lorry traffic did the most damage to the road.

The worst failures which I saw in California were crow's-foot cracks at the edges of the pavements or at the corners of slabs, and would certainly seem to indicate the necessity for greater thickness at the sides.

The question of expansion and contraction joints has never been satisfactorily solved. One of the most noted English authorities at the last International Road Congress stated that "the cracks formed by expansion and contraction of concrete through temperature, moisture, and subsoil changes cannot be eliminated by the provision of expansion-joints." The majority of plain concrete pavements in America are now constructed without transverse joints. They are considered unnecessary if the concrete is laid when the air-temperature is not below 50° F.

Bituminous Surfacings.—When concrete roads were first made a bituminous carpet was usually applied with the idea of forming a wearing-surface and reducing the impact on the slab. This practice is now being generally discontinued. It is found that a bituminous surface approximately ¼ in. in thickness has little, if any, cushioning-value, and consequently does not lessen the impact to any appreciable extent. The chief advantage of such a treatment lies in the fact that cracks are automatically bridged over as they appear, and surface water is prevented from reaching the subgrade through these cracks. The difficulty of securing proper adhesion of the bituminous surface to the concrete, its cost, and the necessity for continuous maintenance, constitute its greatest disadvantages. In both America and England it is being recognized that these disadvantages greatly outweigh any possible advantages that might be obtained through its use. An example of a very unsatisfactory surfacing of this type may be seen in Napier at the present time.

Good shoulders should always be provided to concrete pavements, and if earth, gravel, or macadam, they should not be less than 5 ft. each in width.

At Arlington, Virginia, I inspected sections of concrete road undergoing tests by the Bureau of Public Roads. These tests were being made to determine what relations, if any, exist between the surface behaviour of concrete roads under traffic and the various laboratory tests for the quality of the aggregates. The results of the tests have just been published in the issue of *Public Roads* dated May, 1924.

Other tests were being carried out to determine the stresses induced in a pavement by a loaded lorry travelling at a given rate of speed and passing over a small bump such as a piece of thin board.

Sheet Asphalt.

Sheet asphalt is the most popular form of city pavement in the United States. Sheet-asphalt pavements have a wearing-surface of asphalt-cement combined with an inert aggregate of graded sand and filler, laid upon a foundation which is usually cement concrete, although bituminous concrete, old macadam, brick or stone blocks are sometimes used. The thickness of this wearing-surface is usually from 1½ in. to 2½ in., depending on the amount of traffic to be carried.

The pavement is ordinarily built in two courses. The first, called the "binder" course, is of asphalt and graded crushed stone, and varies in thickness from 1 in. to 1½ in. The aggregate is heated and then mixed in a rotary mixer with a minimum quantity (about 6 per cent.) of refined asphalt. It is then spread on the foundation with shovels or rakes, and rolled with a 5 to 7 ton roller. Sometimes the binder course is replaced by a coat of paint-binder consisting of asphalt-cement dissolved in gasoline, which is applied with a brush to the concrete foundation. The wearing-course is placed directly on the binder course or paint-coat.

The aggregate of the wearing-course consists of carefully graded particles of sand ranging from the size of dust grains to about ⅛ in. in size. The sand constitutes nearly 80 per cent. of the surface mixture, and takes nearly all the wear of the traffic. It should therefore be hard, clean, moderately sharp, and have a suitable surface to which the asphalt may adhere. It should be free from organic matter, and should pack together well when dry.

With the sand there should be used a filler of very fine material, such as powdered chalk or limestone, Portland cement, or slate-dust. This should be fine enough to pass a 200-mesh screen in order to fill properly the voids in the sand. After mixing the sand and the filler, the material should be heated to about 350° F. and then mixed with from 9·5 to 11·5 per cent. of asphalt-cement heated to about 300° F. The mixture is then hauled to the street in canvas-covered wagons or lorries, and spread on the lower course prepared as previously described. Hot rakes, shovels, and tampers are used to place the mixture, which must be thoroughly loosened to ensure uniformity. The course is immediately rolled with an 8-ton roller, sprinkled with Portland cement, and rerolled.

Sheet asphalt is more suited for fast concentrated traffic than for light or slowly moving heavy traffic, but it is disastrous for any horse traffic or for grades steeper than 1 in 25. In Los Angeles after several months dry weather a shower of rain on the sheet-asphalt pavements makes any speed over ten miles an hour exceedingly dangerous, and cars may be observed performing the wildest of evolutions.

Fifth Avenue in New York is laid down in sheet asphalt, and there it has given remarkable service. On the California highways concrete shoulders are being laid down to sheet-asphalt pavement, and where they have been laid down some time the road-surface seems to be in better condition. Sheet asphalt is dustless, easily cleaned, and easily repaired. Its cost in California, including 5 in. concrete base, is about 10s. per square yard.

The following tabulation shows two American specifications for the composition of a sheet-asphalt wearing-surface. Both are representative of this year's practice, and I saw both being laid down.

	Specification No. 1. Per Cent.	Specification No. 2. Per Cent.
Asphalt-cement	9½ to 11½	10 to 12
Sand and stone-dust passing 200-mesh screen	13 to 18	12 to 15
Passing 80-mesh and retained on 200-mesh screen	18 to 28	20 to 34
Passing 50-mesh and retained on 80-mesh screen	16 to 24	20 to 34
Passing 30-mesh and retained on 50-mesh screen	18 to 26	11 to 20
Passing 20-mesh and retained on 30-mesh screen	4 to 9	4 to 10
Passing 10-mesh and retained on 20-mesh screen	2 to 5	1½ to 5

A typical sheet-asphalt mixture in England is as follows:—

	Per Cent.
Bitumen soluble in CS_2	12
Aggregate passing 200-mesh screen	16
„ 100-mesh screen	12
„ 80-mesh screen	10
„ 50-mesh screen	40
„ 40-mesh screen	4
„ 30-mesh screen	3
„ 20-mesh screen	2
„ 10-mesh screen	1
	100

When the climate is humid it is considered good practice to use not less than 12 per cent. of bitumen. 10 per cent. by weight of filler may be regarded as the minimum requirement for any sheet-asphalt mixture.

Wood Block.

It is now comparatively unusual to see wood-block pavements being put down in America.

The practice is to use chiefly long yellow-leaf pine or Douglas fir blocks impregnated with from 16 lb. to 20 lb. of coal-tar creosote per cubic foot of block. The blocks are usually 8 in. by 4 in. by 4 in.,

and, of course, are laid with the grain vertical. A 5 in. or 6 in. concrete base is usually used, and the blocks are either laid on a cement-sand cushion or the base is painted with asphalt and the blocks laid directly on it. A bituminous filler is then thoroughly mopped into the joints, and is followed by a coating of coarse sand.

In London creosoted soft-wood blocks are still being used extensively. A very heavy concrete base is first put down, and finished off accurately to template with 2 in. to 3 in. of fine aggregate concrete and grout, making a total thickness of about 12 in. The blocks are then laid without any cushion, and a coating of tar, cement, and sand or small chips applied later. The blocks are laid with their length at right angles to the traffic, with the exception of two rows adjoining each channel. An expansion-joint, 1 in. in width, is left next the channel, and is filled with pitch. The blocks are very accurately sawn. Little care is used in curing the concrete base. Taking into consideration the great deal of horse traffic, wood block is still the best pavement for London. It is interesting to note that no hardwood blocks were laid in London during 1923.

Brick Pavements.

Many brick pavements have been laid in the cities in the United States, but very little of this type of work has been put down on highways. As the best practice is to lay the bricks on a concrete base, the cost is very high, and there would seem to be little reason for the adoption of the type in New Zealand. They are preferred in America on comparatively steep grades, as their surface is less slippery than sheet asphalt or concrete. In some places they have worn very unevenly, on account of varying hardness of the bricks.

Rubber Roads.

Small sections of rubber pavement have been laid down in England during the past few years. I made a close inspection of a section which had been down for seven months. It is situated around the cenotaph in London, and is 50 yards in length. The rubber blocks are approximately the size of ordinary wood blocks, and are made of two different kinds of rubber, the lower portion being hard and unyielding, and the upper thinner layer being quite resilient. The blocks are laid on concrete, and are interlocked. The most noticeable feature of the pavement is the very large distance it has crept in the direction of the traffic, the maximum movement being about 4 ft., which amount has been apparently taken up by compression. The pavement has needed constant attention. The wearing surface of the blocks do not show the slightest sign of wear, but on several occasions the blocks have bulged up over small areas. I was told by the foreman making repairs that when water finds its way down to the concrete the movement of the blocks under traffic in places caused them to wear depressions in the concrete. The foreman also considered the lugs on the blocks required for interlocking to be impracticable when it came to repairs. The experiment certainly cannot be classed as a success.

The cost of the pavement is said to be £4 per square yard. Rubber slabs, 9 ft. by 4 ft. 6 in., anchored to a concrete base, with steel cone rings, have recently been laid in other places in England, but I did not have the opportunity of seeing them.

Guard-rails.

The use of guard-rails of varying design is exceedingly common on the main highways of the United States. They are often used in places which to the colonial eye seem reasonably safe without such a precaution. In some places every embankment is provided with guard-rails.

Various combinations of timber, concrete, and wire rope are used in their construction. Many of the rails erected in the past are far too light and offer only a moral protection to a vehicle, but the later and more elaborate types are strong, substantial affairs. The centre of the top rail is usually only about 2 ft. above the ground.

A modern timber guard-rail consists of 8 in. by 8 in. posts at about 7 ft. centres with a 6 in. by 6 in. rail. Concrete posts with timber rails is a common form of construction. A wire-rope guard-rail consists of timber or concrete posts strung with two $\frac{3}{4}$ in. diameter galvanized-steel wire ropes. The ropes are provided with turnbuckles, and are anchored every few hundred feet. I think this type is superior to the timber or concrete rail. In some places where rails cannot be afforded large boulders painted white are placed at small intervals along the edge of the embankment.

Safety-devices and Warning Signs on Highways.

The most effective warning-device used in America for railway-crossings is what is colloquially called the "wig-wag" signal. It consists of a red disc on an arm which is electrically operated by an approaching train and swings with a pendulum motion. It is mounted on a post in a position that will catch the eye of the approaching traveller. At every swing the arm also strikes a gong. For night use the disc is fitted with a red light.

At many crossings fearsome posters depicting imminent collisions are affixed to posts. At one crossing I saw the remains of a motor-car which had been practically demolished by a locomotive set up on a platform in a prominent position as a warning.

For some railway-crossings in the north of Italy large skull and cross-bones signs are used.

At sharp curves on concrete or other good pavements in the United States it is customary to paint white lines along the centre of the pavement. These have an excellent effect in defining the limits of passing traffic.

Under overbridges and other similar structures where visibility is poor a concrete kerb is often placed along the centre of the road for a certain length to guide the traffic and prevent collisions. In some places concrete shoulders and tree-trunks are whitened to assist the motorist at night.

Large mirrors are occasionally used, both in England and America, at important road-junctions to show approaching traffic. Cast-iron "buttons" set in the roadway are very much used to define turning-points at junctions, and some are fitted with lighting-devices for night work.

It is not uncommon to see such notices as the following posted up at dangerous points on highways in America :—

" Twelve-year-old boy killed by auto here on March 28th, 1921.—Dr. W. A. CORSON, Coroner."

" Drive carefully. Nearest hospital now at least nine miles."

" Caution. Blind crossing. Better play safe than the harp and a golden crown."

ROAD-SIGNS AND DIRECTION-POSTS.

In the United States the provision of these conveniences is left largely to the automobile associations : for example, the Southern California Automobile Association alone has erected ninety thousand signs in its territory, its membership being eighty thousand.

English roads are very well provided with signs, the most common materials used being cast iron and wood. In America sheet iron and wood seem to be most favoured. Black or blue lettering on a while background is usually used. One of the automobile associations in England is using circular signs with black letters on a yellow background. I am of the opinion that the yellow background is better from the point of view of the motorist, and will also withstand the ravages of the weather better. An important point in the erection of signs is that they should always be placed at a standard height from the ground : the motorist then picks up the signs much more readily. Standards for supporting signs may be of ornamental cast-iron, 2½ in. galvanized-iron piping filled with cement grout, tee iron, angle-iron, or wood. In England the automobile associations have erected many signs at small bridges and culverts, giving the name of the bridge and the name of the stream.

MAINTENANCE : GENERAL.

New Zealand's effort with about 40 per cent. of her roads surfaced with gravel or something better compares more than favourably with that of the United States, which has only 13 per cent. of her road mileage surfaced with gravel or something better. New Zealand is behind, however, in the standards of construction of her more important highways. These standards must be raised, but the mileage so affected will be only a very small percentage of the highway system. The bulk of the roads in the country will not be materially improved by the proposed programme for reconstruction, on account of the restrictions of finance. There is a phase of the road problem, however, in which New Zealand lags further behind than any other country that I have visited. New Zealand must learn to *maintain* the roads she already possesses. The capital invested in the past must be given a chance to earn, in spite of the motor-vehicle. Improved maintenance will affect every mile of road in the Dominion. It is becoming the habit to sit back and say the day of the gravel or macadam road is over. It is the day of lax maintenance of these surfacings that is over.

There are gravelled roads in the United States successfully taking motor traffic of a greater volume than any recorded on our main highways by the recent traffic census, and yet the condition of many of our highways is deplorable. The reason for this apparent paradox is simply maintenance. We all know of odd sections of gravelled road in this country which with very little attention seem to keep a good surface under considerable traffic. In such cases there are usually some natural causes which assist the roadman, but these instances teach the lesson that it is possible under certain conditions for a gravel road to carry economically a considerable amount of traffic. The art of maintenance is in endeavouring to create those conditions on all stretches of road.

The way to get good roads throughout the country with moderate finance is not to make a fevered search for a supreme traffic-defying form of pavement and then build a few miles per annum. As great a mileage as possible of the medium types of construction must be laid down, but even the most optimistic must admit that this mileage can only be very small. The slogan for the country must be " Better maintenance."

The few miles of high-class surfacing can only be obtained with heavy expenditure which will impose a burden upon the taxpayer for many years. The maintenance of the bulk of the roads can be much improved with no further annual expense to the taxpayer by the introduction of better methods, by better supervision, and by educating the actual man who works on the road. A moderate increase in the annual payments for scientific maintenance of our ordinary roads will also give a better return than the same money expended in defraying the overhead charges on a few miles of expensive pavement. This attitude seems to be the one adopted in England and the Continent, where the roads are, in my opinion, more carefully maintained than in the United States.

Where America has gone in for vast construction programmes England has rather given more attention to maintenance. In 1914–15 England spent 9s. 6d. per head on maintenance. The figures for 1920–21 were £1 0s. 3d. per head. On most of the main roads leading out from London the cost of maintenance is from £700 to £1,000 per mile per annum. The average expenditure on these roads works out at ⅓d. per ton-mile of traffic.

In May last I motored over two thousand miles of England's main roads, and was astounded at the enormous amount of maintenance work that was being undertaken in the way of annual bituminous surfacing. A very noticeable feature was the great number of road-rollers used, as many as five being seen on one job. I also saw many signs in France of preparations for the spring maintenance work on her matchless macadam roads. The distinguishing feature was the enormous supplies of road-metal piled everywhere on the roadside ready for use.

Before leaving the general subject of maintenance I would like to say that there is no country with which I am acquainted where steel bridges receive as little care after construction as in New Zealand.

MAINTENANCE OF GRAVEL ROADS.

The theory of all maintenance is " little and often." Subsoil drainage and surface drainage must primarily be dealt with. The maintenance of the surface of gravelled roads is best attended to by means of a road-drag ; the use of this very cheap and most effective piece of plant should be compulsory

on every gravel road in the country. Roadmen should be educated in its use and in the knowledge of the right times to use it. Its operating-cost is so small that it can be used very frequently. The best time to use it is after a shower, just as the road is beginning to dry. There are many unsatisfactory gravel roads upon which more money is spent carting fresh materials to fill ruts and potholes than would be necessary to maintain the same roads in good condition by means of the road-drag. The pamphlet "The Road-drag and how it is used," prepared by the Bureau of Public Roads in the United States, should be in the hands of every road engineer, road overseer, and road foreman in the Dominion.

Maintenance of Macadam Roads.

The theory of the old macadam road was that the abrasive effect of traffic on the larger stones produced just sufficient fine material to bond the larger stones and replace the original filler as fast as it was removed.

The introduction of the motor-vehicle has meant that (1) more of the filler is quickly removed, and (2) the abrasive effect on the larger stones is absent, on account of the rubber tires. It is quite evident, therefore, that the old theory fails and the road-surface rapidly disintegrates. If a macadam road is to be maintained to carry a reasonable amount of motor traffic, the obvious thing to do is to endeavour to replace the binding-material as fast as it is removed, or to provide such small fragments of suitable material on the surface of the road so that the reduced amount of steel-tired traffic can by abrasion and impact increase the supply of binder to replace the excessive amount removed by rubber tires.

A ½ in. layer of fine gravel, coarse sand, or fine screenings is effective. As it is thrown off the road by motor traffic, it must be replaced by dragging or scraping. The filling of potholes and depressions in macadam roads should receive close attention. A most important point is that each hole should be excavated until it is sufficiently deep to take satisfactorily the size of the stone used in repairs. The edges of the hole should also be cut out vertically, and the thickness of the patch should be uniform. The same kind of stone as exists in the road-surface should be used, and it should be compacted, rolled, or thoroughly tamped, and watered just as if it were new construction. To enable a patch to stand the traffic more satisfactorily, cold bituminous mixtures are often used to coat the metal. Tar or bituminous surfacing the whole of a water-bound macadam road is really a form of maintenance, as under much traffic it is usually necessary to replace such a surfacing annually or biennially.

Maintenance of Concrete Roads.

I would like to mention that the greatest of caution must be used in accepting maintenance figures for concrete pavements in cities as any criterion of what maintenance per mile on a concrete rural highway is likely to cost. It must be remembered that with a rural concrete road the ditches and culverts still have to be attended to, and the shoulders really have to receive more attention than in the case of other types, on account of the difference in hardness and rigidity of the contiguous surfaces. For example, in 1919, in Wisconsin, the following were the average costs of maintenance per mile for various types of road: Earth, $223; gravel, $212; water-bound macadam, $516; penetration macadam, $252; concrete, $337. Of the latter figure only $62 per mile was spent on the concrete surfacing itself. Again, in Minnesota, in 1923, of the total annual expenditure on the maintenance of concrete pavements, only 9 per cent. was for the maintenance of the slab proper.

Testing of Road-materials.

Testing of road-materials is carried on very elaborately in the United States. The Bureau of Public Roads publishes regularly the results of the tests carried out in its laboratory in Washington, D.C., which I had an opportunity of inspecting. The information given concerning a sample of stone includes its locality, geological classification, weight per cubic foot, absorption in pounds per cubic foot, French coefficient of wear, hardness, and toughness. Now that the main-highways scheme is under way in New Zealand it is most important that similar classified information be obtained about our roadmaking materials. The tests are not infallible, but they form an excellent guide for highway engineers.

The following table, compiled by the Bureau of Public Roads, shows the limiting-values for rock suitable for the wearing-course of a water-bound-macadam road:—

	French Coefficient: 40 (Per Cent. of Wear.)	Toughness.	Hardness.
Light traffic	.. 5 to 8	5 to 9	10 to 17
Medium traffic	.. 9 to 15	10 to 18	Over 14
Heavy traffic	.. Over 15	Over 18	Over 17.

If cementation tests are made the cementing-value should be over 25.

An English interpretation of physical tests on road-stones follows:—

——	Deval Abrasion Test (per Cent. of Wear).	Impact Test (Number of Blows for Failure).	Hardness Test.	Cementation Value (Number of Blows for Failure).	Absorption of Water (Pounds per Cubic Foot).
Very good ..	2 and under	19 and over	19 and over	over 100	0–10 and under
Good	2·1–2·5	16–18	17–18·9	76–100	0·11–0·40
Fairly good ..	2·6–3·1	13–15	16–16·9	26–75	0·41–1·00
Rather poor ..	3·2–4·0	8–12	15–15·9	10–25	1–01–3·00
Poor	Over 4·0	Under 8	Under 15	Under 10	Over 3·0

Tests should not be confined to road-metal. Our many and varied gravels should be tested and classified according to their value for roadmaking, as for many, many years gravelled surfaces will form the greatest portion of our improved highway system, as it does in the United States to-day. Gravel is subjected to abrasion tests, washing and elutriation tests, and grading tests.

Modern research tends to show that the amount of water used in mixing concrete has a vital effect on its future strength. To enable the consistency of a mix to be somewhat standardized the slump test has been devised. The test consists of carefully filling a conical frustum-shaped mould of galvanized iron (4 in. top diameter, 8 in. base diameter, and 12 in. in height) with the freshly mixed sample of concrete, and after leaving it stand for three minutes the mould is withdrawn. The difference between the height of the mould and the height of the concrete mass after it has "slumped" is the measure of the consistency. This difference should not be more than 1 in., nor less than $\frac{1}{2}$ in. for proper consistency.

In addition to the slump test, the flow-table test has been devised, also to measure consistency.

Recently a penetration test for determining the work ability of concrete has been brought into use by the Bureau of Standards, Washington.

Bituminous Materials.

Under this general heading I include tar and tar products, petroleum products, and natural asphalts. Tar and tar products are rapidly losing ground in the field of highway-construction. The overproduction of asphaltic base petroleums particularly in the Californian fields has so reduced the price of oil asphalts that the use of tar, with its shorter life and other detrimental qualities, is now seldom heard of in the United States. Oil asphalts are also finding great favour in England. The most modern methods of gas-production result in inferior tars, and this factor in addition is tending to increase the popularity of asphaltic petroleum residuals.

As it is likely that by far the greater portion of the mileage of improved surfaces on our highways will involve the use of oil asphalts rather than tars and natural asphalts I will confine my remarks to this class of materials.

The chief feature of bituminous materials as far as the highway engineer is concerned is the consistency. The consistency is tested and designated in three different ways according to whether the material is very liquid, moderately liquid, or semi-solid. In the first case the viscosity is determined by means of the Engler viscosimeter. The viscosity may be recorded in seconds, or it may be recorded as specific viscosity—that is, the viscosity of the material as compared with that of water. This test is used for tars and liquid petroleum residues suitable for use as dust palliatives. In the second case the consistency is determined by the float test. This test is recorded in seconds, and is used in classifying heavy refined tars and asphaltic oils suitable for sealing road surfaces and fluxing solid bitumens. For the third class of material the consistency is determined by the penetration test. This test is recorded in hundredths of a centimeter, and is used in classifying oil asphalts suitable for the construction of bituminous macadam (penetration method), bituminous concrete, and sheet-asphalt pavements.

There are three chief factors to be considered in determining the correct consistency of a suitable product for any job: (1) The method of construction; (2) the climatic conditions; (3) the nature of the traffic which the improved road is expected to take.

The following tabulation shows the recommendations of the Asphalt Association of America:—

Penetration Limits for Asphalt-cement.

Type of Pavement.	Traffic.	Temperatures.		
		Low.	Moderate.	High.
Bituminous macadam	Light	120–150	90–120	80–90
	Moderate	90–120	90–120	80–90
	Heavy	80–90	80–90	80–90
Bituminous concrete	Light	60–70	60–70	50–60
	Moderate	60–70	60–70	50–60
	Heavy	50–60	50–60	50–60
Sheet asphalt	Light	50 60	50–60	40–50
	Moderate	50–60	50–60	40–50
	Heavy	40–50	40–50	30–40

For most places in New Zealand the figures in the "Moderate temperature" column are suitable.

I have heard complaints in New Zealand that it is sometimes difficult to get bitumen to adhere directly to a dry clean surface. I believe that an investigation of these cases will disclose that a bitumen of a penetration of something less than 150 has been used. In the United States it is not customary to use for sealing purposes any bitumen which is viscous enough to be classified by the penetration test. If for the first coat a fluid bitumen or liquid asphalt is used which when tested will show a specific viscosity at 100° C. of not more than 60 I am sure the above trouble would not be experienced.

In connection with the manufacture of bitumen from semi-asphaltic petroleums such as are found in Texas and southern Illinois, it is desirable to know that usually the blowing process, as well as the distillation process has to be used, although subjecting the oil to a special preliminary cracking process may make blowing unnecessary. Blown asphalts have a much higher melting-point for a given penetration and a much lower ductility and lower specific gravity.

For the purpose of fluxing solid or semi-solid bitumens in England tar is very often used, but I would not recommend the use of tar in this country. Liquid asphalts should be used.

Costs.

While costs of various pavements abroad are not of very much use in this country, the following information may be of some interest. Generally speaking the cost of pavement-construction is heavier in England than in America, although wages are considerably less.

In Los Angeles the average costs of city pavements at present rates of exchange are as follows :—

	Per Square Yard. s. d.
Asphalt pavement—	
5 in. concrete base, paint binder 1½ in. surface	10 6
5 in. concrete base, 1 in. asphalt-concrete binder, 2 in. surface	10 11
6 in. concrete base, 1 in. binder, 2 in. surface	12 2
3½ in. bituminous base, 1½ in. surface	7 11
5 in. bituminous base, 1½ in. surface	9 8
Warrenite-Bitulithic—	
3½ in. bituminous base, 1½ in. surface	8 10
5 in. bituminous base, 1½ in. surface	10 6
5 in. concrete base, paint binder 1½ in. surface	10 11
6 in. concrete base, paint binder 2 in. surface	12 7
Topeka pavement, 5 in. concrete base, paint binder 2 in. surface	10 6
Concrete pavement, 5 in. thick	9 8
Concrete pavement, 6 in. thick	10 8
Concrete pavement, 7 in. thick	11 9

The following shows some very recent typical London prices :—	Per Square Yard. s. d.	s. d.
Asphalt pavement, 5 in. thick	17 6 to	21 0
Asphalt pavement, 2 in. thick with two years' maintenance	12 0 to	15 0
Wood block on 9 in. concrete foundation		38 3
Rock asphalt, 1½ in. thick, with one year's maintenance		12 0
Wood block on 12 in. concrete base		54 2
12 in. concrete foundation only		30 0
4 in. tar-slag macadam		8 2
2 in. asphalt carpet		10 5
Rubber pavement		80 0
Tar-spraying and gritting	0 4 to	0 5

The Chester City Council has carried out work recently for the following prices :—	Per Square Yard. s. d.
Granite sets on 7 in. reinforced-concrete foundation	32 6
2 in. rock asphalt on 7 in. reinforced-concrete foundation	21 0
4 in. wood block on 7 in. reinforced-concrete foundation	28 10
5 in. wood block on 7 in. reinforced-concrete foundation	31 10
2 coat bituminous macadam	16 3
4 in. penetration pavement	11 0
7 in. reinforced-concrete tar-sprayed	16 6

Recording Costs.—Elaborate costing systems are a feature of a number of American jobs. It would be impossible to get the average New Zealand foreman or overseer to carry them out satisfactorily. They usually seem to be operated in the United States by university graduates in engineering, who, to gain experience on works, take up subordinate positions as timekeepers, &c. There always seems to be an ample supply of such men for reasonably large jobs.

In New Zealand there is a very great field for improvement in recording costs, but accuracy and up-to-dateness should never be sacrificed for detail. In general it may be said that engineering costs cannot be entirely entrusted to a book-keeper or accountant; the value of the record consists in the data being reduced to units that will be immediately applicable to future work in the statement of the conditions governing the data, and in the logical arrangement and clearness of tabulation employed.

Plant.

With the great increase in road-development and the big changes in type of construction during the past ten years there has been considerable activity in the design and manufacture of new plant, particularly in America.

Motor-trucks and Steam-wagons.—Where haulage of road-materials over good surfaces is required the heavy motor-truck or steam-wagon is most efficient. Unfortunately we have in New Zealand very few roads capable of withstanding such heavy traffic except in the driest of weather, and comparatively light trucks on pneumatic tires would appear to be the most suitable for construction

purposes on our weak country roads. On good grades the use of trailers with broad-flanged wheels is to be recommended. The tip-truck in its various forms is now almost universal on highway-construction. End-tip trucks with regulating-doors at the back are often used to spread stone in a uniform layer directly on the road. A very successful machine for small work is a Ford 1-ton truck fitted with a roll-over body, made by the Easton Car and Construction Company of New York.

Loading-machines.—Portable loading-machines are very greatly used in America for loading trucks from stock piles. They save considerable labour and time. Many insignificant coal-dealers use these machines.

Portable Compressors.—A portable compressed-air drilling outfit is found on practically every small quarry job one sees in America. Portable compressors are also now used in all big cities in England and America for breaking up city pavements.

Road-rollers.—Road-rollers are used much more extensively in other countries than in New Zealand. For example, in Essex County, in England, there is a roller to every thirty miles of road. In New Zealand there is only about one roller to every hundred miles of main highway, and only one to about every thousand miles of road. The small rollers now being built by the Austin Company in America, and Barford and Perkins in England, are most useful implements for light construction. A number of the latter were used for the construction of the roads in the Exhibition at Wembley. I was much impressed with the work that is accomplished on gravel roads in America with these small machines. They are used not only for rolling, but also for shaping a road-surface. For finishing off a subgrade they are very convenient. Tandem quick-reverse rollers are almost universally used for the higher types of bituminous construction.

Bituminous Spraying Plant.—There is a very great difference between the plant used in America and the plant used in England. In America the bituminous materials are handled in bulk in railroad tank cars holding 10,000 gallons each and fitted with internal steam-piping for heating purposes. The bitumen is transferred to large motor-truck distributors, which spray the road-surface at a great rate. In England the bituminous materials are usually distributed in barrels alongside the road, and small spraying-machines similar to those seen in New Zealand are used in great numbers. The American method is no doubt considerably cheaper, but is only possible where bitumen or tar is available in bulk.

Gravel and Chip Distributors.—I saw a number of these machines working in England, and where a large programme of surfacing is to be carried out they are to be recommended.

Asphalt Plants.—The most common asphalt-mixing plants to be seen in the United States are those manufactured by Cummer and Son, Barber Asphalt Paving Company, and the Austin Company. The following is a simple description of the operation of a typical machine:—

"At one end is placed a continuous elevator of the belt-and-bucket type, into which broken stone, sand, or other mineral matter is fed from nearby storage piles. The elevator discharges into a cylindrical metal drum set over a firebox. As the drum revolves the aggregate passes through and is dried and heated by meeting the hot gases from the furnace which discharge through the drum. The hot aggregate is then lifted by means of an elevator to a hot storage-bin, sometimes being first screened into different sizes. The bin discharges into a measuring-box on the mixing-platform, where operators are stationed to proportion and handle the mix. Here the proper quantities of hot aggregate and asphalt are weighed out for each batch to be mixed. The asphalt is heated in kettles, and here, if too hard, it is also fluxed to proper consistency. It is forced through pipes to a weighing-bucket on the mixing-platform. The mixer is set so as to discharge directly into wagons or trucks below the platform, and usually consists of an iron box equipped with a double set of blades revolving on two horizontal shafts extending through the box. The mixer is first charged with the mineral aggregate, including limestone dust or Portland-cement filler, if any is to be used. After preliminary mixing, the hot asphalt is added, and mixing continued for one or two minutes until every particle is uniformly coated. The mix is then dumped into a truck and another batch prepared."

Concrete-paving Machines.—These machines have been well developed in America. I saw several American machines working in England. A very large gang is required to attend on them, but their output is enormous, 1,200 square yards of 8 in. pavement per ten-hour day not being uncommon. I have seen as many as forty men attending on one mixer. This number includes the road-finishing gang.

Water-spraying Motor-trucks.—These are now very frequently used not only in England and America but also on the Continent. I saw many machines fitted with the sprays in front. The driver thus is given excellent control.

Fordson Tractors.—These tractors are becoming very popular abroad, particularly where good road-surfaces exist. They are invaluable in such places as timber-yards and on wharves. In America I saw some fitted with a small hoisting-winch in front. On one job the winch was being used to assist negroes to push their concrete carts up a short grade.

Turntables for Motor-trucks.—These are frequently used in the United States. There are several makes on the market which can be operated by one man. For mountain-road work they are extremely useful.

Graders, Scoops, &c.—There are innumerable types of graders, scoops, trench-excavators, drag-excavators, &c., on the market in the United States which are peculiar to the country. Many are of very light design and are only used for a short period and then scrapped.

Traffic Census.

The traffic census is daily assuming greater and greater importance in the highway engineering world. No real study of any highway problem can be made without its assistance. Traffic statistics form the basis of all economic investigations, and the importance of having such information to hand cannot be too greatly stressed.

The purposes of a census may be detailed as follows :—

(1.) To determine the average daily volume of traffic using the highway, and the nature and destructive effect of the traffic :

(2.) To establish a record of the development and increase of motor traffic and the decrease of horse traffic :

(3.) To determine the variation in volume and congestion of different periods of the day, week, month, and year :

(4.) To enable an estimate to be formed showing the probable speeds of vehicles and the average distances between them :

(5.) To determine the difference in volume of traffic before and after any improvement or reconstruction :

(6.) To enable the cost of road-maintenance per unit vehicle to be determined :

(7.) To assist the engineer in designing, maintaining, or reconstructing the highway :

(8.) To assist the police authorities in allocating staff for regulation of traffic at congested or dangerous points :

(9.) To assist in drafting regional town-planning schemes :

(10.) To assist in making an equable distribution of Government funds.

A general traffic census is now taken annually in England.

Parking of Vehicles.

While this question does not crop up in connection with rural thoroughfares, still the problem of parking has become so acute in the large American cities, and even in the main streets of relatively small towns, that a few remarks may be opportune.

The width of a street is quickly and cheaply fixed in the early history of a town, but the cost of increasing the width of a street when congestion of traffic demands such a step is usually appalling. The parking problem has considerably aggravated the position, so that even where seemingly ample widths of streets originally were provided in many American cities the condition of affairs to-day is very sad. New Zealand is a country of great wealth *per capita*, and a very heavy increase in motor-vehicles is sure to follow main-highway developments. Therefore, in planning main streets of young towns or city streets that are likely to become busy thoroughfares an additional 16 ft. should be allowed for parking two lines of vehicles over and above the estimated widths required for moving traffic.

Detours and By-passes.

One of the great problems in England is the question of constructing detours around towns and villages. The old English towns are noted for their narrow tortuous streets, with the result that through traffic is seriously held up, the local traffic is impeded, and there is considerable danger to the inhabitants. On account of high land-values in the suburban areas, the construction of detours will involve enormous sums.

The possibilities of such difficulties in the future should be anticipated in New Zealand. There are already indications that there is trouble ahead—for example, the traffic coming from the north into Wellington is requested to travel via Featherston Street rather than by Lambton Quay.

Horse Traffic.

There is still considerable horse traffic in New Zealand, particularly in the country districts; and, while it is likely that such traffic will gradually decrease as time goes on, nevertheless when a decision is being made as to a type of pavement it must receive its share of consideration. In the United States the problem of horse traffic receives scant attention, but in England of recent years there has been considerable agitation against the modern types of bituminous pavement. This agitation cannot stay the progress in road-construction which is demanded by motor-vehicles, and so some means of rendering the modern smooth pavement reasonably safe for horses is being sought. There seem to be two possible remedies. The first is the practice of gritting the pavements when they become slippery, just as is done to the ice coating on pavements in the east of the United States. This is not looked on with favour, on account of possible damage to the dense asphalt surfaces, and also the grit turns into dust or mud.

The second possible remedy is to design special shoes for the horses which will give the necessary adhesion. Shoes have been designed with rubber pads, and have been used quite successfully in a small way in England. A committee of experts set up by the Ministry of Transport in 1919 failed to find a satisfactory solution for the difficulty, but considered a reasonable measure of safety could be obtained by using such special designs of shoes.

In tar or bitumen surfacing of roads the use of chips instead of sand gives the horse an advantage.

A matter which often creates difficulty is that the camber usually given to a water-bound-macadam road is excessive for horse traffic when that same road is tar or bitumen sealed.

The horse-owner naturally is to some extent prejudiced against the new types of pavement which have been brought about by his rival in the sphere of transportation, and it is an interesting historical fact that when the road-roller was first introduced and macadam roads with smooth surfaces began to be made, the farmers of England objected strongly on account of their slipperiness. It is to be hoped that the objections to the bituminous surfaces will be as easily overcome.

Pneumatic versus Solid Rubber Tires.

The substitution of the pneumatic tire for the solid rubber tire on motor-vehicles cannot be too strongly urged. An elaborate series of tests carried out by the Bureau of Public Roads showed that probably this change would do more to save the roads from wear and heavy maintenance charges

than any reform in road-engineering practice. Fortunately the pneumatic tire can hold its own with the solid or cushioned tire as an economical proposition for the motor-vehicle owner. In addition, a sliding scale of taxation in favour of the pneumatic tire is being adopted in many places, so that the position from the point of view of the highway engineer should improve very considerably. The solid tire is blamed as being a contributory factor in causing corrugation. The damage varies according to the amount of wear which the tire has undergone. The rubber itself also may have ceased to be resilient. The elastic property of the rubber is very much diminished when under pressure, so that where the pressure is greatest the modulus of elasticity of the rubber is least.

Tests were carried out by the Bureau of Public Roads to determine the values of the impact on a pavement produced by vehicles with (1) pneumatic tires, (2) cushion tires, (3) solid tires. As a typical example of the results it was found that a motor-truck at a speed of 17½ miles per hour gave with pneumatic tires an impact value of only 1·75 times the rear-wheel pressure on the road-surface, with the cushion tires over three times, and with the solid tires 4·3 to 5·1 times; that is, the cushion tires gave an impact value of 63 per cent. of the solid-tire average and the pneumatic only 36 per cent. It was also observed that the impact value for the pneumatic tire increased only very slightly with an increase in speed. It was concluded that solid rubber tires should have a high rate of tire-deflection to produce the lowest impact, and worn tires should not be tolerated.

In 1922 Messrs. Michelin, in France, also carried out tests to enable a comparison to be made of the effect of pneumatic and solid tires on road-surfaces. In the case of the solid tire the unit pressure on the area of contact varies from a maximum at the centre of the area to nil at the edges of the area. In the case of the pneumatic tire the intensity over the area of contact is practically uniform, since it is transmitted and distributed by the air-pressure itself. It was deduced that the maximum intensity of pressure in the case of the solid tire exceeded the maximum intensity of pressure in the case of the pneumatic tire in the ratio of, roughly, 4½ to 1. The Michelin tests did not take into consideration at all the question of impact.

Labour Comparisons.

In view of the extremely low costs that are sometimes reported from America, I took particular notice of the labour on construction jobs. My impression is that there is plenty of work done which must show very excessive labour costs. Great outputs are obtained from machinery, but I often noted that to enable the machinery to give the performance the jobs were simply flooded with men. This statement applies more particularly to concrete-work. Such skilled men as steam-shovel drivers, however, show a great superiority over our New Zealand operators. In the shifting, rigging, and operating of such plant as pile-driving equipment, cranes, dredges, &c., the average American foreman is almost magical, and it is to such men that the credit of most of the speed records of the United States in construction work is due.

Propaganda and Education.

In many spheres of modern civilized development the value of publicity and propaganda is more and more being recognized. In this respect there is no doubt that the United States leads the world. In attaining the enormous road-building activity of the past few years the education of the people to the idea of good roads and their value has been a most important factor. Every endeavour has been made to cultivate a sentiment. With the aid of the Press, the moving pictures, and many capable lecturers, the public at large has been forced to think "good roads." The Federal Bureau of Public Roads has taken a big part in assisting the movement. Not only at the commencement of a scheme, but also during the construction, the public interest is maintained by elaborate official statements as to the progress of the various works. In this way the public confidence is also gained. On many projects enormous signboards detail the outstanding features of the scheme, together with the names of the responsible persons. A public pride in the progress being made is fostered.

Photographs.

A very noticeable feature in American engineering practice is the great extent to which photographs are used to illustrate reports, to support arguments, to assist in research, to record inspections, to advertise proposals, to give information to contractors, to estimate and record traffic congestion, and so on. As a typical example, the United States Federal Bureau of Public Roads, in making a study and criticism of 1,262 miles of the Californian highway system, took no less than 7,500 photographs, which were filed and recorded. The pictures were taken at standard intervals of from one-tenth to five-tenths of a mile, and assisted greatly in arriving at a rational classification of the roads, besides forming an invaluable record for future reference. Supplementary close-up pictures of special features or defects were also taken. I think the camera to be more necessary to the highway engineer than the theodolite, and would urge its greater use in this country. Photography would be of the greatest assistance in rationally and fairly administering the Highways Act.

I would mention that the permanent staff engaged on the two vehicular tunnels being driven under the Hudson River in New York includes a particularly expert photographer, who is more or less of a specialist in pictorially interpreting engineering features. The Southern Californian Edison Company at Big Creek, California, has set up in a suitable fixed position an automatic moving-picture camera which takes pictures at regular intervals throughout the day, so that a continuous record of the progress of the work is obtained. For the purpose of educating the people up to realizing the full value of good roads the Bureau of Public Roads has a number of excellent films of road-construction, which are shown on every fitting occasion, and loaned to public bodies desiring to foster a "good roads" sentiment.

The "Best" Road.

Wherever important road-improvements are being considered there will always be a persistent search for a universally supreme type of road. Conferences of engineers will be continually asked to decide the question, experts from other countries or States will be consulted to enable a decision to be made, and many fruitless arguments will eventuate, particularly between sales engineers of rival organizations. Nevertheless there is no universally best road, any more than there is a best size for boots.

When the Federal Aid Road Act first came into force in America in 1916 the only specification supplied was that the roadwork carried out with Federal assistance should be "substantial in character." The interpretation of this expression was left to the Secretary of Agriculture, who decided that it was impossible to apply fixed and definite standards because none could be found which would meet the variety of conditions found throughout the country. Each scheme accordingly had to be considered on its own merits. To enable a decision to be arrived at, the following matters were investigated:—

(1.) The amount and nature of traffic using the road at the time of the application as determined by a traffic census:
(2.) The probable amount and nature of the traffic which would use the road after improvement:
(3.) The type of adjacent roads:
(4.) The relation of the road to the State highway system:
(5.) The technical questions brought about by local conditions.

With thoroughly reliable information on the above points no particular difficulty was encountered in making a fair decision as to the "best" type of road for any particular location.

For any particular traffic intensity the economic type is that which can be paid for with the savings in operating costs accruing from the improvement. No road should be improved to an extent in excess of its earning-capacity, but all roads should be developed to the highest degree consistent with the return in the form of traffic economies.

Guided by these considerations all types of roads, from the unsurfaced graded earth roads to concrete, have been approved by the Bureau of Public Roads. Of the total mileage completed or under construction up to the 30th June, 1922, gravel, sand-clay, and earth roads comprised about 70 per cent., water-bound macadam and bituminous macadam about 10 per cent., and concrete, brick, and bituminous concrete about 20 per cent. Of this 20 per cent. the mileage of bituminous concrete formed under 3 per cent.

The percentage of the money expended on the three main groups was as follows:—Gravel, sand-clay, and earth, 41 per cent.; waterbound macadam and bituminous macadam, 14 per cent.; concrete, brick, and bituminous concrete, 41 per cent. The percentage of Federal Aid money spent on bituminous concrete roads was well under 5 per cent. of the whole amount.

As the automobile density with reference to the population in the United States is about 300 per cent. greater than in New Zealand, it will be seen that if a policy somewhat akin to that of the Bureau of Public Roads is followed by the Main Highways Board in this country, then only a moderate fraction of the proposed expenditure for a number of years will be for the high-class pavements. It would be as well to point out also that the States in which a considerable proportion of the mileage of concrete roads has been laid down have an automobile density 500 per cent. greater than that of New Zealand.

Suitable types of Road for New Zealand Main Highways.

As mentioned in the previous section, the type of pavement to be chosen for any particular locality depends on local conditions, the most important of which are the existing traffic, and the possible future traffic after improvement. The future of the motor-vehicle in New Zealand can only be estimated by investigating the expansion that has taken place in the American States, as this Dominion per unit of population already possess twice as many motor-vehicles as England, which again is more advanced than any of the other European countries.

The American States which have embarked on the most expensive concrete-road programmes have about 170 motor-vehicles per mile of declared main highway. New Zealand at the present time has about ten motor-vehicles per mile of main highway. Assuming in the next ten years a 500 per cent. increase (which would appear to provide a satisfactory margin), one can see that even ten years hence, if the American precedents are taken as any guide, the question of introducing concrete roads to any great extent on the main highways will scarcely warrant serious discussion.

Estimates of the capability of various types of roads to take traffic economically in other countries vary to some extent, but there is sufficient information available to make it quite clear what types should be generally used in New Zealand for some considerable time. The following tabulation shows some comparative values by four various authorities:—

	Motor-vehicles per Day.			
16 ft. gravel road	..	..	50–75	500
16 ft. gravel road, tar or bituminous surface	500*	660	500–700	2,000
16 ft. waterbound macadam with bituminous surfacing	1,000	1,000	1,500	2,500
16 ft. waterbound-macadam road	..	..	50	..
16 ft. bituminous penetration road	..	1,550	..	5,000
16 ft. asphaltic concrete	..	3,000	..	..
16 ft. concrete road	2,000	5,000	..	..

* No loaded lorry to be over 8 tons in gross weight.

A recent careful investigation in the United States is said to have proved that with *proper methods of maintenance* 16 ft. gravel roads without bituminous surfacing can economically carry an average daily traffic of 350 vehicles. As no main highway in New Zealand has at present an average traffic of over five hundred motor-vehicles per day, and as most of the mileage is subjected to not more than a hundred motor-vehicles per day, it can again be deduced that the cheaper types of bituminous surfacing should economically satisfy the traffic conditions on practically all our highways for at least ten years to come. England's highway system on the whole is unrivalled, and it is the adoption of the cheaper forms of bituminous construction for by far the greater portion of her main country roads that has put her in this position.

Conclusion.

New Zealand is a young vigorous country anxious to have the best of everything. Visitors from abroad, to our disadvantage, compare our transportation facilities with those afforded the inhabitants of older and more populous countries.

The *per capita* wealth of New Zealand is claimed to be as great, if not greater, than that of any other country, and when Government assistance is forthcoming the tendency is for the local "good roads" enthusiast to demand the most expensive forms of paving for the roads in which he is particularly interested. The enormous activity of the United States in the construction of high-class pavements is held up as an example of what we should strive for.

Already the position of New Zealand as regards proportion of surfaced mileage has been pointed out, and before concluding I would like to draw attention to the peculiar position this country holds when total road mileage is compared with population. There is one mile of road—in England, to every 253 persons; in Scotland, to every 192 persons; in Ireland, to every 80 persons; in United States of America, to every 40 persons; in Canada, to every 32 persons; in New Zealand, to every 20 persons.

New Zealand, having double the mileage of the United States per unit of population, can therefore only afford to spend half as much per mile as is spent in the United States, if her people are to be equally taxed.

Where the traffic warrants it, by all means build expensive high-class pavements, but we must never allow our desire for a smooth luxurious road to outweigh rational economics. We all like Rolls-Royce cars, but most of us ride in Fords.

Permanent improvements, such as better alignments, better grades, better drainage, and better foundations must also universally precede high-class surfacings.

ENCLOSURE A.—SPECIFICATION FOR SUBGRADE.

(*a.*) *Description.*—The subgrade will be considered as that portion of the highway upon which surfacing or paving is to be placed. Before surfacing or paving is placed a subgrade shall be constructed, conforming to the grades and cross-sections shown on the plans and in accordance with these specifications. The finished subgrade shall be true to cross-section, hard, uniform, smooth, and must support without perceptible indentation the wheels of heavily loaded trucks, except where the soil is too sandy.

(*b.*) *Rolling and Watering.*—Thorough rolling and watering of the earth grade shall be done prior to the operations of making subgrade. If the shaping of the subgrade does not follow closely the watering and rolling the grade shall, if damaged by traffic and when ordered by the engineer, be reshaped and again watered and rolled. If the shaping of the subgrade follows closely the watering and rolling specified in paragraph (*w*) of the Grading Specifications, so that the moisture then applied can be utilized, reshaping and rewatering will not be required.

(*c.*) When the grade has been finished to a flat cross-section, and the side forms set to the line and grade given by the engineer, the subgrade shall be prepared by cultivating, shaping, pulverizing, watering, and rolling to a true cross-section as specified below.

(*d.*) With rooter, scarifier, or plough, thoroughly loosen the earth between the side forms to the full depth of the implement—12 in. is not too much. Break up clods with cultivator and disk to full depth of loose material. Run diagonally across road to see that all ribs are broken.

(*e.*) Use Fresno to lower high places, and raise low places. Continue the deep cultivating. When roughly shaped to cross-section, thoroughly dry-roll with a power roller of approved type weighing not less than 350 lb. per lineal inch of tire-width. Fill spots which roll below uniform grade when using shaper.

(*f.*) When clods are broken, earth pulverized, and dry rolling done, by means of the subgrader or any shaper riding on the headers, grade the loose earth uniformly to the desired height above finished grade. Cultivate when shaped to make shallow lengthwise furrows.

(*g.*) In the afternoon, preferably around 3 o'clock, begin watering on a section—say, 500 ft. to 600 ft. High water-pressure and large hose necessary. Proceed by directing the stream into the earth in straight lines crosswise of the subgrade, advancing 4 in. to 6 in. each time across. Plenty of water to be used; speed at which man walks governs amount of water applied. Watering of the section should be finished in a continuous operation.

(*h.*) The next morning, cultivate deeply to mix excess of wet earth with dry earth beneath. Cultivation to be continued until the loose earth for full depth is at the proper consistency for rolling. If dry spots are uncovered, showing that insufficient water was applied, they should be rewatered carefully before proceeding any further with the subgrade.

(*i.*) When the earth is at the proper state of moisture, give it the rolling. Continue until there is practically no more compression indicated under the wheels. If the subgrade at this stage shows spongy or wavy places it indicates too much water and not enough harrowing. In such cases it is useless to proceed until this condition has been corrected.

(*j.*) The grade should roll down within 1 in. of finished grade. Immediately after the rolling the cutting of subgrade should be done. On the final cut the wheels should rest on the headers at all points, as indicated when they are turning. Follow the cutter with sufficient men to throw out the excess earth, so that the return cut can be made quickly.

(*k.*) After final cut, by means of ropes at each end, drag the scratch templet the full length of the subgrade to check for depth. The nails in this templet shall not be more than 3 in. apart, and shall project at least $\frac{3}{4}$ in. from the wood in such a manner as to be on line for the true depth and surface of the subgrade when the templet is supported on each side by the side forms. If the depth is O.K., immediately give it an application of water, letting it bake the balance of the day. Examine it frequently, and when indications show that it is drying out too much, water again.

The detail of the operations of making subgrade shall be under the direction of the engineer, and he shall at all times have authority to stop the operation if in his opinion these specifications are not being complied with in a manner which will result in the character of subgrade specified.

Continued use of sections of prepared subgrade for hauling, so as to cut up or deform it from the true cross-section, will not be permitted. The contractor shall protect the prepared subgrade from both his own and public traffic.

(This elaborate specification is to some extent the result of experiments on a test road at Pittsburgh during 1921–22.)

ENCLOSURE B.—SPECIFICATION FOR ASPHALT-CONCRETE PAVEMENT.

(*a.*) *Description.*—Upon the subgrade prepared as hereinbefore specified shall be laid the asphalt-concrete pavement composed of broken stone, sand, stone-dust, and asphaltic cement. No pavement shall be laid when the subgrade is wet or shows indications of being spongy, soft, or unstable; loose dirt and other foreign matter shall be removed before any asphaltic mixture is placed on the subgrade.

The thickness of the pavement shall be controlled by the typical cross-section shown on the plans; when final compression is attained the top surface of the finished pavement shall conform to the grade and cross-section indicated on the plans. The pavement shall be laid in two courses, or compressions; the lower or base course shall be $3\frac{1}{2}$ in. in thickness after compression, and the top or wearing course shall be $1\frac{1}{2}$ in. in thickness after compression.

Side Forms.—Pavement.

Timber side forms shall be No. 1 common Oregon pine, and straight. They shall be not less than 16 ft. long, not less than $2\frac{1}{2}$ in. thick, and their depth shall be at least $\frac{1}{2}$ in. more than the specified depth of the edge of the base course. They shall have square top edges, square butt joints, and shall not contain enough knots or other imperfections to impair their strength. They shall have no wane on the edge to be placed uppermost.

Timber side forms shall rest upon 2 in. by 3 in. stakes, spaced not greater than 4 ft. apart, driven with their tops to the line and grade for the bottom of the side form. Stakes for nailing on the outside shall be placed 4 ft. apart at the intermediate points.

Timber side forms shall be secured by side stakes not less than 3 in. in width, $1\frac{1}{2}$ in. in thickness, and not less than 18 in. in length. The length of stakes shall be increased when the character of the soil will not give sufficient bearing to an 18 in. stake. Side forms shall be staked at intervals not greater than 4 ft., and the tops of the stakes shall be 1 in. below the top edge of the side form. Side forms shall be spliced with a section of timber 2 ft. in length, 1 in. thick, and 4 in. wide, which shall be nailed lengthwise, lapping the joints.

The stakes shall be sufficient in size and number to support the asphalt-concrete pavement. The headers shall remain in place as a part of the completed pavement.

On completion of the rolling of the base course additional strips $1\frac{1}{2}$ in. deep and not less than $2\frac{1}{2}$ in. wide shall be nailed in place on the base headers with their upper edges conforming to the lines and grades of the edge of the finished pavement.

Base Course.

The different mineral ingredients composing the base course shall be mixed in such proportions that the percentage by weight shall be within the following limits when tested on laboratory sieves:—

Broken stone and sand as follows:—

- Passing 200-mesh screen—between 2 and 4 per cent.
- Passing 80-mesh screen—between 6 and 12 per cent.
- Passing 40-mesh screen—between 12 and 20 per cent.
- Passing 10-mesh screen—between 20 and 30 per cent.
- Passing screen having $\frac{1}{4}$ in. square openings—between 30 and 40 per cent.
- Passing screen having $\frac{1}{2}$ in. round openings—between 40 and 50 per cent.
- Passing screen having $1\frac{1}{4}$ in. round openings—between 65 and 75 per cent.
- Passing screen having $2\frac{1}{2}$ in. round openings—100 per cent.

To the above shall be added asphaltic cement, 4 to 8 per cent.

Sand and screenings passing the 10-mesh sieve shall conform to the following proportions by weight :—

Passing 200-mesh sieve—between 4 and 10 per cent.
Passing 80-mesh sieve—between 25 and 50 per cent.
Passing 40-mesh sieve—between 60 and 80 per cent.
Passing 10-mesh sieve—100 per cent.

Sand passing the 10-mesh sieve shall conform to the following proportions by weight :—

Passing 200-mesh sieve—between 2 and 6 per cent.
Passing 80-mesh sieve—between 24 and 48 per cent.
Passing 40-mesh sieve—between 60 and 80 per cent.
Passing 10-mesh sieve—100 per cent.

The exact proportions, within the above limits, shall be regulated to produce a dense mixture with minimum voids and with the voids filled with bituminous material.

Asphaltic Cement.—Asphaltic cement used under these specifications must be prepared from the products of California crude asphlatic petroleum. It shall be an oil asphalt of the required degree of penetration, or a mixture of a refined liquid asphalt with a refined solid oil asphalt, and must be free from admixture with any residues obtained by the artificial distillation of coal-tar or paraffin oil.

Asphaltic cement shall be tested in accordance with the methods prescribed by the American Society for Testing Materials, except as to the test for solubility in carbon tetrachloride, which shall be made in accordance with the methods of the California Highway Commission hereinafter prescribed, and shall conform to the following requirements :—

(*a.*) Asphaltic cement shall be homogeneous and free from water.
(*b.*) Penetration of original sample at 77° F. during five seconds with 100-gramme weight—50° to 60°.
(*c.*) Penetration of same sample at 77° F. during five seconds with 100-gramme weight after heating for five hours at 325° F.—not less than 60 per cent. of original penetration.
(*d.*) Loss, after heating five hours at 325° F.—not more than 2 per cent.
(*e.*) Total bitumen soluble in carbon disulphide—not less than 99·5 per cent.
(*f.*) Per cent. of total bitumen soluble in carbon tetrachloride 98 per cent.
(*g.*) Ductility at 77° F.—30 to 40 centimetres.

In the test for solubility in cold carbon tetrachloride 200 cubic centimetres of the solvent shall be poured on 1 gramme of the asphaltic cement, and the mixture allowed to stand for eighteen hours at a temperature of 77° F. and then filtered at 77° F.

During the test the mixture shall be subjected to nonactinic light only.

All shipments of material shall be marked with a lot-number and penetration, and ten samples taken on random from each lot shall not vary more than 15 per cent. from the average penetration.

Broken Stone.—The broken stone used for the asphaltic concrete shall be clean, hard, and tough stone of uniform quality, free from disintegrated material, and such that when tested with the Page-Deval abrasion machine in the laboratory of the Commission it shall have an average coefficient of wear (French) of not less than 10. Said tests to be made in accordance with the methods in use at the laboratory of the California Highway Commission.

Sand.—The sand for the asphaltic concrete may be either a natural or a manufactured product, and shall be clean, hard-grained, and moderately sharp, and shall contain not more than 3 per cent. of loam, clay, organic matter, or other earthy impurities, nor, in the opinion of the engineer, mica in sufficient quantity or quality to be detrimental to the material. All impurities shall be determined in accordance with the methods in use at the laboratory of the California Highway Commission. It shall be so graded as to produce in the finished surface mixture the mesh requirements elsewhere herein specified. It shall not contain more than 6 per cent. of material that will pass a No. 200 sieve.

Screenings.—Screenings shall be the product of the crusher which will pass a $\frac{1}{4}$ in. square screen, and shall be made from rock conforming in hardness to the requirements for broken stone hereinbefore specified. Screenings shall not contain more than 5 per cent. of mica, loam, clay, organic matter, or other earthy impurities.

Stone-dust.—The stone-dust may be finely powdered limestone or Portland cement, and shall be of such fineness that all of it will pass a No. 50 sieve, and at least 66 per cent. shall pass a No. 200 sieve.

Samples.—The contractor shall furnish to the engineer for test whenever called for, and free of charge, samples of all the materials entering into the composition of the pavement, the asphalt and asphaltic cement to be furnished in boxes; and the said engineers shall have access at all times to all branches of the work. All tests shall be open to the contractor.

Mixing.—The materials above described shall be heated, screened, and mixed by the following method: The broken stone and sand shall be roughly mixed and evenly fed to the driers, and shall be thoroughly dried to a temperature between 300° and 375° F. The temperature of the sand and stone shall not vary from each other more than 30°.

Proper screens approved by the engineer shall be provided for separating the materials into various sizes.

The screen sizes shall be $2\frac{1}{2}$ in., $1\frac{1}{4}$ in., and $\frac{1}{2}$ in., either circular or square openings, as the contractor may elect, $\frac{1}{4}$ in. square mesh and 10-mesh. The openings of the 10-mesh screen shall conform to standard 10-mesh size. Screens shall be of such capacity or so arranged that the three larger-mesh screens will screen out at least 90 per cent. of the material coming to them, and the smaller screens at least 80 per cent. of the material coming to them.

The different sizes of material shall be kept in at least four separate metal bins, one for sand and three for broken stone or gravel. Each bin shall be provided with an overflow vent or other suitable warning-device, approved by the engineers, to prevent overflow into adjacent bin.

An armoured thermometer, reading from 200° to 400° F., shall be installed and maintained in the sand-bin in such a position as to be readily observed.

A similar armoured thermometer shall be fixed in the asphalt line at a suitable location, as directed by the engineer.

Weighing Materials.—The mineral aggregate passing through the bins shall be weighed into a weigh-box placed above the mixer by means of multiple-beam charging-scales. These scales shall be enclosed in a box which shall be locked after beam weights have been set to the required weights.

Asphaltic cement and stone-dust shall each be weighed by means of dial scales having a capacity not more than three times the weight of the material to be weighed. Pointers shall be set and maintained at zero with scale ready for weighing.

All scales shall meet the requirements as to accuracy and the tolerances provided by the rules and regulations of the California State Department of Weights and Measures, and shall be approved by the engineer and under his control.

The hot aggregate and cold stone-dust or other fine material, properly proportioned by weight, shall be thoroughly mixed together in a pug-mill mixer, the paddles of which rotate at a speed of from seventy to ninety revolutions per minute. Asphaltic cement heated to a temperature of between 250° and 325° F. shall be added during the mixing, and the operation continued until a thoroughly homogeneous mixture is obtained.

The amount of asphaltic cement to be added, and the time at which it shall be introduced into the mixture, shall be fixed by the engineer. The total time of mixing a batch shall begin with the finish of dumping of asphaltic cement into the mixer and end when the mixer is dumped. The time of mix shall not be less than sixty seconds, but shall be continued until a homogeneous mix of unchanging appearance is secured.

The mixer-paddles shall be of the number and type approved by the engineer. The mixer-platform shall be of ample size to provide safe and convenient access to the mixer and other equipment.

Placing.—The mixture as above prepared shall be brought to the work in suitable wagons or trucks. Tarpaulins shall be provided and used upon all loads unless other methods of covering the mixture during hauling are approved by the engineer. Mixtures shall leave the plant at a temperature between 260° and 320° F., and shall be spread upon the highway at a temperature of not less than 250° F. It shall be dumped at such a distance from the mixture previously laid that all of the mixture must be turned and distributed by means of shovels or forks to the place at which it is to be laid. Should the contractor so elect, however, the mixture may be distributed from the trucks, if suitable equipment is provided to distribute the load at a carefully evened thickness throughout the entire length which a truck-load should cover, and also equipment must be provided for breaking up any compressed masses of mixture as they leave the truck.

The mixture shall be spread to such a thickness by means of rakes that after receiving its compression it shall have the thickness called for in the plans and specifications.

Rolling.—After the asphalt concrete has been uniformly spread as above specified the pavement shall be rolled with two steam or gasoline rollers, neither of which shall weigh less than 8 tons, and one of which shall be a standard three-wheeled roller weighing not less than 10 tons. The rolling shall continue until all possible compression has been obtained and the surface is even and true to cross-section. Where more than 2,500 square yards of pavement are laid as an average day's run a tandem roller weighing not less than 5 tons shall be provided for rolling the seal coat. Rolling shall be continued until the compressed pavement has a specific gravity of not less than 88 per cent. of the specific gravity of the stone.

All rolling shall be done with the temperature of the mixture such that the sum of the sun temperature plus the temperature of the mixture is between 300° and 325° F.

All places inaccessible to the roller must be tamped with a hot iron tamper.

The resulting pavement must show an even and smooth surface with rock uniformly distributed, true to grade and cross-section, and free from elevations or depressions. When a straight-edge 15 ft. long is laid on the rolled mixture or finished surface parallel with the line of the highway, the surface shall in no place vary from the lower edge of the straight-edge more than $\frac{1}{4}$ in.

No traffic shall be allowed on the pavement until it is thoroughly cooled and set.

No asphalt concrete shall be laid in rainy weather, or when the base is wet from rain or any other cause.

Wearing-course.

Description.—Upon the base course prepared as hereinbefore specified shall be laid the asphalt-concrete surface, composed of broken stone, sand, and stone-dust combined in a dry mixture, to which shall be added the asphaltic cement, the whole mixed together as hereinafter specified.

The materials composing the dry mix shall be combined in such proportions that the percentage composition by weight shall be within the following limits when tested with laboratory screens of the sizes specified:—

Passing 200-mesh screen—between 5 and 7 per cent.
Passing 80-mesh screen—between 12 and 20 per cent.
Passing 40-mesh screen—between 20 and 30 per cent.
Passing 10-mesh screen—between 30 and 40 per cent.
Passing screen having $\frac{1}{4}$ in. square openings—between 50 and 60 per cent.
Passing screen having $\frac{1}{2}$ in. round openings—between 70 and 80 per cent.
Passing screen having $1\frac{1}{4}$ in. round openings—between 90 and 100 per cent.
To the above shall be added asphaltic cement—5 to 8 per cent.

The aggregate of materials passing the 1¼ in. screen and retained on a 10-mesh screen shall not exceed 70 per cent. by weight of the dry mixture. The aggregate of materials passing the 10-mesh screen shall not exceed 40 per cent. by weight of the dry mixture. Stone-dust passing the 200-mesh screen shall constitute between 2 and 5 per cent. of the dry mixture.

Sand passing the 10-mesh screen shall conform to the following proportions by weight:—

Passing 200-mesh screen—between 2 and 6 per cent.
Passing 80-mesh screen—between 24 and 48 per cent.
Passing 40-mesh screen—between 60 and 80 per cent.
Passing 10-mesh screen—100 per cent.

The materials of the complete dry mixture, including the addition of stone-dust, which will pass a 10-mesh screen shall conform to the following proportions by weight:—

Passing 200-mesh screen—between 10 and 18 per cent.
Passing 80-mesh screen—between 30 and 50 per cent.
Passing 40-mesh screen—between 60 and 80 per cent.
Passing 10-mesh screen—100 per cent.

The exact proportions within the above limits shall be so regulated, under the direction of the engineer, as to produce a dense mixture with minimum voids, and with the voids filled with bituminous material.

The materials, the method of weighing and mixing, and the placing and rolling of the surface mixture, shall conform to the requirements heretofore specified for asphalt-concrete base.

Seal Coat.—As soon as possible after the rolling of the surface mixture is finished, and while the surface is still fresh and clean, a seal coat of asphaltic cement of proper consistency to be flexible when cold shall be spread over the surface. It shall be applied at a temperature of from 200° to 350° F. and evenly spread with rubber sqeegees or mops. Only a sufficient coat shall be spread to flush the surface voids without leaving an excess. There shall be spread over the asphaltic-cement flush coat a quantity of stone screenings in an amount equal to not less than 20 lb. nor more than 25 lb. per square yard of surface covered. The stone screenings shall be broken to size such that all will pass a ⅜-in.-mesh screen and 75 per cent. of which shall be retained on a 10-mesh screen, and shall be spread either from a spreading-cart or by sweeping with brooms. The time at which the screenings shall be spread and the manner of spreading shall be within the control of the engineer.

ENCLOSURE C.—SPECIFICATION FOR PORTLAND CEMENT CONCRETE PAVEMENT.

Description.—Before placing side forms, the earth beneath them shall be excavated to the proper grade, and shall be hard and compact. Side forms shall have full bearing upon the earth throughout their length.

Side forms of timber or steel shall be placed with exactness to the required grade and alignment of the edge of the finished pavement, and be so supported during the entire operation of placing, tamping, and finishing the pavement that they will not at any time deviate laterally nor at any time deviate vertically more than ¼ in. from a straight-edge 10 ft. in length.

Timber side forms shall be No. 1 common Oregon pine, and straight. They shall not be less than 16 ft. long, not less than 2½ in. thick, and their depth shall be at least 1 in. more than the specified depth of the edge of the pavement. They shall have square top edges, square butt joints, and shall not contain enough knots or other imperfections to impair their strength. They shall have no wane on the edge to be placed uppermost.

Timber side forms shall rest upon 2 in. by 3 in. stakes, spaced not greater than 4 ft. apart, driven with their tops to the line and grade for the bottom of the side form. Stakes for nailing on the outside shall be placed 4 ft. apart at the intermediate points.

Timber side forms shall be secured by side stakes not less than 3 in. in width, 1½ in. in thickness, and not less than 18 in. in length. The length of stakes shall be increased when the character of the soil will not give sufficient bearing to an 18 in. stake. Side forms shall be staked at intervals not greater than 4 ft., and the tops of the stakes shall be 1 in. below the top edge of the side form. Side forms shall be spliced with a section of timber 2 ft. in length, 1 in. thick, and 6 in. wide, which shall be nailed lengthwise, lapping the joints.

Steel side forms for this work shall be straight, free from warp, of approved section, and shall have a flat surface on top of not less than 1¾ in.

When side forms are used more than once, only straight forms shall be used, and all warped forms and split-timber forms shall be discarded.

Before being placed, all forms shall be thoroughly cleaned.

Maintenance.—If material is dumped upon the subgrade it shall be at least 6 in. from the forms. Side forms must be trued up and maintained to the required line and grade in advance of placing concrete for a distance of one day's run of the mixer, and the contractor shall provide expert side-form men for this purpose. When side forms do not conform to the correct line and grade, or have become loose, this shall always be considered sufficient cause to stop the work, until the fault is corrected.

Removing.—Side forms shall not be removed until at least twenty-four hours after placing the pavement, and in all cases they shall remain in place until the edge of the pavement no longer requires the protection of the forms.

The contractor shall provide sufficient forms so that there shall be no delay in the placing of the pavement due to lack of forms.

Basis of Payment.—The cost of all material and the furnishing of all labour, tools, implements, equipment, and supplies, and the doing of all work incidental to placing the side forms, shall be considered as included in the price paid for pavement, and no additional allowance will be made therefor.

Water-supply.

Description.—Before placing surfacing or paving the contractor must develop a good and sufficient supply of water, and have it available along the line of his work in a pipe-line. The supply should be adequate to supply sufficient water for all purposes for which water is needed, including the sprinkling or flooding of the earth grade, for use in making subgrade, for sprinkling surfacing, for use in mixing concrete, and for use in watering the checks used to cure concrete pavement, which shall be kept flooded for two weeks after they are built.

Pipe-line.—In constructing concrete pavement where a mixer is used the capacity of which is four sacks of cement or over per batch, it is recommended that the pipe supplying water to the mixer have the following dimensions: 60 per cent. of the line have a minimum diameter of 3 in., this part of the line connecting with the pump or source of the water-supply; the remaining 40 per cent. of the line have a minimum diameter of 2 in. A pipe-line having a minimum diameter of less than 2 in. will not be considered as satisfactory or as complying with the intent of these specifications.

Faucets and other connections shall be provided at suitable intervals.

Force-pumps shall be installed where necessary in order to provide ample pressure of water at all points along the line.

A deficiency of water-supply will be considered at any and all times a sufficient cause for the delay or shutting down of the concrete mixer. In the case of a deficiency of water-supply the water available shall be devoted to curing the concrete already placed.

Placing Concrete Pavement.

Wetting Subgrade.—Immediately before placing the concrete, the earth subgrade and the side forms shall be thoroughly watered by a hose with a spray nozzle to the extent that the subgrade will not absorb moisture from the concrete that is placed thereon. There shall be no pools on the subgrade caused by using too much water.

Nail Templet.—The contractor shall use a nail templet behind the mixer and in front of the placing of concrete, and all high portions of the subgrade shall be made to conform to it. The filling in of low spots in the subgrade with loose material will not be permitted.

Placing.—Upon the subgrade as hereinbefore specified, and while it is thoroughly damp and firm, there shall be placed a concrete pavement of the thickness, width, and cross-section shown on the plans. Concrete for pavement shall be Class A concrete, consisting of the ingredients and mixed as provided in these specifications under the heading "Portland Cement Concrete." The concrete shall be deposited to the required depth for the entire width between headers in successive batches, and in a continuous operation.

Unsatisfactory Concrete.—All concrete shall be used while fresh and before it has taken an initial set. The retempering with additional water of any concrete that has partially hardened will not be permitted. Any batch showing improper proportions of materials or a surplus or deficiency of water, and which does not have the proper consistency when it comes from the mixer, shall not be used in the pavement.

Cross-header.—Whenever necessary to stop the mixer the work shall be finished square across the pavement by use of a special header 4 in. in width conforming to the shape of the pavement. This header shall be set $\frac{1}{2}$ in. below the surface of the pavement, in order to ensure the construction of a smooth-riding joint.

Protecting Concrete Pavement.—In all work done under this contract the contractor shall adequately protect the surface of the concrete pavement against all damage and markings both from foot and other traffic.

At all places where it is necessary to maintain public or private crossings over the pavement the contractor shall, at his own expense, provide and maintain bridges or other devices such as will prevent the damage or marking of the concrete pavement.

Finishing Concrete Pavement.

Tamping.—The tamping and finishing of the concrete pavement shall be accomplished by the use of an approved automatic tamping and finishing machine, operated by a man experienced in the handling of the particular make of machine in use.

The operation of tamping shall produce a satisfactory and high-grade quality of concrete, with the surface of the pavement smooth and uniform, true to grade and cross-section, and free from all hollows and inequalities.

During the process of tamping and finishing concrete, if any yielding takes place in the header-boards they shall be immediately stiffened by additional stakes until they stand the weight of the tamper without yielding. After the concrete has been struck off and tamped it shall not be disturbed by walking upon it or by any other cause.

Grades over 5 per Cent.—On grades in excess of 5 per cent. a light strike-board shall follow from 25 ft. to 50 ft. back of the heavy strike-board or tamper, and shall be used in the same way, so as to remove waves caused by the flow of the concrete.

Testing Templet.—The templet and tamper boards shall at frequent intervals of time be tested for shape. In making these tests the templet and tamper boards shall be placed in the same relative position that they occupy when in use, and in no case shall they be tested when turned upside down.

In case they deviate from the required crown they shall be immediately corrected. If the proper correction cannot be made they shall be discarded and new ones placed in service by the contractor.

Rolling.—After the concrete is tamped as above specified it shall be rolled three times with intervals of from five to fifteen minutes between rollings. The roller shall be provided by the contractor, and shall be a hollow cylinder of smooth iron, not less than 6 ft. long, and shall be from 9 in. to 12 in. in diameter, and weigh not less than 1 lb. per lineal inch.

The roller shall be used transversely to roll off the excess water which comes to the surface of the concrete, and shall be used from 10 ft. to 20 ft. behind the newly placed concrete. The roller shall be moved forward one-half its length each time across.

Finishing.—After rolling with the hand-roller has been completed as specified, a straight-edge templet not less than 16 ft. nor more than 18 ft. in length, with a trowelling or smoothing surface not less than 8 in. nor more than 10 in. in width, shall be used with its length parallel to the centre-line of the pavement, and operated from bridges with a combined longitudinal and transverse motion, planing off the high places and filling in the depressions.

Final Finishing.—The surface of the concrete shall be finally finished smooth and true to grade with a canvas belt or trowel, as the engineer may direct.

Finishing Edge of Pavement.—All outside edges of the pavement shall be rounded to $\frac{1}{2}$ in. radius.

Testing Surface.—When a straight-edge 10 ft. long is laid on the finished surface of the roadway and parallel with the line of the road, the surface shall in no place vary more than $\frac{1}{4}$ in. from the lower edge of the straight-edge.

Cracks and Hair-checks. — In case fine cracks or hair-checks appear in newly placed concrete before it is thoroughly set, immediate steps shall be taken by the contractor to remedy this condition. Pavement which shows serious checking shall, if required by the engineer, be removed by the contractor and replaced at his expense.

Curing Concrete Pavement.

Curing.—Fresh concrete shall be covered with heavy burlap laid directly on the pavement. This burlap covering shall, as soon as placed, be sprinkled with water by means of an adjustable garden-hose nozzle, so adjusted that it will spray, and it shall be kept wet until it is removed.

The burlap may be made up in mats approximately 12 ft. in width and 4 ft. longer than the specified width of the pavement to be built, and placed by hand; or it may be made up in mats 50 ft. in length and 2 ft. wider than the specified width of the pavement, and wound on spools supported on wheels running on the shoulders.

The contractor shall provide with each mixer on the work sufficient burlap to cover the maximum amount of pavement laid in one day's run. This burlap shall be used exclusively for covering pavement, and shall be replaced by new burlap when ordered by the engineer.

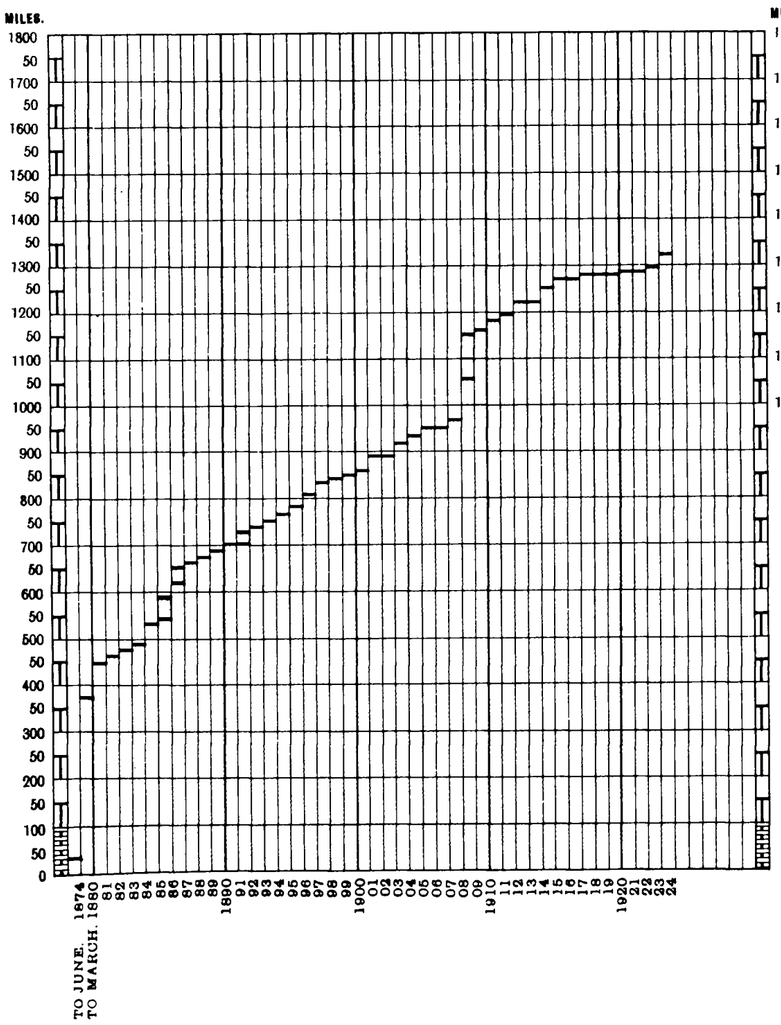
Earth Dykes.—After the concrete pavement has set sufficiently so that the earth will not become incorporated in the surface of the concrete the burlap shall be removed, earth dykes shall be constructed along each side of the pavement, and across the pavement at intervals not greater than 25 ft. In placing earth no teams or wheelbarrows shall be allowed on the concrete. The earth dykes shall be built sufficiently high so as to hold at least 2 in. of water over the crown of the pavement. Earth for dykes shall be taken from outside the limits of the shoulders. These dykes shall be flooded with water immediately after they are built, and shall be kept flooded for a period of fourteen days. The water shall then be allowed to evaporate.

Earth Blanket.—Where it is not feasible to flood the pavement for curing by means of earth dykes on account of grades or soil conditions, a blanket of earth or sand, 2 in. or more in thickness, shall be placed on the concrete, and kept thoroughly wet for a period of fourteen days. After remaining in place for fourteen days the earth or other covering may be removed.

By Authority: W. A. G. Skinner, Government Printer, Wellington.—1924.

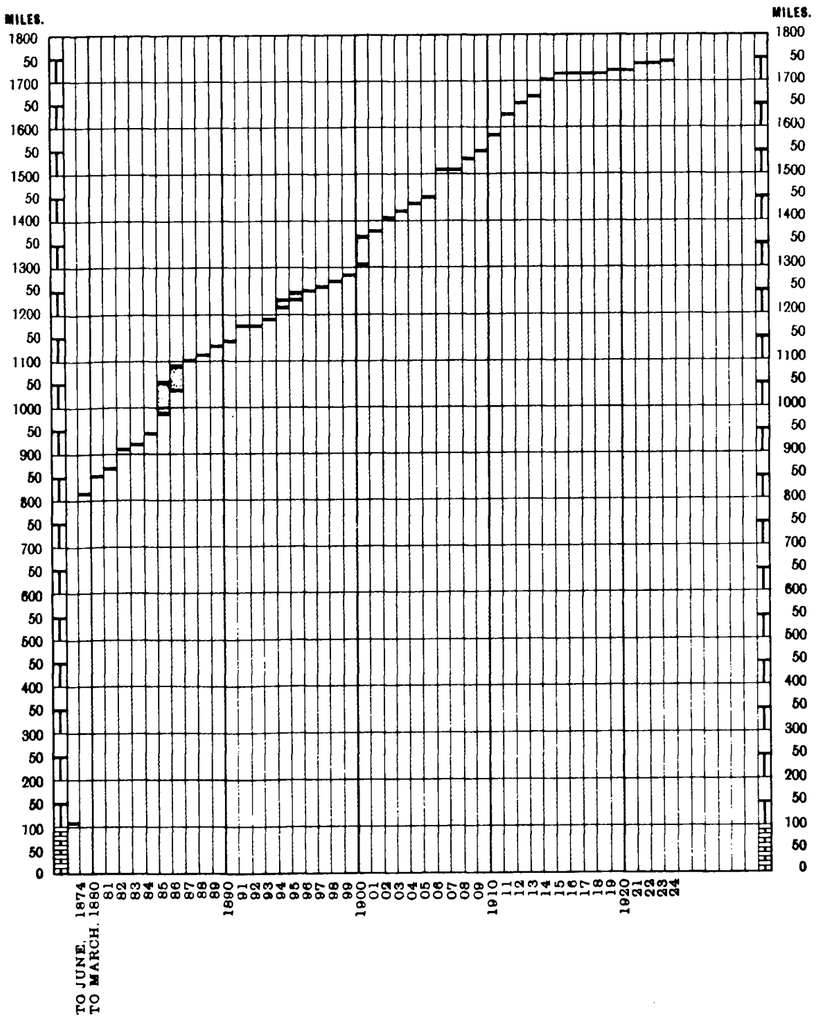
NUMBER OF MILES OPEN OF GOVERNMENT LINES.

NORTH ISLAND.



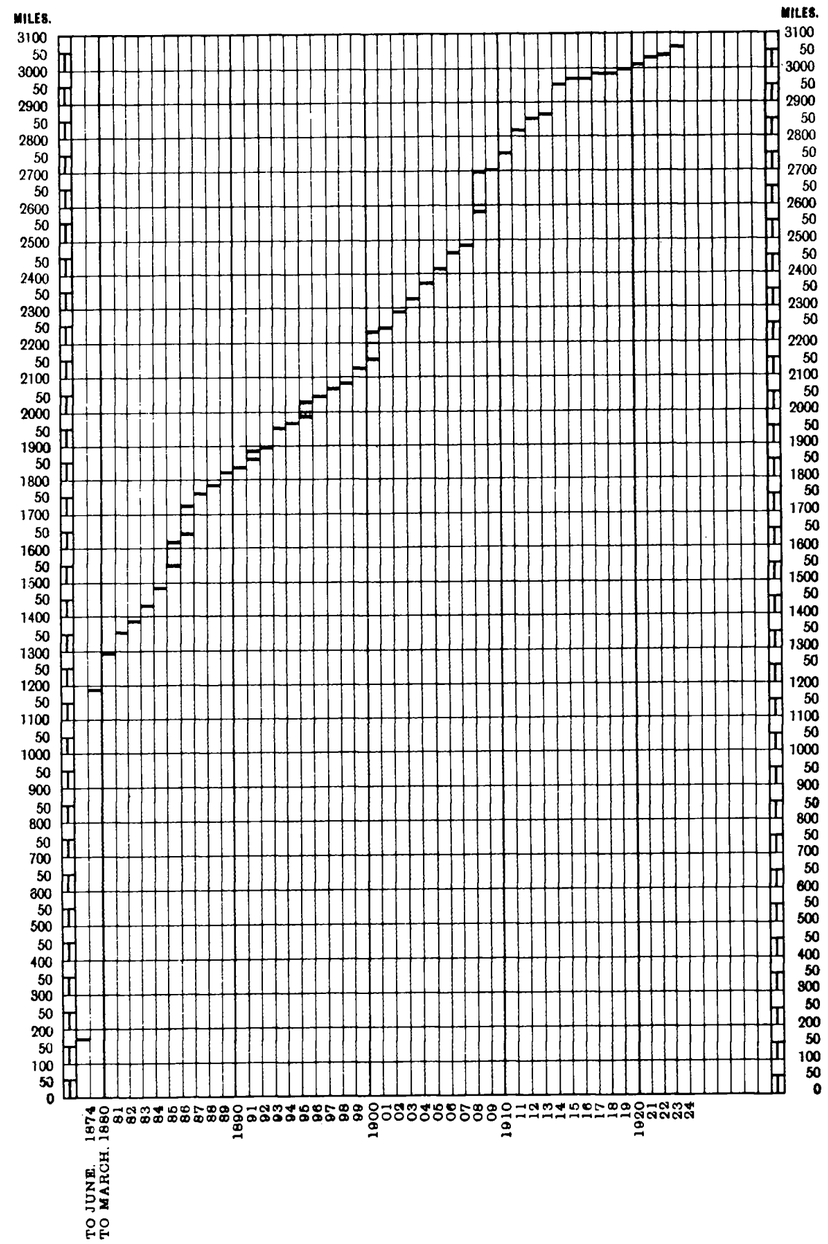
NUMBER OF MILES OPEN OF GOVERNMENT LINES.

SOUTH ISLAND.



NUMBER OF MILES OPEN OF GOVERNMENT LINES.

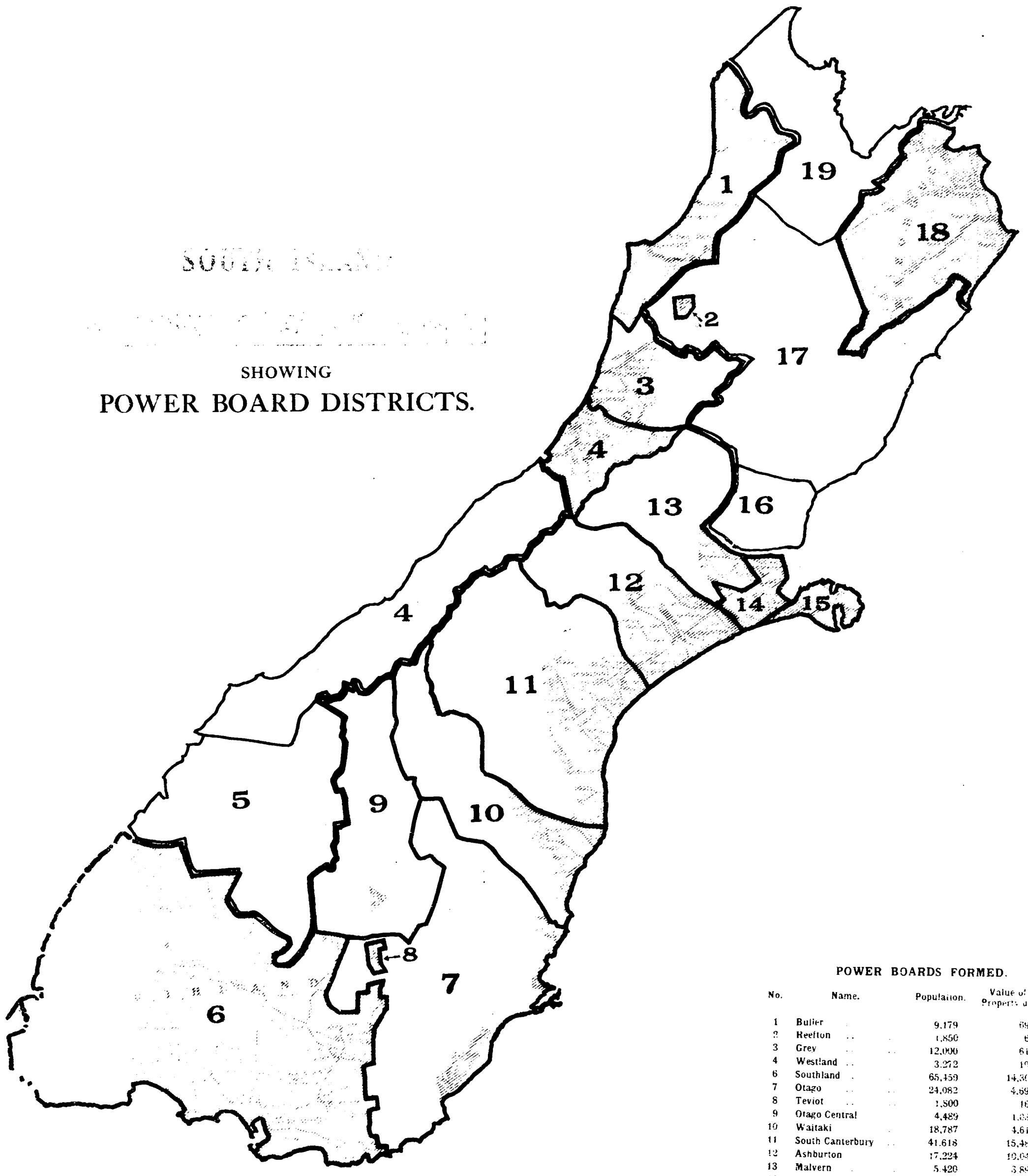
NORTH AND SOUTH ISLANDS COMBINED.



Private railways acquired by the Government shown thus: ▭

SHOWING

POWER BOARD DISTRICTS.



POWER BOARDS FORMED.

No.	Name.	Population.	Value of Rateable Property unimproved.
1	Buller	9,179	696,574
2	Reefton	1,850	64,476
3	Grey	12,000	613,694
4	Westland	3,272	196,268
6	Southland	65,459	14,301,465
7	Otago	24,082	4,695,448
8	Teviot	1,800	169,137
9	Otago Central	4,489	1,834,924
10	Waitaki	18,787	4,613,738
11	South Canterbury	41,618	15,483,654
12	Ashburton	17,224	10,047,044
13	Malvern	5,420	3,891,668
14	Springs, Ellesmere	16,822	6,566,696
15	Bank's Peninsula	3,935	5,086,935
18	Marlborough	13,637	3,901,309

POWER BOARDS PROPOSED.

4	Westland outer area	17	Waimea.
5	Queenstown.	19	Nelson
16	Rangiora.		

Inner areas shown red.

NORTH ISLAND

NEW ZEALAND

SHOWING

POWER BOARD DISTRICTS.

Scale: 35 miles to an inch.

Reference

Cities	thus	AUCKLAND
Provincial Centres	..	O NAPIER
Boroughs	..	O FEILDING
Town Districts	..	O MANAIA
Small Centres	..	o Tokomaru
Railways	..	
Coach Routes	..	
Boundaries of Land Districts	..	

POWER BOARDS FORMED.

No.	Name.	Population.	Value of Rateable Property unimproved.
3	Hobson	7,017	1,389,467
5	Kaipara	1,600	327,635
6	Auckland	145,870	42,469,650
9	Wairere	2,500	872,434
10	Waitomo	..	..
12	Taranaki	22,190	5,974,732
13	Opunake	3,244	916,111
15	Wanganui-Rangitikei	42,014	7,976,750
16	Manawatu-Oroua ..	38,500	13,955,493
17	Horowhenua ..	11,795	3,403,255
18	Hutt Valley ..	22,422	2,656,299
19	Wairarapa	19,252	9 370,503
20	Tararua	10,266	4,059,450
21	Dannevirke ..	12,061	4,666,713
22	Central Hawke's Bay	8,980	6,653,485
25	Wairoa	4,366	2,660,292
26	Poverty Bay ..	23,320	4,391,344
28	Tauranga	7,762	1,282,100
29	Thames	30,475	7,550,000
30	Te Awamutu ..	8,500	1,668,500
31	Cambridge	6,000	1,841,209
32	Central	11,000	3,958,494

POWER BOARDS PROPOSED.

1	Whangaroa.	14	Waimarino.
2	Whangarei.	23	Hawke's Bay.
4	Rodney.	29	East Taupo.
7	Franklin.	26	Poverty Bay (outer area).
8	Waikato.	27	Bay of Plenty.
11	Taumarunui.	29	Thames.

Inner areas shown red.

TASMAN SEA

SOUTH PACIFIC OCEAN

Bay of Plenty

Hawke Bay

North Taranaki Bight

South Taranaki Bight

Tasman Bay

Golden Bay

Karamea Bight

Cloudy Bay

Mahia Peninsula

South Latitude

SOUTH ISLAND

Three Kings Is

North Cape

Cavalli Is

Poor Knights Is

Little Barrier I

Great Barrier I

Kawau I

Hauraki Gulf

Waiheke I

Mercury Bay

Mayor I

White I

Moko Hinau

Gannet I

Portland I

D'Urville I

Stephen I

Kapiti I

Mana I

Cook Strait

NEW PLYMOUTH

WHANGANUI

PALMERSTON NORTH

WELLINGTON

NELSON

BLENHEIM

GISBORNE

NAPIER

HASTINGS

ROTORUA

TAUMARUNUI

WAITARA

INGLEWOOD

STRATFORD

HAWERA

OPUNAKE

PATEA

WAVERLEY

CASTLECLIFF

MANAIA

OKAIHAU

KAWHIA

AOTEA

WHAINGAROA

RAGLAN

HUNTLY

PUKEKOHE

PAPAKURA

PAPAMOA

TE KAHA

OPOTIKI

WHAKATANE

TE TEKO

TE WHAIKO

TAUPO

LAKE TAUPO

TOKOMARU BAY

TOLAGA BAY

PORT AWANUI

OPEN BAY

WAIPIRO

BUCKLEY

GABLE END FORELAND

POVERTY BAY

TUAHINE PT

TABLE CAPE

CASTLE POINT

MASTERTON

CARTERTON

GREYTOWN

PETONE

HUTT

PORIRUA

PAEKAKARIKI

OTAKI

FOXTON

FEILDING

HUNTERVILLE

MARTON

HAWERA

WAVERLEY

PATEA

WANGANUI

RANGITIKEI

MANAWATU

HOROWHENUA

WAIRARAPA

TARARUA

DANNEVIRKE

CENTRAL HAWKE'S BAY

WAIROA

WAIMARINO

WAIRERE

WAITOMO

TARANAKI

OPUNAKE

WANGANUI-RANGITIKEI

MANAWATU-OROUA

HOROWHENUA

HUTT VALLEY

WAIRARAPA

TARARUA

DANNEVIRKE

CENTRAL HAWKE'S BAY

WAIROA

POVERTY BAY

TAURANGA

THAMES

TE AWAMUTU

CAMBRIDGE

CENTRAL

WHANGAROA

WHANGAREI

RODNEY

FRANKLIN

WAIKATO

TAUMARUNUI

KAIPARA

AUCKLAND

HOBSON

WAIRERE

WAITOMO

TARANAKI

OPUNAKE

WANGANUI-RANGITIKEI

MANAWATU-OROUA

HOROWHENUA

HUTT VALLEY

WAIRARAPA

TARARUA

DANNEVIRKE

CENTRAL HAWKE'S BAY

WAIROA

POVERTY BAY

TAURANGA

THAMES

TE AWAMUTU

CAMBRIDGE

CENTRAL

WHANGAROA

WHANGAREI

RODNEY

FRANKLIN

WAIKATO

TAUMARUNUI

KAIPARA

AUCKLAND

HOBSON

WAIMARINO

HAWKE'S BAY

EAST TAUPO

POVERTY BAY (OUTER AREA)

BAY OF PLENTY

THAMES

Bream Head

Bream Bay

Bream Tail

Kaipara Har.

Manukau Har.

Whaingaroa Har.

Aotea Har.

Kawhia Har.

Raglan

Albatross Pt

Reef Pt

Three Kings Is

Houhora Pt

C. Reinga

C. Maria Van Diemen

Rangaunu B.

C. Karikari

Doubtless Bay

Whangaroa B.

Cavalli Is

Kaeo

Whangaruru B.

Bay of Islands

C. Brett

Poor Knights Is

Whangarei Har.

Mangonui

Kerikeri

Opua

Paihia

Russell

Waitangi

Ahipara B.

Ohaeawai

Kaikohe

Okaihau

Kawakawa

Moerewa

Kaitaia

Awanui

Ahipara

Oruaiti

Herekino

Whangape

Hokianga Har.

Rawene

Omapere

Opononi

Waimamaku

Waipoua

Kaihu

Dargaville

Matakohe

Helensville

Kumeu

Waitakere

Henderson

Avondale

Onehunga

Otahuhu

Papakura

Pukekohe

Tuakau

Port Waikato

Mercer

Huntly

Ngaruawahia

Taupiri

Hamilton

Cambridge

Te Awamutu

Kihikihi

Otorohanga

Kawhia

Waitomo

Te Kuiti

Piopio

Awakino

Mokau

Urenui

Oakura

Omata

Hurworth

Inglewood

Egmont

Stratford

Eltham

Whangamomona

Tangarakau

Tahora

Whangamomona

Patea

Waverley

Hawera

Normanby

Opunake

Pihama

Manaia

Kaponga

Cardiff

Eltham

Hawera

Normanby

Waitotara

Castlecliff

Wanganui

Mosston

Aramoho

Kai Iwi

Mowhanau

Turakina

Rangitikei

Marton

Bulls

Sandon

Feilding

Kimbolton

Halcombe

Hunterville

Taihape

Mangaweka

Utiku

Bunnythorpe

Palmerston North

Ashhurst

Woodville

Pahiatua

Eketahuna

Mangamahoe

Manawatu

Foxton

Shannon

Levin

Otaki

Waikanae

Paekakariki

Pukerua

Porirua

Tawa

Johnsonville

Ngauranga

Petone

Lower Hutt

Upper Hutt

Featherston

Greytown

Carterton

Masterton

Castlepoint

Whakatakiki

Flat Point

Cape Palliser

Turakirae Head

Pencarrow

Wellington

Miramar

Seatoun

Eastbourne

Days Bay

Wainui

Pinehaven

Kaitoke

Rimutaka

Tauherenikau

Waingawa

Opaki

Kaiparoro

Tuhitarata

Tinui

Akitio

Pongaroa

Waipawa

Waipukurau

Takapau

Porangahau

Wimbledon

Waipukurau

Waipawa

Otane

Waipukurau

Waipawa

Otane

Waipukurau

Waipawa

Otane

PUBLIC WORKS
Engineer's Department
NEW ZEALAND.

F. W. FURKERT, M.INST.C.E
ENGINEER-IN-CHIEF

PUBLIC WORKS MAP
SHOWING THE RAILWAYS
SOUTH ISLAND
OF
NEW ZEALAND
1924

— Scale of Miles —

10 0 10 20 30 40 50 60 70 80

— REFERENCE —

GOVERNMENT RAILWAYS.

Opened - - ———
Under construction - - - - - -
Proposed - - ———
Explored - - - - - -

PRIVATE RAILWAYS.

Opened - - ———

168° 169° 170° 171° 172° 173° 174°

40° 41° 42° 43° 44° 45° 46° 47° 48°

TASMAN SEA

PACIFIC OCEAN

SOUTH

C. Farewell
GOLDEN BAY
D'Urville Id
French Pass
COOK STRAIT
WELLINGTON
TASMAN BAY
Karamea R.
KARAMEA BIGHT
Mokikinui R.
C. Foulwind
Buller River
C. Campbell
Clarence R.
Kaikoura Peninsula
Conway R.
Waiau-ua R.
Hurunui R.
Ashley R.
PEGASUS BAY
Waimakariri R.
Banks Peninsula
Abut Hd
Pt Elizabeth
Arahura R.
Mt Cook 12349ft
Mt Harper
Mt Sefton 10959ft
HERMITAGE 8705ft
Haast R.
JACKSON'S BAY
L. Tekapo
Pukaki L.
L. Ohau
Rakaia R.
Ashburton R.
Hinds R.
Rangitata R.
CANTERBURY BIGHT
L. Wanaka
L. Hawea
Milford Sound
Ada L.
L. Wakatipu
L. Te Anau
Manapouri L.
Monowai L.
Hauroto L.
Waitaki R.
Taieri R.
Clutha R.
Shag Point
C. Saunders
DUNEDIN
OTAGO HAR.
LYTTELTON HAR.
FOVEAUX STRAIT
SOLANDER Id
RUAPUKE Id
The Bluff
Port William
MASON BAY
STEWART Id
East Head
S.W. Cape
Port Pegasus

DISTANCES BY RAILWAY BETWEEN PRINCIPAL PLACES.

	Miles.	Miles.
Bluff to Invercargill	17	
Invercargill to Lumsden	50	
Lumsden to Kingston	37	
Bluff to Kingston		**104**
Invercargill to Gore	39	
Gore to Balclutha	47	
Balclutha to Milton	17	
Milton to Dunedin	36	
Invercargill to Dunedin		**139**
Invercargill to Tuatapere		56
Invercargill to Tokanui		34
Balclutha to Tahakopa		43
Dunedin to Clyde		143
Dunedin to Port Chalmers		8
Gore to Lumsden		37
Gore to Waikaka		16
Waipahi to Edievale		26
Milton to Big Hill		31
Dunedin to Oamaru	78	
Oamaru to Timaru	53	
Timaru to Ashburton	47	
Ashburton to Rolleston	38	
Rolleston to Christchurch	14	
Dunedin to Christchurch		**230**
Christchurch to Lyttelton		7
Oamaru to Hakataramea		43
Timaru to Fairlie Creek		39
Christchurch to Arthur's Pass ..		87
Christchurch to Little River		36
Christchurch to Waiau		82
Christchurch to Mina		76
Picton to Wharanui		56
Nelson to Glenhope		59
Greymouth to Reefton		47
Greymouth to Ross		39
Greymouth to Otira		51
Westport to Mokihinui Colliery ..		31

BY AUTHORITY W. A. G. SKINNER GOVERNMENT PRINTER WELLINGTON

PUBLIC WORKS
Engineer's Department
NEW ZEALAND.

F. W. FURKERT, M.INST.C.E.
ENGINEER-IN-CHIEF.

PUBLIC WORKS MAP
SHOWING THE RAILWAYS
NORTH ISLAND
OF
NEW ZEALAND
1924

— Scale of Miles —

10 0 10 20 30 40 50 60 70 80

— REFERENCE —

GOVERNMENT RAILWAYS.

Opened - - ———————
Under construction - - - - - - - - -
Proposed - - ———————
Explored - - - - - - - - -

PRIVATE RAILWAYS.

Opened - - ———————

DISTANCES BY RAILWAY BETWEEN PRINCIPAL PLACES.

	Miles.	Miles.
Wellington to Palmerston North	87	
Palmerston North to Wanganui (Aramoho Junction)	60	
Aramoho to New Plymouth	104	
Wellington to New Plymouth		251
Wellington to Palmerston North	87	
Palmerston North to Woodville	18	
Woodville to Napier (Spit)	97	
Wellington to Napier via Manawatu .. .		202
Wellington to Woodville	115	
Woodville to Napier (Spit)	97	
Wellington to Napier via Wairarapa .. .		213
Auckland to Onehunga		8
Auckland to Hamilton (Frankton Junction) ..	85	
Hamilton to Ongarue	75	
Ongarue to Taumarunui	15	
Taumarunui to Ohakune	50	
Ohakune to Waiouru	17	
Waiouru to Marton	88	
Marton to Wellington	116	
Auckland to Wellington		426
Auckland to Hamilton (Frankton Junction) ..	85	
Hamilton to Te Aroha	38	
Te Aroha to Thames	23	
Auckland to Thames		146
Auckland to Rotorua		171
Auckland to Rangaunu		25
Rangaunu to Taumarunui		73
Whangarei to Kamaiwera		45
Ohaiwa to Hukaheru		69
Thames to Waihi		32