1928.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(ANNUAL REPORT OF THE).

Laid on the Table of the House of Representatives by Leave.

INTRODUCTION.

THE Department of Scientific and Industrial Research was established as the result of the growing realization that the future prosperity of the industries of the Dominion depended more than ever upon the assistance which scientific guidance could render. This realization led the Government in 1926 to seek a practical means for giving effect to this growing need. A number of proposals for dealing with the question had been put forward from time to time, but none was of such a comprehensive kind as to warrant its adoption. The Government accordingly decided to secure an outside opinion, and in 1926 invited Sir Frank Heath, of the Department of Scientific and Industrial Research of Great Britain, to visit the Dominion, and, with his experience of scientific organization already gained in Great Britain, to furnish a report and elaborate a scheme to meet the requirements of New Zealand. Accordingly Sir Frank Heath visited the Dominion and, after inspecting its industries and scientific facilities, furnished recommendations for an organized scheme of scientific and industrial research. These recommendations were given statutory effect by the Scientific and Industrial Research Act of 1926, which established a Council and Department of State charged with the duty of advising the Government upon matters of research into all phases of industry, and conferred executive powers for the promotion and pursuit of industrial investigations.

Upon the establishment of the Council in 1926 steps were taken to survey both the scientific needs of the industries of the Dominion and the facilities available for meeting these needs. The primary industries and those other industries closely connected therewith called for first attention, and accordingly investigations were established in connection with dairying, noxious weeds, mineral content of pastures, wheat, meat, seed and plant, and cold-storage problems.

The policy adopted has been that of co-operation in research, already proved as being very successful in Great Britain. This policy permits of the closest association and contact of representatives of industry with research workers and State Departments in the control and rewards of the investigations. Co-operation on an Imperial scale has also received attention, and has been made possible through the assistance rendered by the Empire Marketing Board by grants made to assist in a number of very important investigations.

The Department has sought to make use of such staff, accommodation, and scientific facilities as have already been established in the Dominion for the prosecution of research work, new establishments and organizations being set up only in those cases where such provision was absent. In this way care has been taken to avoid any unnecessary duplication and overlapping. The direction of the various researches has been delegated to a series of specialist committees comprised of representatives of industry, together with others from interested Departments of State and other institutions.

The provision of scientific assistance to a number of the Dominion's main industries has up to the present demanded a great deal of organization. The provision of adequate staff, funds, and facilities makes progress slow, but within the next year or so a considerable amount of actual research work will be in active progress. Nevertheless, a number of industries as yet remain without any scientific assistance, but in the course of time it is hoped that the Dominion will be provided with

a scientific service on an organized basis such as will ensure its industries having the fullest assistance towards overcoming their difficulties. By this means it is hoped to increase both the quantity and quality of the output of the industries of the Dominion, and to ensure that their future prosperity will be established upon a sound scientific basis.

The extent to which the scientific services made available to industry have been developed will be gathered from the details of the reports following.

J. G. Coates,
Minister in Charge,
Department of Scientific and Industrial Research.

Sir,— Department of Scientific and Industrial Research, Wellington.

I have the honour to submit herewith the annual report of the Department for the year ended 31st March, 1928.

I have, &c.

21st May, 1928. E. Marsden, Secretary.

The Right Hon. J. G. Coates, Minister in Charge of Scientific and Industrial Research.

REPORT.

Research Council.

The following members comprised the Council of Scientific and Industrial Research during the year:—

Mr. George Shirtcliffe, O.B.E. (Chairman), Wellington.
Professor Henry George Denham, M.A., D.Sc., Ph.D., Professor of Chemistry, Canterbury College, Christchurch.
Mr. Quentin Donald, Featherston (Deputy Chairman).
Professor John Malcolm, M.B., Ch.B., Professor of Physiology, University of Otago, Dunedin.
Mr. Theodore Rigg, M.Sc., Assistant Director, Cawthron Institute, Nelson.
Mr. Charles W. Rhodes, Manager of the New Zealand Mines Trust, Auckland.
Mr. Hugh Vickerman, D.S.O., O.B.E., M.Sc., M.Inst.C.E., Wellington.
Dr. E. Marsden (Secretary).

Leave of absence from the 1st April, 1927, to the 1st August, 1928, was granted to Mr. T. Rigg, who proceeded to the United States of America and Great Britain for a special study of the problem of mineral content of pastures investigation technique at Rowett Institute, Cambridge and Wisconsin. While abroad Mr. Rigg represented the Council of Scientific and Industrial Research at the Agricultural Research Conference, held in Great Britain, and at the Soil Science Congress, held at Washington, U.S.A.

Leave of absence was also granted to the Chairman, Mr. George Shirtcliffe, who left on a visit to Great Britain and Europe at the beginning of 1928.

During the absence abroad of the Chairman, Mr. Quentin Donald has acted as Chairman of the Council.

Meetings.

Six meetings of the Council have been held in Wellington during the year, at two-monthly intervals.

Scope of the Department.

In considering the financial cost of the Department for the year (total, £44,823) it must be remembered that the major portion of this sum, £30,606, is used in maintenance of Government scientific services. These services are as follows:—

(1) Dominion Laboratory—Director, Dr. J. S. Maclaurin, Dominion Analyst.
(2) Meteorological Office—Director, Dr. E. Kidson, Dominion Meteorologist.
(3) Geological Survey Office—Director, Dr. J. Henderson.
(4) Dominion Observatory—Dr. C. E. Adams, Dominion Astronomer and Seismologist.
(5) Stone-testing Laboratory and Petrological Advisory Service—Dr. P. Marshall.

New expenditure indicated under "Grants for research" totalled £8,562, including a special statutory grant of £3,700 to Lincoln College, although a considerable portion of the commitments for research projects does not come to charge until the financial year 1928–29.

Before enumerating and describing the work of the Department along particular lines it may be well to preface some general remarks as to its objects and policy.

The main business of the Department is to accumulate, either by assembly or direct inquiry, scientific results of a character suitable for immediate application in support of industry, and to lay sure foundations for its further development. No one who knows anything about the subject nowadays disputes the contention that organized research, broadly speaking, is a paying proposition, although there may be a considerable lag between the expenditure and its profitable return. Individual researches may, and often do, lead to no practical advantage, whereas others realize a handsome profit out of all proportion to the cost.

Only a few of the industrial concerns or organizations in New Zealand at present have the means or are willing to support capital charges of laboratories and salaries of staff adequate to ensure a profitable proportion of major commercially successful results; but even the smallest concerns can participate in the rewards of such investigation by supporting the work on a co-operative basis. In general, therefore, the policy of the Department has been to endeavour to prove to particular industries that research work is worth while, and that co-operation in this regard is a practical proposition. In the case of industries of national concern, by making grants supplementing moneys raised for this purpose, the Department has aimed to encourage such effort.

While nearly all are agreed on the general principle that scientific effort in industry is worth while, difficulties sometimes are raised. The first results from the tendency of late years for industry to lean too much on the Government, and to expect the latter to provide scientific services gratis. Apart from objections on general principles to this procedure, there would appear to be no doubt that such scientific services would be in danger of lack of direct application and would get out of touch with actual major problems. Moreover, those directly concerned would fail to appreciate them and ultimately lose all interest in the work. The outcome of this would be failure to make direct application of the results, in consequence of the absence of incentive to industrialists to "get their money's worth."

The second difficulty sometimes arises from those conservatives who, while quite prepared to admit that science has an application in every other industry, declare that scientists can scarcely appreciate or grasp sufficiently their own particular practical problems. They feel conservatively averse to any changes of plant, methods, or procedure which might result from scientific suggestions. Fortunately, during the past two years this type of objector has become somewhat uneasy, and industry generally, viewing the question with an awakening interest, is adopting a more experimental and alert attitude to new processes and possible new technical developments. The operations of modern industry, both primary and secondary, tend more and more to be based on scientific knowledge of processes, and the undoubtedly increased realization of this fact in New Zealand is one of the most hopeful auguries for future development.

The third difficulty arises from mutual distrust occurring between the firms or organizations which comprise the units of our various industries. In the past, co-operative action often has been concerned with or limited to such activities as price-fixation of both the product of industry and the wage of labourers. Co-operation has been fashioned for defence purposes, and not always has been actuated by the broader desire for the general forward development of industry. Each firm or concern is apt to consider itself in possession of knowledge of methods superior to those of its rivals, and feels that by co-operative research there is a danger of these methods being stolen and broadcasted to its own particular detriment. However, experience of co-operative research organizations elsewhere has shown that they do not lead to loss of initiative or special development by individual concerns, but, on the contrary, where successful, act as an educative force stimulating individual inquiry and experiment. There is ample room for healthy competition apart from research along lines of common necessity and interest. Moreover, in most of our industries the presence on the market of New Zealand goods of reputedly inferior quality has a far-reaching effect on the marketing of the product of the most progressive concerns. In these matters, again, evidence is not wanting of the development of a higher and broader point of view of honest endeavour to allow no petty jealousies to stand in the way of the production of a better article based on scientific standards, and the giving of better service to the community. Indeed, the units of New Zealand industries must close their ranks and assemble their scientific reserves to withstand the large-scale attack of overseas competitors, many of whom have almost unlimited resources at their disposal.

A fourth difficulty, fortunately rarely met with, is the fear of so-called "Government interference." This is the opposite point of view from the first difficulty mentioned above, and arises from the belief that the community, as represented by the Government, constantly hampers the progress of industry with a plethora of controlling regulations. Whatever justification there may be for this belief, the fact remains that the State must needs take a longer view of national industries and adopt such measures for the future permanence of industrial progress as are not possible to individual members of industry itself. Scientific assistance is one of these measures, and recollection of what was done and still is being done in Great Britain, Germany, the United States of America, Australia, Japan, and Canada should suffice to convince those who doubt the wisdom of State encouragement. The method of control of the various researches under the ægis of the Department effectively disposes of the contention of beaurocratic departmental control generally understood by the term, "Government interference."

The policy of the Department is that, as far as possible, industries should be encouraged to organize and conduct their own researches in a comprehensive way, and ultimately, to do this at their own expense. With regard to Government grants towards such researches, while public interest necessitates such control as will ensure that these grants are properly spent, it is realized that freedom and flexibility are essential conditions of fruitful research. It is the policy of the Department, based on its belief in the efficacy of scientific assistance to industry, to induce the development of a practical scientific attitude of mind among those connected with our primary and secondary industries. It is realized that this is not possible of immediate attainment, but that there is need for the Department to play the role of educator to a certain extent, to render the financial assistance necessary to place the scientific equipment of industry upon a sound basis, and to endeavour to point out the possibilities which lie ahead. There is a very real danger in any industry where scientific progress is at a standstill, for then stagnation is not far distant.

Grants that have been made to promote research are an earnest of this policy. In every instance where these have been made members of the industry itself have been entrusted with the major control

of the expenditure, the staff, and the programme of investigation proposed. The industry itself is expected to pull its weight both financially and by direct personal interest and guidance. In no instance is a programme of investigaton developed apart from the direct touch and active co-operation of those intimately concerned with the industry itself.

With regard to the laboratories and scientific services maintained wholly by the Department, these are concerned with fundamental scientific problems underlying industry, or of State administrative Departments of national rather than of sectional interest; yet it is intended that they should be of the fullest possible use (in so far as their extent permits) to industries and industrial concerns finding themselves confronted by particular scientific problems which cannot be solved by other means.

Up to the present the energies of the Department have been concerned mainly in an endeavour to induce the units of the greater primary industries of the Dominion to co-operate for the purpose of equipping themselves with thoroughly sound scientific outfits. As a result, the dairy, wheat, meat, seed and plant, flax, mineral content of pastures, cool storage, noxious-weeds control, pig, pork and bacon, wool, leather, and fuel researches and research organizations, have been established. While co-operative effort has been advocated among the various industries, separately and in turn, the wider aspect of co-operation possible between the scientists themselves who are engaged in the various spheres of activity that have arisen has not been lost sight of. It is part of the policy of the Department to develop the principle of team-work among the scientific workers who will be employed in the different spheres of industrial investigation. So wide and specialized have the various phases of science become in recent times that it is realized that association of one scientist with another for the purpose of reference and discussion of special problems is indispensable if progress is to be made. This association should be the means of ensuring that the Dominion will be provided not only with trained men for dealing with the technical problems of its various industries, but also with a combination of scientists capable of supplying mutually the deeper expert knowledge underlying fundamental problems.

The scientists under appointment for the various research associations, together with the permanent staff and University staffs, should provide such a team.

Dominion Laboratory.

The Dominion Laboratory, originally established as the Mines Department Laboratory, now carries out the analytical and chemical work required by all Government Departments except that of Agriculture. The central laboratory is at Wellington, and there are branches at Auckland, Christchurch, and Dunedin. The work is wide in scope and varied in character.

The chemical composition of many imports is required by the Customs Department, either to determine their classification for tariff purposes, or in the case of foodstuffs, to ascertain whether they comply with New Zealand standards.

Type rocks are carefully analysed for the Geological Survey, and metals determined in various ores. Mineral waters, natural gas, and oil are also analysed. At the present time work is proceeding on a large number of samples of water, gas, sulphur, and rock from Rotorua, Taupo, and White Island.

The work for the Main Highways Board has greatly increased. A "Rotarex" separator, installed during the year, has facilitated analysis of bituminous concrete. A close check is kept on tar preparations used for roading.

The work for the Mines Department comprises chiefly analysis of coal, clay, various minerals, mine-air (to check the ventilation of mines), and mine-dust (to ensure that safety provisions *re* stone-dusting of coal-mines are being carried out). Prospectors' samples are also examined, and any person finding a mineral may forward it to the laboratory for identification free of charge, provided the locality is given.

Regular and systematic analysis of foods, including milk, for the Health Department has resulted in a general improvement in recent years in the average quality of many foodstuffs sold in New Zealand. Milk-analyses are also carried out for Plunket nurses in the four centres.

Analyses of stores are carried out for the Post and Telegraph, Public Works, Railways, Stores Control, and other Departments, both to determine the relative quality of samples submitted on tender, and to check the quality of goods supplied. This work is regarded as highly important.

Regular tests of town gas for calorific value, purity, and pressure are carried out in the four centres, and will be extended shortly to some of the country towns.

A certain amount of research work is carried out by the Laboratory, some of which is preliminary to the formation of research associations, and some on minor subjects not covered by any research body.

In connection with an investigation by the Health Department of the incidence of goitre, a research on the iodine content of soil and water in the Wellington District has been undertaken and is now nearing completion.

A research on moulding-sands for foundry use has enabled some desirable physical properties to be defined and investigated, and will greatly assist in the search for suitable sands in New Zealand.

Two minor investigations now completed had reference to the gold-plating of duralumin and to the manufacture of roofing-tiles.

A considerable amount of work has been done in adapting the nitrite process of curing meat to existing practice in New Zealand meat-works. This was most successful.

Some preliminary examinations have been made of wool, wool-scouring liquors, and bacon.

The Fuel Research Association formed during the year will carry out its researches at the Wellington laboratory, a member of the staff having been seconded to the charge of the work. A Fischer retort has been installed for low-temperature carbonization.

The Dominion Analyst is continuously consulted on industrial and research matters.

The members of the staff collectively have considerable chemical knowledge covering a wide field, and this is being made available as much as possible for advice and suggestions on industrial matters under consideration by the Departments of Industries and Commerce or Scientific and Industrial Research.

Geological Survey.

Since last year's report was presented the Geological Survey has issued an areal bulletin (with maps), covering 1,021 square miles of North Taranaki, a palæontological bulletin, and a comprehensive work on the minerals of New Zealand—the result of several years' preparation.

During the twenty-two years that detailed mapping has been in progress an area of over 25,000 square miles (about a quarter of the Dominion) has been examined, and an inventory of natural resources continues steadily to be made. Though much of what is ascertained may not be immediately required for developmental purposes, stock-taking of this kind can never be conducted too early. To have facts in reserve is the best kind of national preparedness, and in the future will enable the wisest use to be made of the country's economic wealth. Even investigations that yield negative or unfavourable results, though not always popular, probably save greater expenditure in projects doomed to failure, and much waste of labour and capital.

The scope of field-work varies little from year to year, but at different periods the demand for accurate and authoritative information has varied in kind and intensity. Sometimes the examinations have been directed to our gold resources, at other times to our coal reserves, and at still other to our oil possibilities, or, again, to materials of less intrinsic value. The demand now is that more attention should be devoted to the greatest natural resource of all—the soil. Already some soil surveys have been undertaken, and a large amount of the necessary work has been done for those parts of New Zealand geologically examined in detail, seeing that the distribution of the soil types, once these have been established for any district, can be accurately and quickly shown on the published maps.

The unexpected death last November of Mr. P. G. Morgan, Director of the Geological Survey since 1911, must be recorded with regret and as a distinct loss to the Dominion. The late Mr. Morgan was a conscientious officer, whose untiring industry, wide knowledge, and ripe judgment on all matters of geological interest in New Zealand have in the past proved of great value.

Meteorological Office.

The most important function of a meteorological service is to furnish precise statistics of average climatic conditions and the variations to be expected therefrom. Such information is required for the most efficient and economic working of innumerable human industries, but most notably for agriculture and engineering. For its proper collection observations covering many years, made in satisfactory and permanent sites by qualified observers with instruments of standard pattern are needed. Owing partly to the mode of growth of the meteorological service, and partly to the difficulties associated with the development of a new country, the necessary conditions have not been fulfilled in New Zealand. No station with a satisfactory long-period record exists. The most urgent duty of the Meteorological Office is to take steps towards the remedying of this defect. Some progress has been made during the past year; the instrumental outfit is being gradually improved; observing-stations are being inspected, observers instructed, and defects of exposure corrected. With the assistance of Government Departments and Municipal Councils, a number of new climatological stations have been established under satisfactory conditions.

The usefulness of the forecast service has been greatly increased by the issue of forecasts on week-ends and holidays. The broadcasting of the forecast twice daily by the Radio Broadcasting Company has made it much more readily available to the public. Efforts to increase the accuracy of prediction have been greatly assisted by the increasing number of reports received from vessels in surrounding ocean waters. This could not have been possible without the co-operation of the shipping companies. The assistance given by the Union Steamship Company should be specially mentioned. It is anticipated that it will be possible during the coming year to inaugurate the issue of meteorological reports from a network of stations by wireless, so that mariners and others with a working-knowledge of meteorology will be able to draw charts and make their own deductions therefrom in the light of the official forecast.

During the year advice and assistance in connection with protection against frost were given to orchardists in Otago Central and Hawke's Bay.

In September last the Dominion was visited by the British Empire Airship Mission. The Meteorological Office co-operated with the mission by providing meteorological information useful for the selection of sites suitable for an airship base, and the preparation of plans for the necessary extension of the service when airships are in operation. Forecasts for aviators have been issued on numerous occasions.

The amount of information on meteorological subjects furnished on request to private individuals and Government Departments shows a marked increase. Work has been commenced on a new rain map of New Zealand, and the preparation of various other data regarding rainfall for the use of engineers is planned. It is hoped, also, that it will be possible to co-operate more closely with the Department of Agriculture and special research institutes in various researches in which meteorological conditions are of prime importance.

Petrological Laboratory.

This laboratory has for the past year been engaged upon investigations of the building-stone and gravel resources of New Zealand. While it is generally recognized that there are extensive deposits of building-stone in the Dominion, these resources have not as yet been subjected to careful scientific tests, and in consequence the absence of such knowledge has proved a handicap to their utilization by

builders and architects. As time progresses, the need for the greater utilization of stone in all construction work renders it imperative that definite scientific information regarding such matters as durability, water-absorbtive capacity, strength, and other characteristics should be available. In view of the increasing use of the Dominion's extensive gravel-supplies for roadmaking, concrete and ferro-concrete construction, more investigations of the character and behaviour of the various forms of gravel have become necessary in order to afford sound guidance to road engineers, builders, and contractors.

The behaviour of the gravel deposits which occur on great lengths of the beaches in the Dominion has also been made the subject of investigation. Particular attention has been devoted to the rate and peculiarities associated with the abrasion that proceeds, and this information will prove of considerable value in harbour-works, shore-protection, and land-reclamation schemes.

This laboratory has also carried out the testing of road-materials. Numerous samples of rock, gravel, stone, and fillers used in connection with highway-construction have been submitted to careful tests.

In addition, the Laboratory's staff has acted in a consultative capacity in furnishing reports to the Public Works Department concerning the geological features to be taken into consideration where large constructive works are proposed.

Reports of the Research Committees of the Council of Scientific and Industrial Research.

Dairy Research.

Advisory Committee: Hon. George Fowlds (Chairman), Mr. A. Morton, Mr. T. A. Winks, Mr. W. Grounds, Mr. W. Goodfellow, Mr. Q. Donald, Professor H. G. Denham, Dr. C. J. Reakes, and Mr. W. Singleton. Director of Research: Professor W. Riddet.

During the year work has been concerned mainly with securing staff, providing buildings and equipment, and making the other necessary arrangements preliminary to commencing work at the beginning of the 1928 dairy season.

Temporary buildings to accommodate the chemical and bacteriological laboratories have been erected at Palmerston North in proximity to the experimental dairy factory erected by the Massey College Council.

Dr. F. H. McDowall has been appointed to the position of Dairy Research Chemist, and Mr. H. R. Whitehead to that of Dairy Research Bacteriologist. Both officers have undergone a specialized training in their respective sciences in relation to dairying in dairy-research institutions of Great Britain, and during the past year have investigated the conditions of New Zealand dairy-produce as it arrives at its overseas destination. An officer has been appointed as Farm Dairy Assistant, and during the year has been engaged upon investigations into the daily fluctuations in milk and butterfat yield of the dairy herd at Massey College. Arrangements have been made for the scientists appointed to procure while in England the best scientific apparatus for the laboratories, in order to ensure that the most up-to-date equipment will be available when the work is in full operation. Arrangements have been made to provide the Hawera Dairy Research Laboratory, as from the beginning of July, 1928, with funds for the purpose of permitting its continuance as a research station in the Taranaki District. Similar arrangements for the promotion of research at the Hamilton laboratory of the New Zealand Co-operative Dairy Company have been made. These stations thus will be enabled to work in co-operation with the main station at Palmerston North. The large volume of records now available from the group herd-testing associations are being subjected to statistical examination in co-operation with the Census and Statistics Office with a view to ascertaining the nature of certain trends and variations occurring in the milk and butterfat production of a large number of New Zealand dairy-cows.

Investigations have also been proceeding in the direction of ascertaining the economic utilization of heat and power in dairy factories. Co-operation with the Lister Institute in investigations upon the vitamin content of New Zealand butter has been continuing at Otago University since the middle of the 1927 dairy season.

Wheat Research Institute.

Advisory Committee: Professor H. G. Denham (Chairman), Mr. James Carr, Mr. W. W. Mulholland, Mr. C. J. Talbot, Mr. C. E. Boon, Mr. F. H. Hawker, Mr. R. K. Ireland, Mr. R. J. Lyon, Mr. W. Pratt, Mr. C. H. Hewlett, Mr. J. W. Hadfield, and Mr. D. Colquhoun. Director of Research: Dr. F. W. Hilgendorf.

During the year negotiations which had been proceeding between wheat-growers, flourmillers, bakers, representatives of Lincoln College, and the Departments of Agriculture, Industries and Commerce, and Scientific and Industrial Research, were finalized, and a scheme of co-operative research launched. Owing to the complexity of the position, statutory authority empowering the collection of the necessary funds by means of levies on wheat and flour was secured in a section of the Finance Act of 1927. Regulations giving effect to this and establishing the research organization were gazetted on the 24th February, 1928, and the fully-constituted committee held its first meeting on the 9th May, 1928.

Funds for this research will be provided by means of levies secured in equal amounts from wheat-growers, flour-millers, and bakers, on the following basis: Wheat-growers, 1½d. per 50 bushels of wheat sold; millers, 1½d. per ton of flour milled; bakers, 1½d. per ton of flour purchased. On an average yield of 6,000,000 bushels of wheat, these levies are expected to yield approximately £2,000. To this sum will be added an amount from the Department of Scientific and Industrial Research on a pound-for-pound basis.

A full programme of work, involving investigation into every phase of the wheat industry, has been prepared; but first efforts will be directed towards establishing and equipping a testing laboratory in Christchurch. At the same time, provision has been made for continuance and extension of the wheat-breeding and selection work carried out at Lincoln College, for the manurial and varietal tests of the Department of Agriculture, and for crop-certification. In addition, attention will also be given to the problems occurring in the flour-mill and in the bakehouse, with the ultimate object of assisting in the economic production of bread of the highest possible nutritional value.

Steps have been taken to arrange for co-ordination of effort with the British Flour-millers' Research Association.

Plant-breeding and Seed Research.

Advisory Committee: Mr. W. D. Hunt (Chairman), Dr. C. J. Reakes, Mr. W. Perry, Hon. George Fowlds, Professor C. W. Peren, Mr. T. Rigg, Mr. Q. Donald, Mr. C. H. Hewlett. Director of Research: Mr. A. H. Cockayne.

Representations were made to the Empire Marketing Board and to the Right Hon. L. S. Amery for a grant to assist a programme of seed and plant research work which had been prepared on lines which would extend and permit of co-ordination with similar work in progress at Aberystwyth. Accordingly, in December last, advice was received that the Empire Marketing Board was prepared to make grants of £2,500 towards the capital costs of establishment, and £2,500 annually for five years for running-expenses.

Negotiations have been completed and satisfactory arrangements made by the various interests concerned for the establishment of a plant-breeding and seed research station at Palmerston North in proximity to the Massey Agricultural College, and preliminary work has been commenced.

Under the arrangement agreed upon, it has been decided that the plant-breeding and seed research station and the research activities of the Fields Division of the Department of Agriculture will be operated together in close association with Massey College.

Noxious-weeds-control Research.

Advisory Committee: Professor H. B. Kirk (Chairman), Mr. Q. Donald, Dr. F. W. Hilgendorf, and Mr. A. H. Cockayne. Director of Research: Dr. R. J. Tillyard, succeeded by Dr. David Miller on 1st May, 1928.

The funds for this research have been provided by grants from the Empire Marketing Board and the New Zealand Government, while the Cawthron Trust Board has made portion of its resources available to facilitate the research. The Empire Marketing Board's grant is available for a period of five years from the 31st March, 1927. The grants are as follows:—

	Annual Grant, 1927.	Capital Grant, 1927.	Annual Grant, 1928.
	£	£	£
Empire Marketing Board	2,000	1,333	2,000
New Zealand Government	1,000	667	1,000
Cawthron Trust Board	1,000	200	1,000
	£4,000	£2,200	£4,000

The capital grant made in 1927 was utilized for the purpose of erecting a large insectary (found to be necessary to deal satisfactorily with blackberry insects) and adjoining laboratory. These were completed, and were in use during the latter months of 1927, the official opening ceremony being performed by the Right Hon. L. S. Amery during his tour of the Dominion. The biological station now established at Cawthron Institute is one of the most complete of its kind in the Empire, and eminently fitted for the purpose for which it was designed.

The Director of the research, Dr. R. J. Tillyard, severed his connection with the Cawthron Institute on the 31st January, 1928, in order to accept an appointment as Director of the Commonwealth Entomological Research Service.

Further tests have been completed with the ragwort-moth, *Tyria jacobæa*, and these proved sufficiently successful to warrant the issue of a permit which allowed of provisional release in a restricted area. This step has been deemed a necessary precaution preliminary to the granting of an open permit, which it is hoped will be granted during the coming year, when colonies of this ragwort-attacking moth will be established in the weed-infested areas of the Dominion.

Trials of the gorse-parasite, *Apion ulicis*, are still proceeding, but more difficulty has been experienced in establishing this insect owing to the seasonal change from the Northern Hemisphere.

Owing to the unusually bad summers experienced in the North Hemisphere, unforeseen difficulties have been experienced in the direction of securing adequate supplies of many of the insect species required. In particular, this has adversely affected work on the blackberry-control research, and the tests carried out have been made with limited supplies of insects. Steps are being taken to avoid a recurrence of this shortage by arranging for further supplies to come from southern Europe, where climatic conditions are more equable.

As a result of contacts made with South American investigators, it is hoped that an attack upon piripiri (bidibidi) will be commenced during the coming year.

The work at Cawthron Institute has been carried out in co-ordination with that under the direction of Dr. Imms, of Rothamsted, and with the assistance of Dr. Heslop Harrison, of Durham. These workers have arranged for the collection and transport of the consignments of insects which have been received from overseas.

By arrangement with the authorities of the Commonwealth Council of Scientific and Industrial Research, the services of Dr. R. J. Tillyard have been retained in an advisory capacity and as overseas representative. During his present visit to the United States of America, Great Britain. and Europe, Dr. Tillyard has been asked to ascertain further particulars in regard to sources of supply of insects required for the development of the work in the Dominion.

Mineral Content of Pastures Research.

Advisory Committee: Professor H. G. Denham, Professor W. Riddet, Mr. Q. Donald, Mr. Bruce Levy, Mr. S. Fletcher. Director of Research: Mr. B. C. Aston, in association with Mr. T. Rigg.

Early in 1927 it was decided that Messrs. T. Rigg and R. E. Grimmett (the latter of the Department of Agriculture) should proceed abroad to study the research technique and methods devised by Dr. Orr, of Rowett Institute, Aberdeen, who had been appointed to direct Imperial investigations into the problem of mineral content of pastures. This being the case, it was considered highly desirable that methods of research should be standardized. Pending the time when these methods could be applied to the proposed New Zealand investigations, work remained in abeyance, but was again commenced in April, 1928, when a programme was elaborated and put into action.

Investigations, both laboratory and field, are now proceeding in the King-country, Waikato, and Rotorua districts, where there are wide areas of various classes of soils remarkable for the poor nutritional quality of the often abundant pasture-grasses they maintain. The solution of the deficiency problem on even one of these soil types will increase the carrying-capacity over a very considerable area of land well favoured by reason of location, contour, and climate to become highly productive.

Similar work will be undertaken in the Nelson Province, where already an extensive area has been dealt with in a systematic soil survey, the results of which will serve eminently as a basis for the pasture investigations. A limited number of stock-feeding trials will be conducted in all the areas under investigation.

The funds for the research are provided as follows: Empire Marketing Board, £2,000 for two years; New Zealand Government, per Department of Scientific and Industrial Research, £1,000; New Zealand Government, per Department of Agriculture, £1,000: total, £4,000.

The Cawthron Trust Board has placed its laboratory and staff at the disposal of the committee for the purpose of assisting in the work.

The total of the combined Empire Marketing Board and Department of Scientific and Industrial Research grants is being apportioned to the Department of Agriculture and the Cawthron Institute in the approximate ratio of 2 to 1.

Fuel Research.

Advisory Committee: Colonel W. D. Holgate (Chairman), Professor H. G. Denham, Mr. A. H. Kimbell, Mr. Robert Lee, Mr. T. O. Bishop, Mr. H. Vickerman, Mr. Flauvel.

Arrangements have been made for the establishment of a fuel-research laboratory, financed by the sum of £1,000 per annum from the coal-mine owners, and £1,000 subsidy from the Government. Two officers, Messrs. W. A. Joiner and W. G. Hughson, have been appointed, and the necessary apparatus is now to hand and has been set up. Many varieties of New Zealand coal will be analyzed with a view to obtaining data as to their applicability to the different distillation and other processes in course of development in Europe and America. Two bulletins have been issued during the year—

(1) "Report on the Carbonization and Briquetting of Waikato Lignites," by Sir Richard Redmayne.

(2) "Report on the Bergius Process for the Liquefaction of Coal," by Dr. H. O. Askew.

Two others are in the press—

(1) "Report on the Fischer Process," by Dr. H. O. Askew.

(2) "Summary of Work carried out to Date on New Zealand Coals," by W. Donovan.

A special investigation on coal-dust in mines is also in progress. To date, some eight mines have been thoroughly examined.

Pig-industry Investigations.

Advisory Committee: Mr. Q. Donald (Chairman), Mr. H. Morton, Mr. J. Lyons, Professor Riddet, Mr. M. J. Scott, Mr. E. J. Fawcett, Mr. A. H. Cockayne.

In order that the pig industry, to which a subsidy of £30,000 per annum has been granted, may be given additional technical information, a programme of research along four main lines has been arranged. This involves—(1) Fundamental investigations at Otago University into the various foodstuffs available; (2) feeding trials conducted on carefully supervised experimental lines at Lincoln and Massey Agricultural Colleges; (3) the establishment of pig-recording groups at Lincoln and Massey Colleges, and, in conjunction with the Group Herd-testing Association, at Hamilton; (4) investigations into factory processes connected with pork and bacon production. Work has commenced in almost all the four lines of research indicated, but full activity will not be reached until the end of the present year.

A considerable amount of investigation is necessary in order that this industry, which gives such good promise of development, may be placed upon a sound footing, enabling a successful export trade to overseas markets to be secured.

Food Values and Vitamins.

Advisory Committee: Dr. J. K. Inglis, Dr. C. M. Hector, Rev. Dr. J. E. Holloway, Mr. S. Bowman. Director of Research: Professor J. Malcolm.

Since research into food values and vitamins is fundamental to all animal nutrition work, investigations have been carried out at Otago University during the past year under the direction of Professor J. Malcolm. Miss A. Pope, who has been trained in animal-nutrition and dietetic investigational work overseas, was appointed research assistant to Professor Malcolm at the beginning of 1928.

The investigations involve—

(1) Work on meat-meals derived from freezing-works where various dry-rendering processes have been installed to supplement the wet-rendering processes so long established for the purpose of dealing with various by-products of the works. In themselves these meals apparently possess high nutritional values, and are likely to prove of considerable use in connection with pig and poultry feeding. The tests in progress at Otago University will form a basis for a number of feeding trials contemplated in various parts of the Dominion.

(2) A series of investigations into the vitamin content of New Zealand butters, in conjunction with the Lister Institute and the Dairy Division of the Department of Agriculture, also has been in progress for some time. These investigations involve monthly tests of selected representative New Zealand butters, and are of vital importance and concern to the New Zealand dairy industry. It is hoped that arrangements for their extension to other dairy-products will be possible.

Wool.

Advisory Committee: Mr. Q. Donald, Mr. A. H. Cockayne, Mr. J. Cook, and the Secretary.

As the result of a special contribution of £100 received from the New Zealand Romney Marsh Sheep Breeders' Association, investigations upon the nature and character of New Zealand wool fibres has been inaugurated. A large number of microscopical and weight examinations of selected portions of known fleeces has been undertaken in order to ascertain the precise nature of the changes alleged to be causing deterioration in New Zealand wool, and a report on the subject has been prepared. Simultaneously, investigations have been proceeding overseas, and opinions on the question of wool research have been exchanged with Australian and British authorities. There is a general conviction that the problem is exceedingly complex, and better suited for co-ordinated Imperial attack than for isolated investigation in any one Dominion. Already, in view of this fact, the Council recommends participation in any Imperial research scheme connected with wool, and in order to provide funds for the promotion of this work suggests that a levy be imposed upon local wool produced and exported.

Cold Storage.

During the year Dr. Franklin Kidd, of the Low-temperature Research Station, Cambridge, paid a visit to New Zealand for the purpose of conducting investigations into the cold-storage conditions throughout the Dominion. As a result of these investigations Dr. Kidd furnished a report of considerable value, which has resulted in increased interest in the question of cold storage, attention being directed generally towards efforts to eliminate the losses incurred through the present methods in vogue.

As a result of his visit much more complete co-operation has been effected during the present year with the Low-temperature Research Station, Cambridge. Very complete arrangements have been made through the Department of Agriculture to investigate the conditions and changes occurring in fruit from the time of its leaving the orchard until its delivery to the consumer in Great Britain.

By arrangements made with the shipping companies transporting fruit, recording thermographs will be placed in the holds of vessels, so that a more complete scientific history chart of the fruit may be secured. By this means more precise information regarding the changes occurring in fruit during the long period of transport will be secured, and means will be devised accordingly to reduce the wastage and loss incurred.

It is realized that the conditions existing in fruit before shipment often contribute as much to any loss suffered in transport as do the allegedly defective transport facilities. However, the storage and transport of a living organism such as fruit presents peculiar difficulties which are not met with in the case of meat or dairy-produce, and these difficulties demand investigation in the interests of growers, shipping companies, and consumers.

Special marked cases of fruit, which have been subjected to close scientific inspection in New Zealand, have also been forwarded to the Cambridge Low-temperature Research Station, together with full details and reports as to the condition of the fruit before shipment. In this work the co-ordinated efforts of the Horticultural and Biological Divisions of the Department of Agriculture have been of the greatest value.

The whole question of cold storage of fruit investigation is at the present time receiving the attention of a special committee.

Phormium Research.

Investigations, based on information collected from millers, and growers have been continued into problems of the phormium industry from the chemical and botanical standpoints.

The researches conducted by Mr. P. W. Aitken, M.Sc., have resulted in the perfection of a chemical process for bleaching fibre by the use of various chemicals. The process involves no weakening of the fibre-strength, eliminates paddocking, reduces labour-cost, and at the same time imparts a pleasing lustre to the fibre itself. Arrangements for the mechanical handling of the fibre on a large scale during the chemical bleaching process are now under investigation.

Dr. J. S. Yeates has conducted extensive surveys of flax areas in search of strains and types of *Phormium tenax* possessing features rendering them desirable from the point of view of fibre-production. Cytological problems of phormium have also been investigated, as on these are based the whole future of flax-breeding. In consequence a considerable amount of selected seed has been saved, and a large number of selected plants transferred to a special nursery at Massey College to allow further investigations to be pursued. In view of the large areas at present being planted and proposed to be planted in flax, this work is of the greatest importance in order that the best possible fibre-yielding strains may be established in these plantations.

Much has been done by these two workers towards collecting, systematizing, and applying the valuable researches previously conducted by other workers.

Up to the present, funds for these investigations have been voted specially by the Council of Scientific and Industrial Research, but as a result of negotiations which have been proceeding for some considerable time, a Co-operative Research Association has been formed in the flax industry. This organization will ensure that the full measure of interest and financial support is forthcoming from the industry.

Pakihi-lands Research.

A grant subsidizing others made by the Westport Borough Council and the Buller County Council, has been made to Cawthron Institute for the purpose of investigating the possibilities of bringing into profitable utilization the large area of pakihi lands (estimated at 180,000 acres) in the Nelson and Westland Districts. With the assistance of this grant, experimental work has been commenced on an area in the vicinity of Westport, and the Director of the Cawthron Institute reports that the outlook is promising.

Fruit Research.

A grant has been made for the purpose of investigating bud-selection as a means of improving the general standard of citrus trees propagated. This grant will be used for the purpose of examining the results of what has already been done in New Zealand in connection with the utilization of specially imported buds and stocks from California and Australia.

The whole question of fruit research at present is receiving consideration by representatives of the industry and departments concerned.

Mammitis and Abortion Diseases of Stock.

The Council of Scientific and Industrial Research has continued to urge the necessity of more concentrated attack upon these diseases, which are responsible for grave economic loss among the dairy herds of the Dominion. Difficulty has been experienced in securing the services of a highly trained bacteriologist capable of dealing with the problem, and until this difficulty is overcome, progress seems very unlikely. The forthcoming visit to New Zealand of so eminent an authority as Sir Arnold Theiler is being looked forward to with considerable anticipation, and it is hoped that his recommendations will indicate means of dealing with the problems of these two serious diseases.

Fisheries.

The research grant made available for the purpose of conducting an investigation into the plankton of waters round the New Zealand coast and the stomach-content of fishes has been continued, and reports dealing with this matter have been prepared. This investigation, being of a fundamental nature, provides information of particular value in regard to the available supply of fish-food and the fish-maintaining capacity of the New Zealand waters.

Research Work for Secondary and Manufacturing Industries.

Many problems in connection with these industries have been undertaken apart from those mentioned elsewhere. In this connection valuable assistance has been rendered by the Department of Industries and Commerce towards bringing the Department into touch with many industrial problems. It is hoped that this co-operation will be continued and extended, since the local officers of the Department of Industries and Commerce are constantly in intimate contact with the industries in their areas. Meetings of local manufacturers have been held in order to obtain the views of members as to the best means of co-operating for the purpose of application of scientific control to particular industries. Practical technical help and advice have been given to many individual manufacturers, including the following: Soap, boot and shoe, fancy leather, margarine, rennet, gelatine, and wool. In addition, a great deal of investigational and advisory work has been carried out by the staff of the Dominion Laboratory.

Meat-industry Problems.

Particular attention has been paid to the freezing-works industry, in view of its primary importance as a key industry. The co-operation of nearly all the freezing-works in New Zealand for the purpose of research into the general problems relating to the industry is now assured. The companies will provide an annual sum of £1,250 which will be supplemented by an annual Government grant of £1,250 for three years. The work will be for the sole benefit of the contributing companies and will not be published without the consent of the committee. Steps are being taken to appoint two chemists—one for the hide and pelt problem, and the other for general problems affecting the industry. There is no doubt that wide scope exists for elimination of waste, improvement in processes, and generally for the application of newer technical methods to the industry as a whole. This can be done efficiently only with the aid of specialists and equipment, not at present available.

Attention has already been given to the production of meat-meals from the materials which previously were converted into fertilizers. There certainly appears to be a great future for the production of such materials, and large-scale tests are already proceeding at Lincoln College and elsewhere on the value of meat-meals for rations of pigs, &c. In addition, fundamental tests are being carried out at Otago University by Professor J. Malcolm on the food values of meat-meals produced by different methods, such as wet and dry rendering. It is hoped that valuable information of immediate application to the industry will be obtained overseas by the Department's technical liaison officer.

During the past year a new canning process has been put into operation in five works. This is known as the sodium-nitrite hot-pickle process, and its application has resulted in a very great annual saving to the industry. The quality of the canned meat produced has been improved, while the process itself has been shortened and simplified. In addition, meat-extracts which hitherto have been waste products are now recoverable.

Processing of Hides and Pelts.

As a result of the general survey made by the Department's Technical Chemist on the processing of hides and pelts, a report was forwarded to some of the largest users of these products in the United States of America and the United Kingdom. In answer to this report valuable criticism and information on the quality and general deficiency in processing of our hides and pelts has been received. It is hoped that by this interchange of ideas on the part of producers and users, useful results will be obtained and the value of the product increased. An increase in price of only 3s. per dozen pelts for improved quality, which appears well within practical realization, will give an increased revenue of about £100,000 for the whole of New Zealand export of this commodity.

Leather Research.

Advisory Committee: Messrs. J. E. Astley, A. E. Lawry, D. Phillips, A. M. Wright, and Dr. J. S. Maclaurin.

A co-operative Leather Research Association has been formed by the majority of the tanners in the Dominion. The industry will subscribe £500 per annum, which will be subsidized to the extent of £500 by the Government. A Research Chemist is now being advertised for, and as soon as he is appointed general organization of the research will be made. Many users of leather in New Zealand claim that the locally-produced article is inferior to that imported from overseas. There is no doubt that there exists a long-standing prejudice against the local product. It is hoped by means of actual practical tests that the foundation, or otherwise, of this prejudice will be proved. In view of the fact that there is in the Dominion an excellent source of raw materials, there would appear to be every reason why the industry, with technical assistance, should prosper and expand.

Immediate attention will be given to chemical and physical tests on New Zealand sole-leather. A special machine which has been devised by the American Bureau of Standards for testing the wearing-qualities of sole-leather has been constructed locally. By carrying out such tests comparison with the imported leathers can be made and information will be obtained which will facilitate the production of the highest possible standard of leather. The local tanners are handicapped by having to import their tanning-materials, and inquiries are now being made as to the possibility of extending the cultivation of wattle-bark and other tanning-materials in the Dominion.

STANDARDIZATION.

(1) *Weights and Measures.*—Some preliminary work has been carried out by the Department's Physicist, in conjunction with the officers of the Labour Department, on the overhaul and testing-out of the balances which will be used for the primary comparisons when the new set of standard weights (at present being verified by the Board of Trade in London) arrive in New Zealand. The Labour Department has provided new and much-improved accommodation for this work.

(2) *Electrical Standards.*—In conjunction with representatives from the Public Works, the Post and Telegraph, and Railway Departments respectively, a general scheme has been formulated for the establishment of a central electrical standardizing laboratory. While the various Departments are each interested in working standards and instruments for measurement, the maintenance of the ultimate electrical standards and the primary comparisons involves highly specialized work, which could be most conveniently and economically rendered by a central laboratory.

The question of electrical tests in connection with standard specifications, particularly in relation to cable-testing, still is receiving consideration.

It is felt that there is great scope for important and useful work along these lines.

BUILDING-STONES.

Under the direction of Dr. P. Marshall, Petrologist, investigations have been continued into the nature and qualities of the building-stone resources of the Dominion. An interim report dealing with the large number of specimens already tested has been prepared, and at present is awaiting publication.

A notable discovery of deposits of vitric tuff which occur in considerable quantities in the upper basin of the Waikato has been made. This stone appears to possess qualities which indicate that it will prove very valuable as a readily worked building-stone.

Another important report concerning the beach-gravels of New Zealand has also been prepared, while the survey of the gravel resources of the Dominion is still in progress.

"Journal of Science and Technology."

This scientific publication has been transferred to the Department of Scientific and Industrial Research, and now is issued directly by the Department. The *Journal* will be used mainly for the publication of the results of investigations conducted by the Department's Research Staff, together with articles of general interest to science and industry. It is hoped to extend the scope of the *Journal* so as to secure prompt publication of the results of the various research activities coming under the general supervision of the Department, together with special reports issued from time to time.

Publications.

The Department has issued a series of bulletins dealing with the following subjects:—

Bulletin No. 1: "Manurial Experiments in the South Island of New Zealand prior to 1923." F. W. Hilgendorf.

Bulletin No. 2: "Pig-production and Results of Feeding Trials." M. J. Scott.

Bulletin No. 3: "Carbonization and Briquetting of Waikato Lignites." Report by Sir Richard Redmayne, K.C.B.

Bulletin No. 4: "Report on the Bergius Process for the Liquefaction of Coal." Dr. H. O. Askew.

Bulletin No. 5: "Plant-breeding Methods and Results." Dr. F. W. Hilgendorf.

Further bulletins are now in the press and will be issued from time to time.

Research Scholarships.

Four research scholarships, each of an annual value of £180, plus £25 additional for books and apparatus, are available each year for the purpose of providing training for University graduates whose attainments give promise of their being able in the future to conduct useful research work in various industries. The present year has been remarkable for the dearth of candidates of first-class honours standard making application for these scholarships. This, in part, is attributable to the number of scholarships provided by the University the tenure of which permits their holders to pursue their studies in Great Britain. The awards made for this year are as follows:—

P. W. Aitken, M.Sc., Otago University: "Investigation into Flax-gum and Chemical Treatment of Flax-fibre." (Extension.)

E. A. Beaglehole, M.A., Victoria University College: "The Relation between Lighting and Humidity in Factories and the Efficiency and Health of the Employees in such Factories."

J. K. Dixon, M.Sc., Canterbury College: "Hydrogen-ion Values of New Zealand Wheats and Flours."

Mr. E. A. Beaglehole subsequently resigned his scholarship in consequence of his having been awarded the University Travelling Scholarship in Arts for the year 1928.

Co-operation with Overseas Research Organizations.

The connection established by the Department with research institutions in the United Kingdom, the United States, Canada, Australia, and other parts of the Empire has proved of considerable value, and a useful exchange of information has resulted. In the case of a number of the researches being conducted under this Department similar work is being carried out elsewhere in the Empire. Co-ordination of efforts with these, when effective, will permit of more rapid results being secured in local investigations.

REPORT OF DOMINION LABORATORY.

The principal function of the Dominion Laboratory is to carry out analytical and other chemical work required by all Government Departments except that of Agriculture, and to act as chemical adviser to these Departments. In the carrying-out of their duties the members of the staff have acquired considerable chemical knowledge, covering a wide field, and it is now hoped, while not curtailing in any way necessary Government work, to make their knowledge and experience available where possible for the betterment of industry in New Zealand.

Main Highways Board.—The work for this Board has almost doubled during the year. A "Rotarex" separator which was installed has enabled analyses of bituminous concrete to be much more quickly carried out than previously.

Mines.—A considerable number of the samples received from the Geological Survey are water, gas, sulphur, and rock from Rotorua, Taupo, and White Island, in connection with the survey of the thermal districts.

Health.—Included in these samples are 259 milks analyzed for the Plunket Society. Milks taken under the Sale of Food and Drugs Act comprise the majority of the remainder. In Wellington City, 1,708 samples were taken, of which six were watered, eight had been skimmed, two were stale, and fifteen were slightly deficient in various ways. These figures reveal the very satisfactory condition of Wellington's retail milk-supply, and are a tribute to the excellent work of the city Milk Inspector.

In the country districts conditions are not quite so good. The number of samples taken was 951, of which fifteen were watered, eleven skimmed, and ten slightly below the standard.

Fifty-three whiskies were examined, and refilling detected in two cases. Sixty-eight samples of beer were analyzed, principally for salt content. In the early part of the year several were over the standard, but in the latter months none exceeded the limit of 50 grains per gallon. Foodstuffs in great variety were also analyzed, and on the whole complied well with the regulations.

Numerous samples of water from existing and proposed town supplies were examined for purity.

Other Departments.—The work done for the Post and Telegraph, Public Works, Railways, and other Departments consisted mainly of the analysis of stores. This is regarded as important, both to determine the relative quality of goods submitted on tender and to ensure that supplies are up to standard.

Research.

A Fuel Research Association was formed during the year, and one of the staff was seconded to the charge of the work, which is to be carried out at the Dominion Laboratory. A special retort has been installed for research on low-temperature carbonization.

In connection with an investigation of the incidence of goitre being carried out by the Health Department, a research on the iodine content of soil and water in the Wellington District was undertaken, and is now nearing completion. A very careful survey of the methods of analysis was required as a preliminary.

A research on moulding-sands for foundry use has enabled the desirable properties to be defined, and will greatly assist in the search for suitable sands in New Zealand.

Two minor investigations that were completed had reference to the plating of duralumin, and the manufacture of roofing-tiles respectively.

A considerable amount of work was done in adopting the nitrite process of curing meat for use in New Zealand meat-freezing works.

Some preliminary examinations were made of wool, wool-scouring liquors, and bacon.

The Dominion Analyst was frequently consulted during the year on numerous industrial matters.

Branch Laboratories.

Auckland.—The number of samples analyzed was as follows: Health Department—Milks, 1,603; other samples, 641; Police, 67; other Departments, 17: total, 2,328.

A few visits were made to factories and works to note processes, and a small amount of industrial work was done.

Christchurch.—The number of samples analyzed was: Health Department—Milks, 1,760; other samples, 227; Police, 35; other Departments, 37: total, 2,059.

The question of stream-pollution engaged considerable attention on the part of the Analyst. His services were also placed at the disposal of the special committee of the Christchurch City Council which dealt with the control of the city milk-supply.

Dunedin.—This branch was established early in the year, but did not get into full working-order for some months. The number of samples analyzed was: Health Department—Milk, 572; other samples, 117; Police, 3; other Departments, 109: total 801.

A considerable number of analyses were carried out for the Plunket Society to assist a research on variations in the composition of human milk.

Some careful determinations of the salinity of sea-water were made in connection with a fisheries investigation at Portobello.

Gas Regulations.

The Board of Trade regulations for the control of the sale and supply of gas provided safeguards in regard to heating-value, purity, pressure, price, and measurement. Regular tests have been made by the Gas-examiners in Auckland, Wellington, and Christchurch during the year, and in Dunedin since August, 1927, when a Gas-examiner was appointed there. These tests show that the gas in each of the four cities has complied with the regulations in regard to pressure and purity, and has been kept well up to the declared calorific values, which are 450, 475, 470, and 500 British thermal units per cubic foot for Auckland, Wellington, Christchurch, and Dunedin respectively.

The Inspectors of Meters in Auckland and Wellington who were appointed in January, 1927, have continued their work during the year. They test and stamp all repaired meters and all new meters not bearing the British Board of Trade stamp before they are issued for use.

During the year the following gas undertakings have been added to the schedule of the Board of Trade (Gas) Regulations, 1924—the first thirteen in April, and the last one in June, 1928: Gas companies—Birkenhead and Northcote, Napier. Gas, coal, and coke companies—Timaru, Ashburton. City Corporations—Wanganui, Nelson. Municipal Corporations—Invercargill, Hamilton, Palmerston North, Dannevirke, Masterton, Lyttelton, Oamaru. Gas-lighting Board—Petone and Lower Hutt.

Prior to August, 1927, no provision was made in the scale of fees for meter-testing for the cost of travelling to gas companies at some distance from the Meter Inspector's headquarters. That necessitated keeping the fees fairly high to cover the cost of travelling, and resulted in the companies in the large centres bearing a considerable proportion of the cost of testing in the small centres. The referees considered that it would be fairer to all concerned to reduce the ordinary fees and to charge extra fees to cover travelling-expenses where such were incurred. A new scale of fees was therefore gazetted, and came into force on the 1st August. In this scale the fees have been considerably reduced as compared with those previously in force, and provision is made for charging an additional fee of 10s. per day when the gas company's testing-room is more than three but within ten miles of the headquarters of a Gas-examiner or an Inspector of Meters, or £1 5s. per day when the testing-room is more than ten miles from such headquarters.

GEOLOGICAL SURVEY BRANCH.

TWENTY-SECOND ANNUAL REPORT (NEW SERIES).

DIRECTOR'S REPORT.

Summary of Field Operations.

During the field season of 1927–28 detailed topographical and geological surveys have been carried out in the following areas:—

(1) Rotorua-Taupo Subdivision, Auckland, by L. I. Grange, M.Sc., A.O.S.M., F.G.S., Assistant Geologist and Vulcanologist;
(2) Wairoa Subdivision, northern Hawke's Bay and southern Gisborne, by M. Ongley, M.A., B.Sc., Geologist;
(3) Murchison Subdivision, Nelson, by H. E. Fyfe, B.Sc., A.O.S.M., Assistant Geologist.
(4) St. Bathans Subdivision (in conjunction with soil survey of Central Otago), Otago, by H. T. Ferrar, M.A., F.G.S., Geologist.

I made brief visits to several points in North Auckland, Arapuni, Taupo, Wairoa, Takaka, and Murchison. Mr. L. I. Grange spent several days at the camp of gold-prospectors in the basin of the Waihaha, a large stream entering the western bay of Lake Taupo from the Hauhungaroa Range. He also visited White Island to collect samples from and obtain data concerning the fumaroles and hot springs. Dr. J. Marwick, Palæontologist, visited northern Hawke's Bay, and collected fossils from different localities in the basins of the Mangapoike, Wairoa, Waikare-Taheke, Waiau, and Waikare rivers.

Progress of Areal Survey.

During the twelve months ended 31st May, 1928, approximately 2,400 square miles was geologically surveyed in detail. Of this area, about 1,100 square miles lies between Rotorua and Lake Taupo, 600 square miles in Wairoa, 400 square miles in Nelson, and 300 square miles in Otago. In addition Mr. Ferrar covered in a soil survey 393 square miles of country, part of which had already been geologically mapped.

The present state of the detailed geological survey of New Zealand is shown in the following table.

	Square Miles.	Square Kilometres.
Surveys completed and maps published on the scale of one mile to an inch	15,478	40,088
Surveys completed and maps published on the scale of two miles to an inch	545	1,411
Field surveys completed, but maps not yet published (approximate)	6,521	16,889
Surveys in progress—area actually surveyed (approximate)	2,969	7,690
Total area surveyed in detail	25,513	66,078
Area of districts in which work is suspended (Heaphy and Mangakahia)	413	1,063
Area resurveyed (Whatatutu and Waihi)	352	911

Dargaville-Rodney Subdivision.

The field-work of the Dargaville-Rodney Subdivision was completed in 1925. The maps are ready for the printer, the manuscript is now well in hand, and it is hoped to issue the bulletin in the coming year.

Rotorua-Taupo Subdivision.

During the year Mr. Grange continued field-work in the Rotorua Subdivision and extended his explorations to Lake Taupo. He has examined most of the area to be included in the bulletin, and will write his report in whole or in part during the winter.

Waiapu Subdivision.

After long delay the report on the Waiapu Subdivision is about to be published.

Wairoa Subdivision.

Mr. Ongley's summary report on his work in this subdivision during the 1927–28 field season appears on another page. The geologists employed by the Taranaki Oil Fields, Ltd., have examined parts of this area in great detail, and that company is now drilling two wells on very favourable structures in the eastern part of the subdivision.

Motueka Subdivision.

The numerous photo-litho drawings for the maps of the Motueka Subdivision are almost finished, and the manuscript will probably be completed this year.

Murchison Subdivision.

Mr. Fyfe has nearly completed the field-work in the Murchison Subdivision, and will begin writing the report this winter.

Kaitangata-Milton Subdivision.

Mr. Ongley wrote part of the report on the Kaitangata-Milton Subdivision last winter, and the draughtsman has the drawings for the maps well in hand.

St. Bathans Subdivision.

Mr. Ferrar's summary report on the St. Bathans Subdivision is printed on a later page. He took the opportunity during his field-work on the soil survey of Central Otago to complete the geological examination of Cluden and Tarras survey districts and these have now been added to the St. Bathans Subdivision. It is unlikely that Mr. Ferrar will have time to begin writing his report this winter.

Soil Survey of Central Otago.

Mr. Ferrar has now finished the soil survey of the lands in Central Otago that the irrigation works, projected or in being, are designed to benefit. Some further areas were also mapped. Half the lithographic drawings for the soil maps to embody the result of three seasons' work await revision and the addition of some details when the scheme of classification is decided upon. Mr. Ferrar will probably complete his report in a few months, by which time the drawings for the maps should be well forward.

Palæontological Work.

Dr. Marwick has worked chiefly on the Tertiary fossils of Gisborne and north Hawke's Bay districts. He has prepared drawings and descriptions of many new species, and it is hoped to publish the results of his work before the end of next year as a Palæontological Bulletin. Dr. Marwick has been absent on leave acting as Professor Cotton's *locum tenens* at Victoria College, since the 5th March.

Publications.

The following official publications were issued in the year ending 31st May, 1928:—

"Twenty-first Annual Report (New Series) of the Geological Survey" (parliamentary paper H.–34, 1927).

Geological Bulletin No. 31: "The Geology of the Tongaporutu-Ohura Subdivision, Taranaki Division," by L. I. Grange.

Geological Bulletin No. 32: "Minerals and Mineral Substances of New Zealand," by P. G. Morgan.

Bulletin No. 30, "The Geology of the Waiapu Subdivision," is shortly to be issued; the maps accompanying this report have been available for some time. A map showing the known faults of New Zealand has been printed, and will be distributed as soon as the notes to accompany it are ready. A paper by Mr. Grange, "On the 'Rodingite' of Nelson," and one by Dr. Marwick, "The Tertiary Mollusca of the Chatham Islands, including the Generic Revision of the New Zealand Pectinidæ," were published in volume 58 of the "Transactions of the New Zealand Institute." The late Mr. Morgan contributed a short paper on the "Bituminous Coal of New Zealand," and Mr. Ferrar one entitled "Geological Notes on Kapiti Island" to the *New Zealand Journal of Science and Technology*. Mr. Morgan and Dr. Marwick reviewed several publications for the same journal.

Office-work, etc.

The office-work during the year was similar to that of other years. Throughout the winter and early spring the professional officers wrote detailed reports on the districts they had examined in the field. The literature on all branches of geology is so extensive that the labour of preparing these reports and the studies necessary before they are written is great and ever increasing. Numerous mineral samples have been identified for the public, many requests for information more or less connected with the work of the survey have been answered, and much other routine work attended to.

Eight large maps and several other plans and blocks for photo-lithographic reproduction, two fault maps, and numerous field sheets have been prepared.

Ten photo-lithographic drawings and seventeen field sheets in connection with the soil survey of Central Otago have also been completed.

The library now contains 6,400 volumes, and a great many pamphlets, duplicates, &c.

Field-work projected.

During the 1928–29 field season the exploration of four subdivisions will be begun. Each of these will require two years or more to complete.

Mr. Ferrar will examine the area about Te Kuiti, extend the geological mapping to the west coast of the North Island, and connect the large area in Taranaki already surveyed in detail (Bulletins Nos. 14, 24, 29, and 31) with the still larger area in the Waikato and Hauraki districts described in Bulletins Nos. 4, 10, 15, 16, and 28. The subdivision contains large amounts of limestone and some coal, resources that in the future will no doubt be fully utilized, but the chief immediate reason for

the survey is to map its soils. There are considerable areas of arable and easy pastoral land on which stock do not thrive, and the survey is undertaken to help to ascertain the cause.

Mr. Ongley will explore the district north of the Wairoa Subdivision, the field-work of which he has just completed, and west of the Gisborne Subdivision (Bulletin No. 21). It was intended to continue the detailed mapping south-westward from the Wairoa Subdivision, but the work of last season showed that an enormous thickness of Tertiary strata covered the possibly petroliferous rocks in this direction. The geologists of the Taranaki Oil Fields, Ltd., have explored part of the upper basin of the Wairoa, and have there discovered at least one favourable structure, so that the mapping of this area in more likely to yield results of value to the community than similar work in the Mohaka district.

Mr. Grange will continue the exploration of the volcanic zone of the North Island, and map the Tongariro-Ruapehu group of volcanoes. Sulphur deposits, though difficult of access, are known to exist on Tongariro, but the survey is extended principally to provide data for systematic vulcanological observations. Special attention will, as in the Rotorua Subdivision, be given to the hot springs and fumaroles of this region.

Mr. Fyfe will explore the district south of the Murchison Subdivision and east of the Reefton Subdivision (Bulletin No. 18). This difficult and mountainous area, in which are the sources of several of the larger tributaries of Buller River, includes the southern part of the Murchison intermontane basin. Alluvial gold has been worked for many years, coal is known to outcrop, and seepages of petroleum show that oil-bearing strata exist. This survey should also yield valuable data on the structure and sequence of the Tertiary rocks of this little-known part of New Zealand.

General.

The maps accompanying this report show the area that has been mapped as the result of twenty-three years' work. It amounts in all to 25,513 square miles—about a quarter of New Zealand. The volume of topographical mapping and geological investigation has always been less than the demand. Of late years the rate of progress has increased, chiefly because the areas examined have, as a whole, been more accessible than those surveyed twenty years ago.

It is essential, if the economic resources of New Zealand are to be utilized to the best advantage, that their amount and distribution be accurately known as soon as possible. Such exploration, though fundamentally necessary, cannot be expected to yield immediate results. One example of the value of long-stored facts may be quoted. At the present time the need for increased agricultural production is focusing attention on our soils. Here the geological maps, some of which have been published more than twenty years, will form the basis of the soil map, for, over wide areas, the composition of the subsoil is one of the most important factors in determining the value of the soil.

The attendance of the members of the staff has been very gratifying. For the year ended the 30th November, 1927, the length of the working year was shortened on the average by seventeen days owing to annual, sick, and special leave, but not including holidays. Records of overtime worked without pay are not available, but it is conservative to estimate it at three days a year. Thus the year for which salary is paid includes a net loss of time not exceeding fourteen working-days.

The late Mr. P. G. Morgan.

The death of Mr. P. G. Morgan, Director of the Geological Survey since 1911, must be recorded with regret. His demonstrated capacity as a geologist and his close personal contact with the many problems relating to the application of geological knowledge to practical use render his death a distinct loss to the mining industry of New Zealand.

SPECIAL REPORTS.

1. ST. BATHANS SUBDIVISION.

(By H. T. Ferrar.)

Introduction.

In conjunction with the soil survey of Central Otago, as mentioned in last year's annual report, tracts of country forming part of or immediately adjoining the irrigation areas were geologically examined. Part of the area covered by this year's soil-survey work lies within the Cromwell and the Queenstown subdivisions, the maps of which were published many years ago, and part is newly mapped. The new areas are adjacent to Cromwell Subdivision and cover the eastern half of Lower Wanaka Survey District, the western half of Lower Hawea Survey District, the whole of Tarras Survey District, the northern half of Cluden Survey District, and part of Coneburn Survey District. The additional area geologically surveyed is thus about 300 square miles in extent. The southern half of Cluden Survey District was surveyed during the previous season, so the completed Cluden and Tarras survey districts can now be provisionally included in the St. Bathans Subdivision.

Physiography.

The main physiographic features are the fault-block mountains of schist separated by intermontane plains or basins similar to those mentioned in last year's report. Mount Pisa Range (6,327 ft.) and Grandview Range (4,577 ft.) rise to the west, and Dunstan Range rises to the east of the Cromwell basin, which is from 700 ft. to 1,000 ft. above sea-level. To the west of the Grandview block mountain are the depressions in which lie Wanaka and Hawea, two lakes maintained at their present level by morainic material and separated from each other by the Mount Maude fault-block. Kernbuts, which according to A. C. Lawson indicate downthrow faulting or subsidence rather than uplift, are noticeable features on the shores of these lakes. The Remarkables Range (Double Cone, 7,688 ft.), in Coneburn Survey District, is part of a fault-block tilted to the east. A broad north-south valley, for which the name Strath Gyle is suggested, lies to the west of the range in continuation northward of the Kingston reach of Lake Wakatipu. Peninsula Hill (2,768 ft.) stands in the angle formed by the intersection of the downfaulted strips now occupied in part by the Queenstown and Kingston reaches of the lake.

The drainage of lakes Wanaka and Hawea and of the Cromwell basin is by way of the Clutha River, which after being joined at Cromwell by the Kawarau from Lake Wakatipu becomes the Molyneux River properly so called.

General Geology.

Previous geological work carried out in the newly mapped areas was done by A. McKay, who journeyed over Lindis Pass to Lake Wanaka. Little need be added to the geological summary contained in last year's report. In general the Maniototo schists of Palæozoic age pass upwards into less-metamorphosed phyllites, but no unmetamorphosed greywackes belonging to the Kakanui Formation were seen. Of Tertiary sediments, the Kyeburn conglomerate as well as the Naseby marine beds are absent. The lowest horizon of the St. Bathans beds is represented in Lindis Valley by remnants of silicified quartz-grit in the form of wetherstones; clays representing the overlying lake-beds outcrop in Lindis Stream near Ardgour; conglomerates, sands, and clays faulted in near Tarras village and near Albert Town represent higher Tertiary horizons.

The greywacke conglomerate or "Maori bottom," that was piled into the intermontane basins was largely washed out again before glaciers invaded the basins. A period of erosion followed this Pleistocene Glacial Epoch. After a second but smaller invasion of ice, the fluvial and fluvio-glacial material now covering the floors of the basins was subjected to the present steppe conditions, under which the existing soil mantle accumulated.

Economic Geology.

Soils.—Soils and irrigation-water are the most important geologic assets of the subdivision. Soil maps, which are being described in a separate report, have been prepared showing, among other things, the distribution of land differentiated according to facilities for irrigation and drainage, irrespective of availability of water. These maps will show how the limited quantities of water available can best be utilized.

Limestone.—In addition to the already known deposits on the shores of lakes Wakatipu, Hayes, and Wanaka, a mound of calcareous travertine at Gibbston is the only new source of limestone mapped.

Building-materials.—Unlimited quantities of schist are available for constructional work. Sandstone beds at Bob's Cove are quarried to a small extent.

Roadmaking-materials.—An abundant supply of roadmaking-material is obtained from deposits of gravel which, being naturally mixed with earth, binds well.

Quartz Sands.—A bed of exceptionally white quartz sand suitable for glassmaking is being quarried near Bannockburn School. This bed extends farther south along Shepherd Creek, but its full extent is not known.

Lignite.—Very little lignite is found in the area covered last season. The mines at Gibbston are abandoned, and the small mine in Doolan Creek is so difficult of access that its output is almost negligible.

Gold.—Alluvial gold is unevenly distributed throughout the fluvial and fluvio-glacial deposits of Central Otago, and was more plentiful in Recent river-gravels than in older beds. The Recent river-gravels are for the most part worked out, while the thicker fluvio-glacial accumulations and old gravels have mostly been abandoned before being worked out. The maximum annual output of gold was made in 1863, three years after the discovery of the goldfield. The population reached a maximum in 1864, after which date miners left the district, rapidly at first and later in gradually decreasing numbers until now there are comparatively few. No miners were seen working in the area covered by Tarras and Cluden survey districts. On the Kawarau River a party is sluicing fluvio-glacial material near Victoria bridge, and between this point and the Kawarau Falls one miner was seen at work. At Arrowtown a sluicing plant is operated at intervals in extensive old workings in Bracken Gully. At The Sugarloaf, near Arthur's Point, on the Shotover River, a party is attacking a thick deposit of fluvio-glacial gravel abandoned many years ago. To the north of Arthur's Point the Shotover River has been diverted through a tunnel so that part of its bed may be worked for gold, and at Sandhills, on the Upper Shotover, an insilted channel is being sluiced open in order to lay bare some 40 chains of channel now occupied by the river. Other parties are at work in Moonlight Creek, a tributary of the Shotover, and in Twelve-mile Creek, west of Queenstown.

2. SOIL SURVEY, CENTRAL OTAGO.

(By H. T. Ferrar.)

Field-work in connection with the soil survey of irrigation areas in Central Otago was resumed on the 17th October, 1927, and ceased on the 10th April, 1928. During this period an area of 393 square miles was surveyed. This area includes and also extends beyond the boundaries of the following irrigation projects—namely, Arrowtown, Crown Terrace, Gibbston, Hawea Flat, Tarras, Ardgour, Bendigo, Pisa Terraces, and Cromwell Flat. These are the areas that remained to be surveyed at the close of the 1926–27 field season, and their mapping completes the flying survey which was begun in January, 1926, at the request of the Hon. the Minister of Public Works. In all, an area of 1,177 square miles, or 753,280 acres, more or less, has been surveyed.

Classification of Soils.

The classification and mapping of soils is usually designed to serve some definite economic purpose, such as combating some disease in man or in animals, or ameliorating stretches of poor or unproductive land. The methods of classification of soils being followed in New Zealand are based on those adopted in other countries. In the United States of America the Bureau of Soils, which has had charge of this work since 1899, makes the *soil type* the unit of mapping. Soil types are differentiated according to some factor or character that may be recognized in the field. Soil types having some relationship or some feature in common are grouped together to form a *soil series*. Several soil series subject to some external influence form a *soil province*. Soils are classed as clays, loams, sands, &c., or combinations of these words, according to their texture as determined by mechanical analyses. By adhering to this form of classification no confusion need arise when a systematic soil survey of New Zealand comes to be carried out.

Central Otago, with its low rainfall and characteristic drought-resisting flora, forms a definite soil province. The soils are mainly derived from five different kinds of rock, and thus form five natural soil series. Since facilities for irrigation and drainage (irrespective of availability of water) determine the cultural and commercial values of the land, the situation factor was adopted as the best criterion for differentiating soil types. In many places, owing to the fact that similar soils were variously situated, there was a temptation to make use of some other differentiating factor; in other words, there was a temptation to be inconsistent. Had inconsistencies been allowed to creep in, the maps would have become too complicated, especially in view of the special purpose for which the survey was made. The following classification has therefore been adopted:—

Vincent Series (consisting of finely divided schist material), embracing the following soil types: Galloway clay; Younghill silty loam; Idaburn, Ranfurly, Lauder, Drybread, Clyde, Naseby, Kyeburn, Blackstone, and Dunstan stony loams.

Hawkdun Series (soils covering greywacke mountain-sides), with one soil type, called Hawkdun stony loam.

Becks Series (soils covering clays, sandstones, and gravels of Tertiary age), with two soil types, called Becks sandy loam and Totara gravel.

Waipiata Series (derived from basic volcanic rocks) with one soil type, the Camphill stony loam, consisting of disintegrated basalt.

Cromwell Series (consisting of blown sand), with one soil type, called Cromwell sand.

Unproductive: Stony river-beds, sluiced and dredged ground, and tailings.

Methods of Mapping.

The methods of mapping outlined in last year's annual report were followed as closely as possible. Naturally, slight changes in the manner of mapping have had to be made as the work was carried into new areas. The result of this has been that slight changes of symbolization appear on the field sheets, but these will be corrected when the whole series is assembled for reproduction.

To a large extent the maps are topographical, but not entirely so. Owing to the climatic conditions ruling in Central Otago, two base-levels of erosion had to be considered—namely, that of an intermittent creek and that of a perennial stream. This difficulty did not present itself until this field season, when the work was carried into Cromwell basin. Here alluvial fans or deltas at the mouths of steep mountain-creeks are spread out upon high-level river-terraces. Such deltas were mapped as if they were normal low-level alluviations. In other places sudden changes in soil-texture or in the natural vegetation attracted attention, but could not be mapped. Nevertheless, pedological differences of this kind were noted upon the field sheets, and can be utilized when the soils of the district are studied in more detail.

Some Consequences of Irrigation.

In last year's report attention was drawn to some of the deleterious effects that follow irrigation. In the area surveyed this year it was noticed not only that salty and waterlogged patches of land were few and far between, but that a visible concentration of saline matter was advantageous, for sheep habitually resort to "licks" on the edges of irrigated fields where salty matter is visible, in order to supplement a deficiency of mineral matter in their pasture. It was also noticed that irrigation was practised wherever water was available, and that very little water was allowed to escape into deep watercourses.

Compared with other irrigated countries, such as Egypt, the impression is gained that Central Otago has not sufficient water available to irrigate all its irrigable land, unless water is lifted at prohibitive cost. This means that some land can be irrigated annually, some only in favourable years, and some not at all. Land-values will therefore vary, and will not become stabilized until all water-supplies are utilized and those areas that require least water become known. In Central Otago water is required most when it is scarce; hence those areas that are most easily irrigated will have the highest value. In consequence of irrigation, therefore, land-values will vary in some inverse ratio to their water-absorbing capacity, a quantity that can only be determined by a long series of weir-discharge measurements.

In view of the recent agitation to have the price of irrigation water reduced, the following quotation is of interest: "The conclusion, based on Italian experience, is that irrigation is very beneficial to the individual farmer, when he can get water by paying 30 to 50 francs per hectare per year (11s. to 17s. per acre), but not to the Administration of the canal during at least the first thirty years; so the undertaking requires a great help from the State during this trying period."* The above charges refer to pre-war conditions. In Central Otago the charges for water are from 10s. to 16s. per acre and are expected to provide interest and sinking fund on the capital cost of construction.†

3. WAIROA SUBDIVISION.

(By M. Ongley.)

Introduction.

In November, 1926, work was begun in the Wairoa Subdivision, lying south of the Gisborne Subdivision described in Bulletin No. 21, and by the end of May, 1927, the survey districts of Paritu, Mahanga, Mahia, and parts of Nuhaka and Nuhaka North had been examined. This season, from October, 1927, to May, 1928, the survey districts of Waiau, Taramarama, Opoiti, Nuhaka North (part), Waihua (part), Clyde, and Nuhaka (part), covering some 600 square miles, were examined and mapped. The whole subdivision may be described as the district between Poverty Bay and Hawke Bay, extending inland to Lake Waikaremoana.

The area examined this season contains none of the Cretaceous rocks previously described in the east of the subdivision, but consists of Tertiary sedimentary rocks, 35,000 ft. thick, divided into several sets by four erosion intervals and one unconformity. The whole is gently folded into a broad syncline forty miles wide, its axis trending south of west from Te Reinga, down the Wairoa River, towards Napier, as pointed out by Smith‡ in 1876.

Physiography.

The district is part of a dissected plateau rising gently inland from 600 ft. near the coast to 2,500 ft. in the north-west of the subdivision, thirty miles inland. It is eroded into two sets of dip-slopes dipping into the Wairoa syncline. On the east side the strongest dip-slope, curving in from Tahaenui River west of north for sixteen miles, forms Whakapunake, which slopes 20° to 30° west. In Opoiti and Nuhaka North the country for ten miles east of this consists of similarly disposed though less well defined dip-slopes. The whole of the district west of the Wairoa River, to the west of the subdivision and beyond it, consists of strong eastward-sloping dip-slopes trending south-south-west beyond the north and south boundaries of the subdivision.

Although the plateau has been eroded into such well-marked strike ridges, most of the streams still maintain their original consequent courses down the slope of the plateau. Examples are Waihua, Waiau for the greater part of its course, Mangaone, Waihi, Waikare-Taheke, Mangaruhe, and Ruakituri streams, all flowing nearly parallel south of east. Subsequent tributaries of these streams and short lengths of the Waiau and Waikare-Taheke flow north-east or south-west along soft beds. The Wairoa River flows south through the subdivision along the Wairoa syncline, and the Nuhaka, twenty miles to the east, along a parallel syncline. Between these the lower Mangapoike and its tributaries, the Makaretu and Tukemokihi, are flowing out westward from the Mangapahi anticline. These streams have many short stretches along soft beds at right angles to their general direction; the upper part of the Mangapoike flows in long reaches along the strike. The Tahaenui, on the contrary, flowing south of east, at an angle of 30° to the coast, appears to be maintaining its consequent direction derived from the original slope of the plateau.

General Geology.

The beds of that part of the subdivision examined in the field season 1926–27 were described and tabulated in last year's annual report. As the work proceeded more information of the structure, relation, and sequence of the beds was obtained, and some difficulties, especially of correlation, arose. The Mangatu beds, described in the previous report, were not found. The erosion interval and basal Tutamoe conglomerate, which proved so useful an horizon-marker last season, was seen at only one place. It indicates that the lowest beds seen in the east limb of the Wairoa syncline belong to the Ihungia Series. The strata overlying can be readily correlated with the Tutamoe, Morere, Mapiri, and Otunua beds. The thick beds of tuffaceous sandstone, last season observed only in

* Luigi Luiggi, *Irrigation Works in Italy*, Brit. Assoc. Adv. Sci. Rep. 1914, p. 658, 1915; and *Engineering*, 18th September, 1914.

† R. B. Tennent and J. R. Marks, *N.Z. Jour. of Agric.*, vol. 28, p. 259, 1924; and *N.Z. Dept. of Agric.*, Bull. No. 120, p. 25, 1925.

‡ Smith, S. P.: "Sketch of the Geology of the Northern Portion of the Hawke Bay" (Trans. N.Z. Inst., vol. 9, pp. 565–76, 1877).

the Mapiri beds, were found this season to continue up to the youngest beds, so that this criterion fails to distinguish Mapiri beds. A set of beds in Opoiti Survey District is separated from the Mapiri beds below by a decided erosion interval, and from the Ormond beds above by an angular unconformity. These correspond in their position in the sequence to the Otunua beds of last year's annual report, and probably represent them in part at least. Since no break was detected last season between the Mapiri and Otunua beds, the strata between the Mapiri and Ormond beds are more suitably named the Opoiti beds. The erosion interval below the Ormond beds was found this season in several places with the bedding in upper and lower sets divergent, and is therefore established as an unconformity.

The Wairoa syncline rises gently north, and, if it is unbroken, the beds forming the well-marked dip-slopes of its eastern side, which pass northward out of the subdivision, should curve round and re-enter the district on the west side of the structure. The beds on the two sides differ: the great Whakapunake dip-slope, formed largely of limestone and conspicuous on the east side for ten miles, could not be matched on the west side of the syncline, where, however, it is probably represented by less resistant beds of thick sandstone containing layers of shell rock up to 3 ft. thick. The known rapid lateral variation of shallow-water beds, such as occur so abundantly in the subdivision, and the probable considerable denudation during the known intervals of erosion probably account for these differences. The table shows the probable correlation, which, however, has yet to be checked by the palæonotological evidence. Fossils are scarce in the lower beds, but from the Mapiri mudstone upwards good collections have been made.

Beds.	East of Wairoa Syncline.	West of Wairoa Syncline.	Age.
Waihua ..	..	Alternating sandstone and mudstone, coarse sandstone, coarse pebbly sandstone with layers of shell rock (3,000 ft.+)	Upper Waitotaran. ?
		(Erosion interval.)	
Ormond ..	Mudstone (2,000 ft.); limestone (50 ft.); mudstone (200 ft.); limestone (50 ft.); mudstone (1,000 ft.); limestone (20–200 ft.)	Coarse tuffaceous sandstone; fine sandstone, and mudstone (2,000 ft.); mudstone, argillaceous sandstone, coarse sandstone (3,400 ft.)	Waitotaran.
	(Unconformity.)	*(Erosion interval.)*	
Opoiti ..	Limestone, fine argillaceous sandstone (2,700 ft.); pebbly shell limestone with bored and phosphatized stones (100 ft.)	Mudstone, argillaceous limestone, thick tuffaceous sandstone (900 ft.); arenaceous mudstone, alternating sandstone and mudstone, coarse sandstone, pebbly shell limestone (3,300 ft.)	Taranakian (includes Urenui and Tongaporutu beds of Bull. No. 29).
	(Erosion interval.)	*(Erosion interval.)*	
Mapiri ..	Sandy mudstone with rare bored pebbles (100 ft.); mudstone with beds of tuffaceous sandstone, thick tuffaceous sandstone (4,000–10,000 ft.)	Mudstone and thick tuffaceous sandstone (2,800 ft.).	
		(Erosion interval.)	
Morere ..	Mudstone (900 ft.)..	Mudstone (1,100 ft.).	
Tutamoe ..	Alternating thick sandstone and thin mudstone, fine pebbly conglomerate (4,500 ft.)	Coarse sandstone (7,000 ft.)	Awamoan.
	(Erosion interval.)		
Ihungia ..	Mudstone (1,000 ft.+); no base exposed		Hutchinsonian.

Structure.

In the 1926–27 season the Morere anticline, the Nuhaka syncline, and the Mangapahi anticline were examined. This season more work was done on the west limb of the Mangapahi anticline. West of that the wide Wairoa anticline was mapped. In the north-west of Opoiti Survey District a narrow anticline crosses the Ruakituri River two miles west of the axis of the Wairoa syncline at Te Reinga. This was followed south across the Mangaruhe to the Waikare-Taheke River, which it crosses three and a half miles west of the Wairoa, and on to the south of Taramarama Survey District, where it dies out.

West of this anticline the beds rise westward from 5° to 18° for at least twenty-one miles in a continuous homocline that extends out of the subdivision. So far as known, they do not again turn over, but still dipping east, lie on the older greywacke.

Economic Geology.

Petroleum.—Although many indications of oil and gas occur in the adjacent districts, none was seen in the part examined this season. The anticline that extends north and south across the subdivision west of the Wairoa syncline is covered with Tertiary beds more than 30,000 ft. thick, and any underlying Cretaceous oil-bearing stratum cannot be reached with the drill. The Tertiary beds themselves are unmetamorphosed marine sediments such as produce oil in other fields, but here they contain no trace. Moreover, if oil was migrating from the mountains under hydraulic pressure, as

according to Munn and others it does move, or by any other process, it would be trapped in the Ruakituri anticline before it reached the Mangapahi and Morere anticlines, which are now being drilled for oil.

Stone.—The best stone mentioned last year—the limestone at Long Point, on Mahia Peninsula—was followed on the mainland from Whakapunake south-east for twenty miles to the coast four miles west of Nuhaka, where it forms a cliff, 100 ft. high, within 6 chains of the railway-line.

This limestone could be used in agriculture, and quarries could be opened in it in any convenient place. Other outcrops of limestone occur in the hills east of the Wairoa Valley, where they form the Marumaru caves and other smaller rock shelters. A more accessible limestone crops out in Taramarama Survey District, on the south side of the Waikare Taheke-Valley, on Trig. K hill, three and a half miles west of Frasertown.

4. ROTORUA–TAUPO SUBDIVISION.

(By L. I. Grange.)

Introduction.

During the field season, which lasted from August, 1927, to May, 1928, the geological survey of the Rotorua district was completed and work in the Taupo district well advanced. Except for relatively small areas near Reporoa and Ohaki, a strip of the Ruapehu – Taupo – Rotorua – White Island active volcanic belt, sixty-nine miles long, has now been surveyed in detail. This season about 1,100 square miles was examined.

In addition, visits were made to White Island, Ngauruhoe, and the head of the Mangatu Stream west of Lake Taupo. A report on the sulphur deposits at Rotokaua was also prepared.

The writer was assisted in the field by Messrs. S. J. H. Sylvester, B.Sc., Lecturer, Canterbury College; L. W. Stevens, Otago University; and W. M. Jones, M.Sc. In the Rotorua district the 20-chain contour maps of the Lands and Survey Department greatly facilitated the work. The Perpetual Forestry Co. kindly allowed the writer to use copies of their detailed map of the district around Atiamuri and Tokoroa.

The rocks of the subdivision are rhyolite, dacite, and basic-andesite tuffs and flows, and lake and fluviatile beds of late Tertiary to Recent age. Of the volcanic rocks much the most abundant are the acid rocks.

Physiography.

The earliest eruptions built up hills of rhyolite. Then came explosive eruptions on a grand scale, which covered the whole subdivision with a thick coating of rhyolite tuff. Since the surface of this deposit, except where disturbed by later movements, is almost flat, it is thought that the fragmental material was laid down in water. Faulting broke up this land surface, and an elongated depression was formed, trending north-north-east, between the little-disturbed upland areas of the Kaingaroa Plains and Mamaku Plateau. The faults bounding the depression are irregular, and southward near Atiamuri are not well defined. Later faulting, eruptions, and thermal activity have been confined to the depressed area. The strong fault on the western side of the Paeroa Range crosses the Waikato River at Orakei Korako and can be traced as far as Oruanui. Southward, late lava-flows obscure the older surface, but this fault probably extends as far as Taupo. Faults appear to determine the course of the Waikato River; one extends from Taupo north-eastward to the mouth of Orakonui Stream, and another follows the Waikato in its westerly course from Whirinaki junction.

After the main faulting, a lake covering an area of fully 300 square miles stretched between Taupo and Rotorua. Between Taupo and Atiamuri it covered the flats in which the Waikato is now entrenched, and in places was more than six miles wide. For a few miles up the Whirinaki Valley from the Waikato River the lake was about three-quarters of a mile wide, but northward opened out to eight miles. At the time the lake was drained it had been fairly well filled with sediments and fragmental material, though earth-movements and volcanic eruptions were most likely the main causes of its final disappearance. Over most parts the lake-beds lie flat at 1,260 ft. above sea-level. South of Hemo Gorge they have been tilted, and on the side of Haparangi Mountain—a late rhyolite volcano—they are above 1,600 ft.

Lake Taupo is believed to have been formed in late Tertiary times, mainly by subsidence and partly by explosions contemporaneous with the tilting of the beds of the former lake between Taupo and Rotorua. Explosions and faulting movements occurring in recent times have altered its outline somewhat. Whangamata and Whakaipo bays are in fault gräben trending north-north-east. Some of the faults of the gräben are still active, and movements along them caused the remarkable swarm of earthquakes between April and December, 1922.* The block between Kaiapo and Whangamata bays was depressed several feet; on the eastern side a series of earthquake rents was opened for seven miles, the throw of the individual rents in places amounting to 3 ft. The western bounding fault, which strikes north-north-east from the mouth of Okaia Creek in Whangamata Bay, has been followed for six miles; in places there are surface steps up to 6 ft. high. Smaller breaks, downthrowing to the west, occur in the depressed block; one extends north-north-east from the mouth of Mapara Stream in Whakaipo Bay, and another follows the cliffs on the eastern side of Whangamata Bay. In Whangamata Bay the old strand-line is now about 12 ft. below normal lake-level.

* See P. G. Morgan: N.Z. Geol. Surv. 17th Ann. Rep., C.-2c, pp. 10–11, 1923.

General Geology.

Below is shown in downward order, what is thought to be the sequence of rocks of the subdivision :—

11. Tarawera basic-andesite shower.
10. Thermally altered tuffs from explosion craters on Maungakakaramea.
9. Pumiceous rhyolite showers : one at Rotorua and one at Taupo.
8. Rotokawau basic-andesite shower.
7. Several showers of pumice.
6. Basic andesite of Karangahape Cliffs, &c.
5. Vesicular hornblende rhyolite (variations spherulitic, lithoidal, and banded rhyolite and spherulitic obsidian), Tauhara dacite.
4. Rhyolite tuff and breccia.
3. Basic-andesite flows and lapilli and pumice contemporaneous with lake-beds.
2. Rhyolite tuff at Mamaku, basic andesite near the top.
1. Spherulitic rhyolite.

1. Only in one place—at the foot of the Paeroa fault-scarp—is the spherulitic rhyolite seen underlying the rhyolite tuff (No. 2). Since it resembles the spherulitic rhyolite associated with the vesicular hornblende rhyolite that was undoubtedly poured out after the main faulting, it is difficult to fix certainly the age of some of the rhyolite masses.

2. The rhyolite tuff that is the predominant rock of the subdivision is undoubtedly sorted only near Atiamuri and east of Tokoroa. The material is widespread and must have been blown from many vents, but in only a few localities is there definite evidence that these were close at hand. A tuff at Te Karaka Point, Lake Taupo, with long silky shreds of pumice grading into the groundmass and reminding one of the "wilsonite" at Waihi, evidently came from a vent near by. Round vesicular bombs of obsidian of the "bread-crust" type up to 5 in. in diameter, in the tuff near Atiamuri, point to vents not far distant. The tuff seems to be similar in mineral composition to the rhyolite-lava flows. Unlike the tuff of No. 4, it is cemented and well jointed. Bombs and lapilli of basic andesite closely resembling those thrown from Tarawera Mountain in 1886 occur near the top of the tuff in the Whangapoa Valley near Atiamuri. Reddish basic-andesite scoria overlain by rhyolite tuff is exposed on Johnson Road, in the Perpetual Forestry plantation, north of Atiamuri. Lapilli from the same source are scattered through a dark band of rhyolite tuff 12 ft. thick in this locality.

3. The beds deposited in the former lake that stretched from Taupo to Rotorua are thin-bedded silts, sands, gravels, tuff, and breccia. In places the silts have small overturned folds due to slumping while the beds were still soft. Beds of diatomite outcrop in the Whirinaki Valley and alongside the Waikato River between Orakei Korako and Whakapapataringa Trig. Station. The gravels are made up of pebbles of rhyolite tuff, silicified silts, and rhyolite. The pumice breccia on the bank of the Waikato two miles below Orakei Korako contains bombs of basic andesite identical with the Tarawera basic andesite. Thick bands of basic-andesite lapilli in the lake-beds at Waikeruru Point, Lake Taupo, evidently came from the old volcano on which Trig. Station K is placed. Thin sections of the flow rock examined under the microscope were seen to contain phenocrysts of basic feldspar, much olivine, and a little augite. Possibly this and other basic andesites mentioned in this report should more correctly be termed basalts. Bombs of basic andesite in fragmental material underlying banded rhyolite at Karangahape Cliffs, Lake Taupo, came from an eruption simultaneous with or a little later than that at Trig. Station K.

4. Thick loose beds of pumice tuff and breccia occur in the depression north of Rotoiti, Rotoehu, and Rotoma, in the Tarawera Valley, between Hemo Gorge and Waiotapu, and in the Waikato Valley in its course northward from Lake Taupo. They rest on lake-beds in the basin south-east of Hemo Gorge and at Taupo. North of Rotoma, in the Pikowai Valley, these tuffs overlie unconformably the hard rhyolite tuff (No. 2). In Stowell Creek, a branch of the Tarawera River four miles downstream from Lake Tarawera, they are overlain by vesicular hornblende rhyolite. The breccias contain lumps of highly vesicular rhyolite, showing big crystals of hornblende and mica, and rhyolite similar to that of No. 5. No doubt in some localities flows of the vesicular hornblende rhyolite preceded the tuff eruptions.

5. The rhyolite volcanoes that were formed after the main faulting—Ngatuku, near Atiamuri, Pukemoremore, Kaimanawa, Ngangiho, and those in Whakaipo Bay—are more or less dome-shaped, and resemble some of the puys of the Auvergne and Hungary. The sides are steep, the top flattish, and some of them carry several small peaks. Hand-specimens of the rock differ considerably : there is vesicular hornblende rhyolite, spherulitic rhyolite, banded rhyolite, lithoidal rhyolite, and black spherulitic obsidian. Several of the variations may be seen on one volcano. Ordinary hornblende, cossyrite or near ally, augite, hypersthene, and possibly enstatite, occur. The feldspars seem to range from albite-oligoclase to andesine. Orthoclase was not recognized with certainty in the thin sections, but the analyses show some to be present. The rocks containing cossyrite or other closely allied soda-hornblende approach the pantellerites. Some of the flows—*e.g.*, that overlying the rhyolite tuff west of Ngongotaha Mountain—may be of dacite.

6. A basic-andesite flow, about 20 ft. thick (Trig. K type) forms the top of Karangahape Cliffs. It came from a wide crater south-east of the cliffs. Only half of this crater is now seen, the other half having subsided below lake-level. Probably the basic-andesite outcropping on the Taupo Totara Timber Co.'s railway one mile north of the bridge over the Waikato, that of Te Apuahoe volcano two miles north-east of Tauhara Mountain, and that exposed in the gorge of the Waikato River a quarter of a mile below the junction of Orakonui Stream are best correlated with the andesite of Trig. K or Karangahape eruptions. The position of the acid hypersthene andesite of Mount Edgecumbe in the sequence is not known, but it is certainly younger than the tuffs of the Kaingaroa Plains, for a dyke of this rock intrudes the tuff close to the Tarawera River on the eastern

edge of Rotoma Survey District. A hypersthene andesite outcropping close to the Manawahe Road north of Rotorua appears to be younger than the hard rhyolite tuff.

7. The source of the showers of pumice in the Taupo district older than the Rotokawau basic andesite has not been found. According to analysis, the pumice of the Rotorua shower is a dacite.

8. The Recent basic-andesite eruptions from vents south of Rotoiti were somewhat like the Tarawera type of eruption. Four craters—Roto Atua, Roto Ngata, Deadman's Gulch, and Rotokawau—are in line, and at least three of them erupted basic-andesite lapilli identical with that blown from Tarawera craters. The basic andesite of Rotokawau contains small phenocrysts of labradorite and augite in a groundmass of feldspar laths, augite, and some doubtful olivine. The silica content is 51·16 per cent. and the lime 11·41 per cent.

9. The latest showers of pumice at Taupo were probably ejected by the Karangahape volcano. Around the lake the fragmental material is coarse, boulders of banded rhyolite in it being up to 4 ft. in greatest diameter. It can be traced northward to Tokoroa and nearly as far as Hemo Gorge.

The history of volcanic eruptions is fairly complex. There were many outbursts, and the intervals of rest seem to have been comparatively short. The Tarawera eruption of 1886 was not isolated; it was one of a series caused by the rising of basic magma along fissures. Similar eruptions in the past have alternated with those due to rhyolitic magmas. So in the future not only may comparatively mild eruptions of the Tarawera type occur, but also the far more devastating pumice explosions.

Hot Springs.

Special attention was paid to the hot springs. Large-scale maps showing accurately the position, temperature, reaction, &c., of the springs of the different localities were made. Mr. Thomas Esdaile, A.O.S.M., under the writer's direction, has been carefully recording the temperatures of forty-one springs near Rotorua.

The Wairakei Valley springs, which are located on a fault along the valley-bottom, are at or close to boiling-point. An open fracture crosses the Champagne Pool, and another joins several of the springs near the Prince of Wales Feathers. Several geysers play regularly at intervals of a few minutes to a height of 10 ft. to 20 ft. With the exception of a few muddy springs, they are alkaline or neutral, and have a salty taste. No sulphur is being deposited.

The springs in the Waiora Valley, a few miles south of Wairakei, which are also along a fault, are acid, and some reach the boiling-point. At the head of the valley a number of small fumaroles are depositing sulphur. The cliffs of rhyolite tuff near the head of the valley are in parts being opalized and pyritized.

The alkaline springs in the valley-bottom behind the Terrace Hotel at Taupo are probably fed by subsurface streams of hot water derived from springs near Tauhara Mountain. Several dry washouts from the foot of Tauhara converge at the springs.

Several clear alkaline boiling springs rise on the east bank of the Waikato near the Spa Hotel. One of them, the Crow's Nest Geyser, is surrounded by a mound of sinter 7 ft. high and 11 ft. across. Back from the river is an area of boiling mud-pots.

There is considerable thermal activity at Rotokaua, north of Taupo, where the ground is altered over an area 90 chains by 60 chains. Many small steam-vents, collapse-holes, small patches of sulphur, and hot pools are to be seen. The springs, a number of which lie at the bottom of collapse-holes 20 ft. to 30 ft. deep, are, with few exceptions, strongly acid. The area is remarkable for the amount of gas that is bubbling up in the water; more gas comes up here than in any other part except Tikitere.

Thermal activity is spread over a wide area at Orakei Korako, on the Waikato River, nine miles south-east of Atiamuri. On the west bank of the river are several clear hot alkaline pools, one of which plays when soaped, and two boiling mud-pots. Across the river from the geyser numerous steam-vents warm the ground for two miles up-stream. All the springs except that in the Alum Cave are neutral or alkaline. The Terrace Geyser boils continuously, throwing water to a height of about 12 ft. in the same manner as Papakura Geyser at Whakarewarewa. Alongside the Terrace Geyser is a beautiful terrace of grey sinter 15 ft. high. Small springs on the bank of the Waikato have an edging of fretted snow-white sinter, and their overflow has formed white terraces.

The hot springs on either side of the Orakonui Stream are alkaline or neutral, and deposit snow-white sinter.

In a branch of the Waipapa Stream north-west of Oruanui Siding are hot alkaline and acid pools and boiling mud-pots. A fault follows the Waipapa from the junction of this branch to its mouth, and at two points along it hot, weakly mineralized water depositing white sinter issues close to the stream.

Water from a spring near Tikitere contains 1,638 parts of sulphate radicle per 100,000. The other mineral waters of the subdivision that have been analysed range in total solids from 22 to 324 parts per 100,000.* The mineral contents are principally alkaline chlorides, aluminium and alkaline sulphates, and silica. The sulphate radicle is the most abundant. The waters of Frying-pan Flat and Inferno lakes in the Waimangu Valley, two springs at Waiotapu, and one on the flank of Maunga-ongaonga contain free hydrochloric acid. Several have appreciable amounts of boric acid. In general, it may be said that the alkaline springs are much weaker in mineral content than the acid. Most of the alkaline springs have fairly strong overflows, and rise apparently in well-defined underground channels.

The samples of gas analysed were similar in composition to those examined last year. They consisted mainly of carbon dioxide, with smaller amounts of carburetted hydrogen, sulphuretted hydrogen, nitrogen, and oxygen. The gas from Hinemoa's Bath, on Mokoia Island, is extraordinary in that it contains 88·30 per cent. of nitrogen and only 2·75 per cent. of oxygen.

* All the summaries of and partial analyses mentioned in this report are from complete analyses made by the Dominion Analyst and his staff.

During the nearly rainless months early in this year (1928) unusually large amounts of fibrous white and yellow salts encrusted the thermally altered ground. Aluminium, ferric and ferrous, and sodium sulphates are the predominating salts in them, though traces of chlorides are also present. Those occurring at Sulphur Gully and Frying-pan Flat contain ammonium salts, the nitrogen of which is generally believed to be derived from the magma.

The temperatures of the springs near Rotorua vary considerably. Over a period of nine and a half months—from 15th September, 1927, to the end of May, 1928—the lowest average temperature of fourteen springs was 173·7° F., and the highest 194° F. On the 6th October, the 10th November, and in the middle of December the temperatures were high. During the whole of January and February they were low, and in March rose slightly, the highest being on the 17th. Temperatures continued to rise during April, reaching, on the 26th, a maximum just a little below the highest for December. They were also high in May, the maximum being on the 15th.

The record from January onward shows the effect of rainfall. The temperatures were low during the dry period and became high after heavy rains. Probably the increase is caused by additional water descending and accelerating the circulation of the ground-waters.

Some of the springs, more particularly the mud-pots, are affected by rainfall in the reverse way. In summer the amounts of water in them decreases and the temperatures increase, whereas during wet weather they are flooded and the temperatures fall. No doubt these springs are shallow, receiving surface waters from small surrounding basins.

Economic.

Sulphur.—The principal sulphur deposits of the subdivision are at Tikitere and Te Tarata (south of Rotoiti), on the eastern side of Rotorua Township, and at Rotokaua. In the few sections that were seen the ore is usually not more than 2 ft. 6 in. thick. Most of it is high-grade, the sulphur content ranging from 60 to 94 per cent. The larger areas in the Rotorua district have been worked for the high-grade material. From the Tikitere–Te Tarata area about 5,000 tons of crude sulphur was obtained between 1900 and 1902, and at Rotorua 6,460 tons has been obtained. Using the scanty data at present available, the writer estimates that between 5,000 and 6,000 tons of sulphur (reckoned on a 100-per-cent. basis) occurs in the Tikitere – Te Tarata area, between 7,000 and 8,000 tons at Rotorua, and about 3,000 tons at Rotokaua.

Gold and Silver.—A visit was made to a quartz vein discovered in 1924 by a Maori in a rill of the Waiaute, a branch of the Tarawera River. An excavation about 15 ft. long by 8 ft. wide in the bed of the rill exposes a light-slate-coloured mineralized rock in which common opal and small crystals of pyrite can be recognized. Thin sections show opal, quartz, and pyrite. Less than a chain up the rill the enclosing rock, a fresh augite hypersthene andesite, outcrops. Still higher up, mineralized rock, pug, and andesite are found for about 3 chains. The extent of the mineralized rock cannot be stated owing to the thick covering of rhyolite tuff. Small outcrops were located in a creek about one mile and a half to the south-east. The highest values per ton in the samples collected by Mr. M. Paul, Inspector of Mines, were gold, 3 dwt. 4 gr., and silver, 9 dwt. 19 gr. The andesite appears to have been altered by hot springs at the surface, and consequently it is not thought that values will be better at a greater depth.

Diatomaceous Earth.—As mentioned above, thick beds of diatomaceous earth occur in the Whirinaki and Waikato valleys. In the Whirinaki Valley it outcrops at intervals over a distance of 90 chains, the thickness being from 15 ft. to 18 ft. In this locality more than a million tons is present. The diatomite in the Waikato Valley is up to 15 ft. thick. A sample from the Whirinaki Valley contained 73·16 per cent. of silica and 12·61 per cent. of water. The impurities are most likely mainly very fine glass-particles.

Clays.—Highly plastic clays—white, grey, and red—formed by the thermal alteration of the rhyolite tuffs and flows occur in many parts. The Dominion Analyst reports that a sample from a large deposit on the western side of Paeroa Range, north-west of Maungaongaonga, consists of finely divided clayey material with about 8·7 per cent. of quartz-particles. If the analysis of the sample, the free quartz being omitted, is recalculated, it agrees fairly well with the theoretical composition of kaolin and very closely with those of kaolins given by Dana.

Roadmaking-material.—Most of the roads of the subdivision are formed of the pumice of the late showers. If graded and repaired often, a good surface can be kept on it. The best road-metal is the basic andesite; the nearest deposit to a road forms the hill west of Taupo on which Trig. K is placed.

5. MURCHISON SUBDIVISION.

(By H. E. Fyfe.)

Introduction.

Field-work was recommenced in the Murchison Subdivision for the second season early in October, 1927, and continued till late in May, 1928. Some 400 square miles in the survey districts of Lyell, Maruia, Tutaki, Matiri, Maunga, and Rotoroa were examined in detail, thus completing, with the exception of a small area in the Maruia Survey District, the survey of this subdivision. The area described adjoins on the west the Buller–Mokihinui and the Reefton subdivisions (Bulletins Nos. 17 and 18), and on the north the Motueka subdivision.

Structure and Physiography.

North-north-east-striking faults divide the area examined into a series of earth-blocks, some elevated, some depressed, and tilted in different directions, east and west dips predominating. Occasionally the covering Tertiary strata are horizontal or gently warped, and in the vicinity of faults

vertical dips are not uncommon. Though the tilted blocks may be so disposed as to simulate folded strata, few, if any, anticlines or synclines exist, and careful examination generally shows that the apparent major folds have been fractured by faults along the crests or troughs.

The west and north-west portions of the area consist of the highlands forming the Brunner and the Victoria ranges, south of the Buller, and the Lyell range, north of that river. These elevated earth-blocks are bounded by faults on both sides. The highlands north of the Buller are drained by the headwaters of the Matiri, and by the Newton and Lyell rivers. The Little Deepdale and the Big Deepdale are the main drainage-channels of the highlands to the south.

That part of the Murchison depression examined is roughly triangular in shape, with a base extending between the headwaters of the Tutaki and Big Deepdale, and an apex five miles due north of the Owen–Buller junction. It is drained by the Maruia, Matiri, Matakitaki, Mangles, and Owen rivers, and by that portion of the Buller between the junctions of the Maruia and Owen.

High-level terraces are conspicuous in the valleys of the Matakitaki, Maruia, and Big Deepdale, and along the Buller from Longford to and beyond the boundaries of the subdivision. The most extensive of these averages in height about 1,000 ft. above the present drainage-levels. In the vicinity of the Maruia–Buller junction and thence down-stream to the Lyell, this terrace is well marked. Terrace-remnants of different heights up to this 1,000 ft. level occur in several of the main valleys.

Small lakes dammed by land-slips are present in Blue Duck Creek, in the Eight-mile (a tributary of the Matakitaki), and in the Matiri River. The most extensive is Lake Matiri, which has an area of 150 acres.

Principal Faults.

From near the Buller–Gowan junction the Tutaki fault has a south-west course to a point three miles south-east of Mount Murchison, whence it swings to the south-south-west, and follows the Mangles and Tutaki valleys, determining the contact of the igneous and sedimentary rocks. It is a reverse fault, the plane dipping at an angle of 60° to 65° to the south-east. The Tertiary strata close to the contact usually dip at from 70° to 80° in the same direction.

The strong fault separating the granite of Mount Murchison from the Tertiary to the west strikes south-west into the younger rocks and three miles south-west of the mountain divides into three branches. The east branch strikes south-south-west and passes about 20 chains west of Noel Peak. Near Mr. Lyon's house, in the Mangles Valley, the throw diminishes and the strata appear to be folded into a syncline; but variable strikes occur west of Page Morel Trig., indicating the probable continuation of the fault south of the Mangles. The middle branch of the fault strikes south-west and passes some 40 chains west of Mount Harte. Near the Blackwater–Mangles junction the fault-zone is 60 chains wide. From here it strikes more to the south and continues up the Blackwater Valley, apparently with diminishing intensity. The west branch crosses the Mangles Valley a mile and a half above the junction of the Blue Duck Creek, and continues beyond the headwaters of that stream into the headwaters of the Six-mile, a branch of the Matakitaki.

The fault following the Buller Valley from Owen junction to Longford continues south-west to and beyond a point near the Glenroy–Matakitaki junction.

The lower course of the Matiri is a fault-line valley. The fault strikes north-east and passes beyond the subdivision into the Wangapeka basin. Its continuation south of the Buller is obscure, but it probably runs up the Matakitaki Valley for two or three miles. Another north-east-striking fault determines the course of the headwaters of the Matiri River.

In the Deepdale, lower Maruia, and Buller valleys narrow strips of steeply dipping and more or less crushed Tertiary strata extend north-east and north-north-east along fault-zones traversing the granites of the western part of the subdivision.

The Boundary Peak fault of Bulletin No. 18 enters the subdivision three miles south-south-west of that mountain and, striking north-east, separates the Lyell and Mount Glasgow ranges.

General Geology.

The following table shows the subdivisions of the strata within the area examined:—

Approximate Age.	Series.	Subdivision.	Thickness.	Description.
Recent and Pleistocene	..	..	..	Fluvio-glacial gravels, varved clays and silts, fluviatile gravels.
		(Unconformity.)		
Miocene and Oligocene	Oamaruian ..	Upper beds	10,000 ft.	Conglomerates and coal-seams; arkositic sandstones, grits; mudstone, argillaceous sandstone, banded sandstone.
		Middle and lower beds	6,000 ft.	Limestone, mudstone, and banded sandstone; calcareous claystone and mudstone.
		(Disconformity.)		
Eocene	Mawheranui	Kaiata beds ..	1,700 ft.	Conglomerate, calcareous mudstone, argillaceous sandstone, carbonaceous mudstone.
		Brunner beds ..	700 ft.	Arkositic grits, conglomerates, sandstones and shales with small sub-bituminous coal-seams.
		Hawk's Crag breccia ..	150 ft.	Breccia of angular and sub-angular argillite, greywacke, quartz and schistose rocks.
		(Unconformity.)		
Ordovician ..	Aorere ..	..	..	Greywacke, argillite, hornfels, phyllite.
Post-Ordovician and pre-Tertiary	..	Igneous rocks ..	..	Basic dykes, acid dykes, granite, diorite quartz porphyry, gneiss.

Palæozoic Rocks.

Lower Aorere Series.—Rocks probably of Lower Ordovician age cover a considerable area in the western part of the subdivision and also a small area near the north boundary. Near Lyell a thick series of greywacke, argillite, phyllite, and slate, in places altered by granite to hornfels, outcrops over the greater part of the basins of Lyell and New creeks. The rocks, which are much jointed, strike meridionally and dip steeply east and west. In place they contain bedded quartz veins, some of whch are payably auriferous. The quartz veins and the containing country of Lyell and Reefton are closely similar, and all writers have correlated them.

Greywackes and finely banded argillites on the Matiri-Wangapeka divide strike north-north-east, and dip east and west at angles up to 75°. They contain quartz veins and, together with similar rocks at Lyell, are correlated with the Aorere Series of Lower Ordovician age.

Rocks of Doubtful Age.—Thick beds of altered sediments consisting of thin bands of quartzite and semi-phyllite outcrop in the basin of Mole River, a branch of the Matakitaki draining the south-west corner of Rotoroa Survey District. These rocks, which contain no internal evidence of their age, do not resemble those of Raglan and Ben Nevis ranges, or those of the Aorere, Mount Arthur, and Haupiri series of the Motueka Subdivision.

Tertiary Rocks.

The subdivisions of the Tertiary described in Bulletin No. 17 are applicable to the present area, though the thicknesses of the individual groups differ considerably in the two areas.

Hawk's Crag Breccia.—On the divide between the Wangapeka and the Matiri rivers one mile north-north-west of Trig. W, is a small outlier of a breccia resembling the Hawk's Crag breccia, and consisting of angular and subangular fragments, pebbles, and boulders (up to 4 ft. 6 in. diameter) of greywacke, argillite, quartz, and schistose rocks, set in a gritty matrix, the whole resting on greywacke and argillite. Interbedded with the breccia are minor bands of shale, carbonaceous shale, and sandstone. Half a mile south of Trig. W, the breccia again outcrops, and here is about 150 ft. thick. Grits, sandstones, shale, and a thin seam of sub-bituminous coal of the Brunner beds overlie the breccia.

Brunner Beds.—The Brunner beds are poorly represented in the area here considered, and from an economic point of view are here regarded as valueless. They outcrop near Trig. W and again six miles due south in a tributary of the Matiri flowing from Trent Peak. Here a succession of strata rests on granite, the lowest beds consisting of about 15 ft. of arkositic grits and fine conglomerate, with angular, and subangular granite and quartz pebbles, occasionally as much as 12 in. in diameter. An indurated sandstone, 1 ft. thick, rests on the above, and is overlain by sub-bituminous coal 2 in. thick, followed by shale and arkositic sandstones. The total thickness of the Brunner beds is here about 35 ft., but a mile and a half south-west of Mount Murchison Trig. these beds are 700 ft. thick, including perhaps some of the overlying Kaiata beds. In this locality the Brunner beds consist of a series of conglomerates, sandstones, arkositic grits, and carbonaceous shales.

Kaiata Beds.—Overlying the Brunner beds in the above-mentioned tributary of the Matiri River are carbonaceous mudstones 700 ft. thick, concretionary in the lower portion, and smelling distinctly of oil on fresh fractures. The mudstone yielded a few Eocene fossils. Mottled, slightly calcareous mudstone, 1,000 ft. thick, overlies and is followed by a band of conglomerate containing well-rounded pebbles, up to 1½ in. in diameter, of sandstone, mudstone, quartz, and granite. This horizon is considered to represent a mild disconformity at the close of the Eocene.

Lower and Middle Oamaruian Beds.—Gritty sandstones containing quartz and granite pebbles rest with disconformity on the Kaiata beds. Above them are sandstones, followed by claystones and marl, passing into a limestone band containing fragmentary fossils as well as mudstone pebbles. In the upper Matiri basin these beds are 2,000 ft. thick, and are followed by 1,500 ft. of mudstone and banded sandstone, all more or less calcareous, and capped with a limestone band. Some of these beds show subaqueous gliding. The limestone outcropping at the limestone-crusher site a mile west of Murchison is considered contemporaneous with this upper limestone band. Here it overlies some 6,000 ft. of mudstones and argillaceous sandstones, all more or less calcareous. This sequence appears to be unbroken, but there are faults in the locality and some of the beds may be repeated. Mudstones probably of this age outcrop in the Mangles-Grassy valley near Mr. McAuliffe's house, in the Blackwater Valley, and in the Matiri Valley near the Sandstone Creek junction. Limestones of Middle Oamaruian age outcrop at the bridge across the Buller two miles below Lyell, at Brown Creek, at a point two miles up the Glengarry from its junction with the Maruia, in Taylor Creek, and at the bluffs at Trig. G in the Tutaki Survey District. Most of these limestones contain angular granitic pebbles and boulders. Though the limestones are represented in many localities, elsewhere in beds of the same age they are absent.

Upper Oamaruian Beds.—The beds of this age consist of banded sandstones, argillaceous sandstones, and mudstones, followed by arkositic sandstones, grits, and conglomerates, with shale and coal-seams. The banded sandstones are exposed close to Murchison in the hills west of the Matakitaki. Here they overlie the limestone of the Middle Oamaruian Series. They outcrop in the Mangles Valley up-stream from the Blackwater, and again in the upper Mangles Valley, where they are 4,000 ft. thick and overlain by conglomerates. The conglomerates, with the associated sandstones, grits, shales, and coal-seams, are thickest north of the Buller from Murchison to Longford; 6,000 ft. of strata are exposed, but faulting may have increased the apparent thickness of these beds.

Pleistocene and Recent.—The deposits of Pleistocene age consist of varved clays and silts and fluvio-glacial and fluviatile gravels. Varved clays are common near Murchison, outcropping at various

places along the Buller River. They also outcrop in the Te Wiriki Valley, a tributary of the upper Mangles, and in the headwaters of the Glengarry. Fluvio-glacial greywacke boulders are scattered from the Tiraumea-Mole saddle to and beyond the Mangles-Nuggety Creek saddle. Fluviatile gravels are found from the present drainage-level to a height of 1,200 ft. above it.

Igneous Rocks.

Granite forms a great part of the mass of the highlands in the western portion of the subdivision. The granite of the Lyell Range and Mount Newton, north of the Buller, extends south of that river and covers nearly the whole of Maruia Survey District. In the Big Deepdale Valley the granite is gneissic. Basic dykes and schlieren, as well as veins of pegmatite and quartz, are common. In the basins of Lyell and New creeks the Ordovician sediments intruded by this granite contain basic dykes, no doubt derived from the same magma.

Mount Murchison is formed of the granite that extends across the Buller from the Hope Range. This granite is not the same as that of the western mountains.

More basic plutonic rocks, consisting of diorite, quartz diorite, and basis granite, outcrop over much of the western part of Rotoroa Survey District.

Economic Geology.

Coal.—Coal outcrops in several localities, and has been worked to a small extent near Longford and in the lower Maruia Valley. The Longford coal, which forms a friable coke, is excellent for household purposes and for steam-raising. The local demand is small, but when gold-dredges were at work in the district several thousand tons were mined yearly. Now that the railway from Nelson has reached the Buller, coal is likely to be regularly mined to supply that market.

In all about eight seams are known, but some of these are crushed or are too thin to work. The coal-measures extend from the Matakitaki–Glenroy junction northward to the Owen, but it is in the locality from Owen to Longford that the coal appears to offer the best prospects.

Gold.—Since about the year 1862 gold has been obtained in the Murchison and Lyell districts. The richly auriferous gravels of Lyell Creek derived their gold from the quartz veins outcropping in its basin. About 1870 quartz-mining here became an important industry, and several rich leaders and ore-shoots were discovered. The most noteworthy mine was the Alpine which, for a period, paid handsome dividends, returning to the shareholders £74,267 to the end of 1896. The Little Wonder, Tyrconnel, and other leader claims were exceptionally rich; the first-mentioned from October, 1872, to January, 1873, yielded 1,573 oz. of gold from 185 tons of stone. Gold-production fell off in 1889 and continued to decrease till 1910, when mining ceased. The bedded reefs are similar to those of Reefton, but the area is perhaps most noteworthy for the extremely rich leaders.

The beaches and terraces of the Buller, Matakitaki, Maruia, and Mangles rivers, and of some of the tributaries of these rivers have been worked from time to time, and from 1892 till 1904 dredging operations were in progress on the two first-mentioned rivers. There are still a few old alluvial miners in the district who eke out their pensions by occasionally washing for gold.

Mineral Oil.—Oil seeps from mudstone near Mr. McAuliffe's house in the Mangles–Grassy valley, and from sandstone near the Blackwater–Mangles junction. Distinct traces of oil can be obtained at several other localities, and gas emanations are not uncommon. The mudstones of the Lower Oamaruian and Kaiata beds at places smell strongly of oil on fresh fracturing.

The Murchison Oil Co. has drilled a hole to 4,085 ft. in the Mangles Valley, but so far has been unsuccessful in producing oil, though traces have from time to time been obtained.

Limestone.—Lime for agricultural uses is crushed at Brown Creek, on the main road from Murchison to the West Coast. The stone is tough and has a high lime content. Other outcrops of similar stone occur within the subdivision, but are difficult of access.

Roadmaking-materials.—Granites, greywackes, and allied rocks, plentiful within the area, yield excellent roadmaking-material, but the terrace-gravels and river-shingles are chiefly used on the roads.

6. PALÆONTOLOGICAL WORK, 1927–28.

(By J. Marwick.)

During the past year work has been continued on the Tertiary Mollusca. Many collections have been examined from Gisborne – East Cape districts, also from Hawke's Bay and Wairarapa. The description of many new species is necessary for the discussion of the faunal relations of the different formations involved, and this work is being proceeded with as opportunity offers.

In January a visit was paid to the Frasertown–Waikaremoana district. Collections were obtained from a number of localities, but unfortunately no good ones could be got from the lower beds. The fauna of the upper limestone along the Mangapoike strongly resembles that of the Te Aute Limestone of Hawke's Bay, and also agrees with the Waitotaran stage of the Wanganuian—*i.e.*, Lower Pliocene.

Other collections were made in the Mangawhero Valley. The fossils appear to be somewhat younger than those in the Waikare-Taheke Valley, but they are not a typical Petane assemblage.

The policy of building up a collection of foreign mollusca has been continued, and last year collections were exchanged with Ceylon and with Western Australia.

Publications: "The Tertiary Mollusca of the Chatham Islands, including a Generic Revision of the New Zealand Pectenidæ" (Trans. N.Z. Inst., vol. 58).

Since the 5th March I have been on leave from the Geological Survey, relieving Dr. Cotton at Victoria College.

7. GOLD IN THE WAIHAHA AND MANGATU, TAUPO.

(By L. I. Grange.)

In December, 1927, the writer visited the Mangatu prospecting party's camp in Mangatu Stream, about a mile and a half below Weraroa Trig. Station. The Mangatu is a large branch of the Waihaha, a considerable stream flowing into Western Bay, Lake Taupo, from the Hauhungaroa Mountains. The party, under the leadership of Messrs. Tennent and Raymond, had for several months been actively prospecting the gravels of the Waihaha and Mangatu, and the quartz veins of the upper valley of the Mangatu. Since the prospectors returned to Waihaha the day after the writer arrived at their camp, his examination of the country was necessarily hasty.

Waihaha, a small Native village in Western Bay, is reached by launch from Taupo Township. From it a track, in places ill-defined and fairly rough, leads to the head of the Mangatu, a distance of about fifteen miles.

The geology of the area is fairly simple. From the western side of Lake Taupo, north of Karangahape Cliffs, an upland surface of low relief extends westward to the foot of the Hauhungaroa Range. Close to the lake-shore it is 1,620 ft. above sea-level, two miles inland about 1,850 ft., and eight miles from the lake about 2,000 ft. On the coast the upland surface ends abruptly in cliffs which rise sheer from the edge of the lake (1,211 ft.). The main streams flowing down the slope of the upland surface are deeply entrenched, the valley-bottoms in places being fringed by precipitous cliffs. Farther inland the country rises to Moutere (3,248 ft.), Weraroa (3,580 ft.), Pareora (3,793 ft.), and other peaks of the Hauhungaroa Range.

The upland surface is composed of hard, well-jointed, rhyolite tuff similar to that occurring on the Kaingaroa Plains, with which, before the collapse and subsidence of the Lake Taupo basin, it was probably continuous. Argillite and greywacke of early Mesozoic or late Palæozoic age, outcropping in the valley-bottoms of some of the tributaries of the Mangatu for more than three miles of its course down the southern slope of Weraroa Mountain, show that the thick rhyolite tuffs occurring on the mountain are only a surface covering. The irregular distribution of the tuffs in the Mangatu Valley indicates that prior to the eruptions deep valleys had been carved in the old rocks. The strike of the old sediments, in the few places it was taken, was north and south, and the dip eastward at 60°. These rocks also outcrop in the head of the Waihaha Stream, since the gravel in it is almost entirely of argillite and greywacke.

The gold-bearing gravels near the mouth of the Mangatu and in the Waihaha were first prospected. Later the alluvial gold was traced up the Mangatu, in the valley of which the quartz veins were searched for. The prospectors state that they obtained as many as ten small "colours," occasionally reaching the size of a pin's head, from dishes panned in the Mangatu, and that concentrates of a yard of gravel from this locality was found on essay to contain a value of 1s. 6d. in gold. The writer panned a quarter of a dish of concentrates, consisting almost wholly of magnetite sand, and found eight angular "colours" ranging in size from $\frac{1}{40}$ in. to $\frac{1}{90}$ in. Thick gold-bearing gravels extend for about half a mile up-stream along the Mangatu, and a stretch of gravel about a mile long in the Waihaha is probably gold-bearing.

Altogether very little data have yet been obtained. The wash in the Mangatu has not been bottomed, the depth of gravel and its average gold content are not known, and much more prospecting would, of course, be required to get an idea of the return that could be expected.

The alluvial gold probably comes from quartz veins in the old rocks forming the range. The writer was shown two crush-zones carrying quartz, calcite, and pyrite. One, called December "Reef," 2,350 ft. above sea-level, about one mile and a quarter south of Weraroa Trig. Station, strikes 15° east of north and dips steeply westward. The crush-band is about 4 ft. wide, and contains much pug. The other, called Hades, in a tributary from the west about one mile and a half below the Trig. Station, strikes 30° east of north and dips eastward at 70°. The greywacke here is not so much shattered. Samples from both crush-zones assayed by the Dominion Analyst were found to contain no gold or silver.

Country in the North Island formed of the same set of ancient rocks has been prospected from time to time in the last fifty years, and although small colours of gold occur in many streams, no alluvial or vein deposit worth working has been found. Rich quartz may be located, but in such country the vein will probably be discontinuous. One cannot say that payable ground or quartz veins will not be found, but the chances are small.

J. Henderson,
Director, Geological Survey.

REPORT OF THE DIRECTOR OF THE METEOROLOGICAL BRANCH.

Observing-stations.

Two different classes of meteorological station have been evolved in New Zealand, each serving a distinct purpose. The first class was designed to provide the information necessary for the daily report and forecast. The first condition controlling the choice of these stations was that they should be readily accessible by telegraph, so that reports could be sent to Wellington with the minimum delay. They have, in general, therefore, been established in connection with post-offices, lighthouses, or Harbour Board offices. The instrumental observations are generally confined to those of pressure and temperature. A high standard of accuracy has not, in most cases, been aimed at. The barometer corrections, particularly that for height above sea-level, have been approximate only. The thermometers

with which the air temperatures have been taken have seldom been properly exposed. Frequently they are in partially screened positions on a south wall of a building. The observations have not been of a sufficiently high accuracy for modern forecasting purposes, much less for a permanent record. In consequence, they have not generally been stored after their use for the daily forecast.

The stations whose records it was intended to keep for the purpose of furnishing climatological statistics were established separately from the telegraphic stations. There is often a climatological station and a forecast station in the same town. This obviously means unnecessary duplication of observations. Another drawback has been that, since the telegraphic stations must have barometers, the climatological stations are usually without them. Few reliable records of pressure are therefore available.

The forecasting-stations have been selected apparently with a view to having reports from all the harbours used by shipping. It would have been preferable to have had a good network of stations, so that the meteorological situation could be thoroughly understood and future developments anticipated. There is a lack of stations on the west coast of the South Island, whereas in other parts they are perhaps unnecessarily numerous.

The prime desideratum for a climatological station is that it should be permanent. Unless the records can be maintained for a large number of years, they are of little value. Unfortunately, too large a proportion of the stations have been maintained by private individuals in their own grounds. The observer is usually unable, for various reasons, to continue the observations for a long period, so that they are either dropped or the outfit is removed to another private person's property. Not only does this mean a break in continuity, but even a slight move will often mean that meteorological conditions are very different. The records from the two stations cannot be combined. Furthermore, no adequate record of changes has been kept; observers have often had to set up their stations themselves without instruction, and there has been no adequate inspection of stations. Consequently instruments are frequently improperly exposed and defective types have sometimes been kept in use.

The most urgent need of the meteorological service in New Zealand is the establishment of properly equipped stations, on permanent sites with satisfactory exposure, and the ensuring of continuity of observations. A beginning could then be made of the collection of homogeneous and reliable data such as are needed in connection with an ever-increasing number of social activities. The accomplishment of this object in a young country where there are few leisured men and where towns are growing rapidly is a difficult matter which cannot be brought about at once. It will not be possible at all without the interest and assistance of local bodies and individuals.

Some progress has been made during the financial year in the desired direction. Steps are being taken to ascertain the exact heights of stations wherever possible. When these have been made available, accurate correction-cards for barometers have been prepared. The correction for gravity, which was previously applied at Wellington only, has been included. New forms have been prepared which provide for observations more in accord with modern practice and requirements. The maximum and minimum wet-bulb thermometers, whose use is not quite sound theoretically, are being replaced by ordinary dry and wet bulb thermometers.

As time and other duties permit, the inspection of stations is being undertaken. The greater part of the Nelson and Marlborough Provinces, and parts of Canterbury, Otago, and Hawke's Bay, have already been covered. Experience has shown that the inspection was most necessary. Numerous defects of exposure have been found, and in some cases portions of the outfit were unserviceable or of unsatisfactory pattern. It is quite easy for a badly exposed or badly designed rain-gauge, for example, to be 10 per cent. or more in error. The proper exposure of thermometers is not less important.

In several cases municipalities have now reserved the ground for a meteorological station and undertaken to secure continuity of observations. It is hoped that this example will be followed by others. It is difficult to believe that the information secured is not worth the expense to the city engineering departments alone. In a number of other instances equipment has been provided to various Government Departments, and the records will be maintained by members of their staffs.

The total number of new climatological stations established is ten, while two have been abandoned.

Frost-fighting.

In August the Director accompanied the Secretary to the Department and Mr. R. B. Tennent, Agricultural Instructor, to Otago Central, where an inspection of the district was made in order to study the problem of the protection of orchards against frost. Assistance has been given to the local Orchard Instructor and the Fruitgrowers' Association. Later in the year visits were paid also to the Hastings district. The Fruitgrowers' Association was addressed on the subject of frost-fighting. Largely through the initiative of the Mayor, a meteorological station was established at Hastings, which should prove useful to fruitgrowers as well as others. A paper on "The Protection of Orchards against Frost" was prepared and published in the *Journal of Science and Technology*. The paper summarized the conditions surrounding the occurrence of frost and frost-damage, and the experience gained in America in combating them. Copies have been distributed to those interested.

British Empire Airship Mission.

At the end of August the Dominion was visited by the British Empire Airship Mission, under the leadership of Group Captain P. F. M. Fellowes, R.A.F., who had with him Flight Lieutenant S. Nixon, R.A.F., and Mr. M. A. Giblet, Superintendent of the Airships Division of the London Meteorological Office. The Meteorological Office co-operated with the mission in the provision of preliminary data

regarding weather conditions in New Zealand as they affect flying, the selection of sites for an airship-base, and the preparation of plans for the extension of the existing meteorological service which will be required when airship services are in operation. In connection with the flying that was done in the course of this visit, and also on other occasions, forecasts have been issued to aviators travelling over parts of the Dominion.

Forecasting.

Wherever possible, attempts have been made to increase the value of the forecast by indicating the general situation. This will enable weather sequences and the forecast to be much better understood and will have a considerable educative value. A long-felt want has been satisfied by the issue of the evening forecast on Saturday and Sunday evenings and holidays as well as other days. This service, however, constitutes a severe tax on a forecasting staff of two, and it may not be found possible to continue it. The week-end issues, together with the inclusion of forecasts for the eastern Tasman Sea, have greatly increased the value of the forecast, especially to mariners. It is hoped that an adequate return has thus been given for the reports received from vessels in surrounding waters. The number of these is continually increasing, and they afford a very great assistance. The Union Steamship Company especially is deserving of thanks for assistance in this direction.

The availability of the forecast to the public, especially the farming community, and consequently its value has been greatly increased by its issue twice daily from the stations of the radio-broadcasting companies. During the coming year it is hoped to include reports from about sixteen stations in the New Zealand area with the evening forecast as broadcasted by wireless, so that mariners and others with a working knowledge of meteorology will be able to draw their own charts and so secure the maximum benefit from the forecast service.

Rainfall Data.

A commencement has been made of the preparation of a new annual rainfall map of New Zealand. When this is completed, attention will be directed to the provision of other data regarding rainfall to meet the requirements more especially of the engineering profession. Thirteen new rainfall stations have been established, and the distribution is gradually being improved.

Miscellaneous.

Numerous requests for meteorological information of various kinds have been received during the year from other Government Departments and private individuals. The use being made in this manner of the records collected by the Meteorological Office is being rapidly increased. Meteorological conditions are perhaps of greater importance to the man on the land than to any other class of the community, and there are numbers of researches in which valuable co-operation with the Department of Agriculture should be possible.

Owing to the extension of the railway-works at Thorndon, the site of the meteorological station there had to be surrendered. A new site was chosen at Kelburn, on the reserve near the Dominion Observatory. In the circumstances, this must be considered a good location, and it is anticipated that it will be permanent. Towards the end of the financial year a proposal was made to erect an office for the Meteorological Branch near the meteorological station. This would enable a much closer watch to be kept on weather conditions, and should in many ways lead to great efficiency.

Short Summary of the Weather for 1927.

Perhaps the most important feature of the year was the very low average velocity of the prevailing westerly winds as compared with other years. The absence of westerlies affected the climate in various ways. The rainfall on most of the west coast of the South Island was reduced. There were few hot, drying winds in Canterbury and other eastern districts. As a result the growth of grass and herbage was unusually luxuriant, and the effect of dry spells was felt remarkably little. Tides, also, appear to have been influenced, reports indicating that they were lower than usual on the west coast and just as consistently good on the east coast. Though we have no record of them, it is probable that ocean currents, also, were seriously affected.

Cyclonic storms were unusually frequent, and this again was probably associated with the absence of westerly winds. In spite of the latter, however, pressure systems moved from the westward with unusual speed.

Rainfall was above normal over the greater part of the North Island. In the South Island there were large areas in the central inland districts and the south where an excess was recorded, but elsewhere the totals were mainly below the normal.

The year was, on the whole, a cold one, temperatures averaging about a degree below normal. Sunshine was less than the average in most parts, but above it in Taranaki and the western portions of the South Island. In the winter and spring months snow lay unusually low down on the mountains, especially in the South Island, and was very thick.

Conditions were generally favourable to agricultural pursuits with an excellent growth of feed and a good yield from crops.

A summary of the observations from some of our more important stations follows.

SUMMARY OF METEOROLOGICAL OBSERVATIONS FOR 1927.

(The observations were taken at 9 a.m.)

Station.	Mean Pressure in Inches reduced to Sea-level and Standard Gravity.	Temperature (Degrees Fahrenheit) in shade.					Hours of Sunshine.	Rainfall.	
		Mean Maximum.	Mean Minimum.	Approximate Mean Temperature.	Extremes.			Total fall (Inches).	Number of Days.
					Maximum and Date.	Minimum and Date.			
Auckland	29·963	64·1	52·9	58·5	80·0, Jan. 24	37·0, June 16	1,928·5	53·56	201
Matamata	..	65·5	44·9	55·1	85·2, Feb. 6	22·4, July 15	..	50·56	157
Ruakura, Hamilton East	..	67·8	44·9	56·3	88·4, Jan. 27	23·6, July 15	..	49·92	174
Te Aroha	..	67·9	48·5	58·2	88·0, Jan. 19, Feb. 6	24·0, June 15, July 15	..	52·63	157
Waihi	..	65·8	47·6	56·7	87·3, Jan. 26	26·5, June 15	1,995·4	82·17	190
Tauranga	..	66·3	47·6	56·9	84·0, Jan. 17, Feb. 4	30·0, July 15	..	60·51	165
Rotorua	..	63·8	45·5	54·6	87·0, Jan. 28	27·0, July 16, July 18	1,997·5	58·05	149
New Plymouth ..	..	62·2	48·9	55·5	80·0 Feb. 13	29·4, July 15	2,071·7	63·93	194
Taihape	..	57·1	43·1	50·1	80·0, Feb. 14	27·7, July 14	..	41·15	184
Palmerston North ..	..	61·9	..	..	89·0, Dec. 26	..	..	38·37	173
Tangimoana ..	..	63 3	46·9	55·1	85·0, Jan. 30	29·0, June 14	..	34·01	142
Weraroa, Levin ..	..	62·2	47·2	54·7	87·0, Feb. 1	29·0, July 24	1,992·7	41·86	166
Napier	..	64·4	49·1	56·7	85·5, Jan. 24	28·5, July 16	2,298·0	31·18	133
Masterton	..	64·0	44·2	54·1	93·0, Feb. 14	26·8, July 16	2,080·4	43·78	162
Wellington ..	29·930	61·7	49·1	55·4	84·0, Feb. 1	31·2, Aug. 29	2,055·1	43·35	167
Nelson	29·899	61·8	44·8	53·3	81·1, Feb. 6	27·9, July 15	2,560·4	36·43	113
Hokitika	30·014	59·7	44·0	51·8	75·0, Jan. 31	26·5, June 20	2,143·1	107·96	188
Hanmer Springs ..	..	60·2	39·2	49·7	95·0, Feb. 14	19·0, May 12	2,135·2	45·45	134
Christchurch ..	29·886	60·2	43·0	51·6	89·2, Feb. 7	25·8, June 2, 5	..	21·36	135
Ashburton ..	..	60·2	40·7	50·4	94·0, Feb. 14	23·0, May 12, May 13, June 5	..	26·43	139
Lake Tekapo ..	..	56·3	33·6	44·9	86·0, Feb. 13	4·0, June 20	2,742·8	19·24	58
Timaru	..	59·9	41·6	50·7	90·4, Jan. 20	24·0, July 1	2,030·0	20·58	139
Waimate	..	59·2	40·8	50·0	87·0, Jan. 17	23·0, July 2	2,169·6	26·80	131
Waipiata	..	57·3	37·3	47·3	84·8, Feb. 14	12·0, June 19	2,275 6	17·80	133
Ophir	..	58·8	36·7	47·7	87·9, Feb. 13	8·7, July 2	..	15·00	82
Dunedin	29·887	58·2	42·6	50·4	85·0, Jan. 18	29·0, June 17	1,630·6	46·63	169
Gore	..	58·8	39·2	49·0	87·0, Feb. 13, Feb. 14	18·0, June 21	2,021·0	34·70	186
Invercargill ..	..	57·0	41·2	49·1	85·0, Feb. 14	24·0, June 19, July 1	1,444·2	43·72	226

EDWARD KIDSON,
Director of Meteorological Services.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR THE YEAR 1927.

BUILDINGS AND EQUIPMENT.

The buildings and equipment have been kept in good order and condition. The Observatory grounds are kept in good order by the Wellington City Corporation.

ASTRONOMY.

Astronomical Observations.

Observations of the meridian transits of stars and the sun have been made for the purpose of controlling the time service. The meridian transits of the sun are observed on every fine day, except on Saturdays, Sundays, and Government holidays, and the stars are observed whenever necessary.

Reception of Radio Time Signals at the Observatory.

The following radio time signals were received at the Observatory: Mean-time signals from Honolulu, 228; Malabar, Java, 216; Nauen, 205; Bordeaux, 57; Kavite, 55; Annapolis, 4. Scientific time signals were also received at the Observatory as follows: Nauen, 111; Bordeaux, 42; Rugby, 1.

The radio time signals received at the Observatory generally agreed with the Observatory clock within one second of time. Greater differences, however, have been observed in the following cases :—

	Differences from Observatory Clock.	
	From 1 to 2 secs.	From 2 to 3 secs.
Honolulu (NPM)	15	1
Nauen (POZ)	6	3
Malabar (PKX)	7	2
Bordeaux (LY)	2	..
Kavite (NPO)	8	..
Annapolis (NSS)	1	..

The Observatory is indebted to the Bureau Internationale de l'Heure, Paris, and to the U.S. Naval Observatory, Washington, for the corrections to the radio time signals sent out by the French and American observatories.

Time Service.

The time service has been maintained, and the regular signals have been sent out. The signals have been transmitted daily. The total number of time signals sent from the Observatory was 1,647. Of these, 460 were sent by wireless telegraph, 657 were sent by special circuit to the Telegraph-office, 300 by the signal lights at the Observatory, 102 by switching off lights on the Harbour Board building at Auckland, 100 by dropping the time-ball at Lyttelton, and 28 by telephone.

No radio time signals were sent on the following dates, owing to—

(1) The Wellington Radio Station (VLW), standing by for distress calls: Friday, 18th February, 1927 (at 09 h. G.M.T.).
(2) Line interruptions between the Wellington Radio Station and the Dominion Observatory: Monday, 21st March, 1927; Thursday, 13th October, 1927; Thursday, 1st December, 1927.
(3) Accident to circuit in Observatory: Saturday, 23rd July, 1927.

The present programme at the Observatory provides for the following time signals, most of which are sent by the Observatory standard clock, which is usually kept accurate to the nearest second of time—

Automatic Time Signals—

(1) To the General Post Office, Wellington, by telegraph, daily:
(2) To the Railway Department, Wellington, by telegraph, daily:
(3) To ships and to the general public at Wellington, by electric lights at the Observatory, daily:
(4) To the Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays, except Government holidays:
(5) To the Lyttelton Harbour Board, by dropping the time-ball at Lyttelton, on Tuesdays and Fridays, except Government holidays:
(6) To the South Island telegraph-offices, by telegraph, on Tuesdays and Fridays:
(7) Radio time signals through the Wellington Radio Station (VLW) every day at 10.30 a.m.
(8) Radio time signals through the Wellington Radio Station (VLW), on Tuesday and Friday evenings at 8.30 p.m., except on Government holidays:

Non-automatic Time Signals :—

(1) To ships and watchmakers in Wellington and to the Public Works Department by telephone, on application to the Observatory.
(2) The Observatory automatic time signals sent to the General Post Office are distributed by telegraphic hand signals at 9 a.m. daily to some 2,300 telegraph and telephone offices distributed all over New Zealand.
(3) Similar hand signals are also sent to all railway offices in New Zealand at 9 a.m. daily—by telegraph to 221 offices, and by telephone to 257 stations.

Government Buildings Clock.—The Government Buildings clock has been kept under fairly close control. A record is obtained at the Observatory by direct circuit from the clock, and the adjusting weights on the pendulum are altered from time to time. On 6th-9th December, 1927, the clock was being cleaned and overhauled, as it was found that it had been running very irregularly. The clock has been showing a better rate since it has been attended to.

Sun-spots.

The regular observation of sun-spots has been discontinued.

An enlarging camera for photographing sun-spots has been obtained, and is fitted for use with the Wellington City Council's 9 in. equatorial telescope. The camera is available for any particularly interesting groups of sun-spots.

International Astronomical Union.

By courtesy of the Central Astronomical Bureau, arrangements have been made for this Observatory to receive advice of all important astronomical discoveries. The information is forwarded by the Bureau at Copenhagen to this Observatory through the Melbourne Observatory.

The following information was received in this way during the calendar year 1927 :—

(1) Discovery of new comet by Blathwayt, magnitude 9·0, 13th January.
(2) Discovery of new comet by Reid, magnitude 8·0, 26th January.
(3) Discovery of new comet by Stearns, magnitude 10·0, 10th March.
(4) Parabolic elements of comet Stearns, by Cunningham.
(5) Discovery of a comet by Gale, magnitude 8·0, 7th June.
(6) Observation of comet Gale, 10th June, by Gonnessiat.
(7) Discovery of a comet by Schwassmann Wachmann, magnitude 14·0, 15th November.
(8) Discovery of a nova by Schwassmann Wachmann, magnitude 10·0, 18th November.
(9) Discovery of comet 1927K, by Skjellerup, magnitude 3·0, 3rd December.
(10) Observation of comet 1927K, by Maristany, 6th December.
(11) Elements of comet 1927K, by Wood.
(12) Parabolic elements for comet 1927K, by Dawson.

A number of these objects were observed throughout New Zealand by members of the Observatory staff and of the New Zealand Astronomical Society, and reports of the observed positions were sent to the Observatory and published in the monthly notes of the New Zealand Astronomical Society.

"New Zealand Nautical Almanac."

An article on the Dominion time-service arrangements, giving full particulars of all the time signals supplied by the Observatory, was prepared for and published in the "New Zealand Nautical Almanac."

International Longitude Determinations.

The results of the international longitude determinations made by the Dominion Observatory, Wellington, were published in Bulletin No. 69. As a result of this work, the value of the longitude of the Observatory adopted in the past, of 11 h. 39 m. 4·27 s. east,* is altered to 11 h. 39 m. 4·03 s. east.† A check value of the longitude was determined from almucantar observations, and was 11 h. 39 m. 4·04 s. east.

A report on the work was presented to the International Astronomical Union at its meeting at Leiden, Holland, in July, 1928.

Occultations.

In response to a request from Professor E. W. Brown, F.R.S., for more observations of occultations, the following New Zealand observatories have expressed their willingness to make the necessary observations: Christchurch, Dunedin, Hawera, Nelson, New Plymouth, Wanganui, Wellington. Accurate time signals are sent out from the Dominion Observatory on two evenings a week at 9 h. G.M.T., and every day at 23 h. G.M.T. It will be necessary to supply additional time signals to obtain the required accuracy in these observations. In addition to the ordinary occultation observations, a photographic method is in use at the Wellington Observatory by means of which the moon and surrounding stars are photographed on the same plate and the time of the exposure on the moon is recorded on the chronograph. In this way six plates were obtained with the 9 in. telescope. The plates have not yet been measured, as there is no staff available for this duty.

The occultations of stars were observed at Wellington on 4th and 30th September, and 1st and 2nd October.

Auroras.

During the calendar year 1927 the following auroras were observed :—

January 9—Aurora australis observed from Ashburton.
January 28—Aurora australis observed from Christchurch.
January 29—Aurora australis observed from Wellington and Christchurch.
May 5—Aurora australis observed from Christchurch and Ashburton.
May 19—Aurora australis observed from Christchurch.
June 12—Aurora australis observed from Christchurch.
July 22—Aurora australis observed from Christchurch.
August 21—Aurora australis observed from Christchurch.
October 22—Aurora australis observed from Dunedin, Invercargill, Christchurch, Wellington.
December 29—Aurora australis observed from Wellington.

Meteors.

SUMMARY OF METEORS FOR 1927.

Place.	New Zealand Date.	d. h. m.	Notes.
Oamaru	January	9 21 00	Newspaper reports.
Rotorua	May	3 19 30	Newspaper reports.
Auckland	June	2 03 30	Radiant from 8 meteors (R. A. McIntosh).
Auckland	June	3 03 45	Radiant from 7 meteors (R. A. McIntosh).
Oamaru	July	5 00 00	Newspaper report.
Foxton	July	6 17 30	Newspaper report; direction N.
New Plymouth ..	July	6 17 30	Newspaper report; direction E.
Cambridge	July	(Not given)	Newspaper report; direction S. to S.E.
Palmerston North ..	August	4 06 00	Newspaper report.
Gisborne	August	19 22 05	Newspaper report.
Auckland	November	(Not given)	Newspaper report.

* Observatory Bulletin No. 66. † Observatory Bulletin No. 69, p. 26.

Mutual Eclipses of Jupiter's Satellites.

Through the courtesy of the British Astronomical Association, predictions of the mutual eclipses of Jupiter's satellites were forwarded to this Observatory, with the result that on two occasions—30th September and 2nd October—two of these eclipses were observed.

Precision Pendulum.

The precision pendulum made by Mr. E. C. Isaac, Wellington, was installed at the Observatory in November, 1926. The pendulun is supplied in a metal cylinder, and this will be exhausted to a fairly low vacuum. An electric impulse dial is in use with the pendulum.

Interferometer.

A research grant from the New Zealand Institute is available for the construction of an interferometer to be used on the 9 in. telescope. The four mirrors have been made at the Mount Wilson Observatory, California, and are now in Wellington. Steps are being taken to have the instrument constructed in England.

Photographs of Moon and Surrounding Stars.

This research was begun by the Dominion Astronomer at the Lick Observatory in 1915, and has been continued from time to time in Wellington. The method is available for—

(1) Fundamental determination of the position of the moon, and was undertaken originally in response to an invitation from Professor Ernest W. Brown to provide material for testing his tables of the motion of the moon.
(2) This method may also be used as an independent one in the determination of longitude.
(3) In the determination of latitude.

In (2) and (3) the errors are different from those in the determination of longitude by wireless telegraphy and in the determination of latitude by zenith telescope observations.

Residential Accommodation.

Residential accommodation at the Observatory is necessary to provide facilities for undertaking astronomical work at night with the equipment now available. With the uncertainties of the climate, it is a difficult matter to take advantage of the clear sky, as it is found that frequently after a hurried journey to the Observatory the sky clouds up and no work can be done. The Dominion Observatory stands alone among British observatories in having no residential accommodation at the Observatory; accordingly its activities are very much reduced from this cause.

Solar Eclipse.

An annular eclipse of the sun, 1927, June 3rd, was visible in New Zealand, and an expedition consisting of the Government Astronomer and two members of the New Zealand Astronomical Society went to Russell, but heavy rains at the time prevented observations there. Successful observations and photographs were secured by members of the society at Kaitaia and at Wellington.

Lunar Eclipses.

The lunar eclipses of June 15th and December 8th were observed generally in New Zealand.

Transit of Mercury, 1927, November 10th.

The transit of mercury was observed at Wellington, a kinematograph record being obtained through the 9 in. city telescope, while photographs of the projected images through the 5 in. and 4 in. telescopes of the Wellington Philosophical Society and the Dominion Observatory were also taken. Mr. R. C. Hayes, in Samoa, obtained a good observation of the first internal contact at 3 h. 03 m. 09 s. G.M.T. For the convenience of New Zealand observers, radio time signals were sent from the Dominion Observatory at every hour and half-hour from 2 h. to 4 h. G.M.T., on a wave-length of 600 metres.

Comets, 1927.

Comet Gale, 1927, was observed by Mr. Townsend, a member of the New Zealand Astronomical Society, at Hawera, on 25th June.

Comet Pons-Winnecke was observed by the Wellington Observatory staff and members of the Astronomical Society in June and July.

Comet 1927K was independently discovered by sixteen New-Zealanders, and numerous observations were made from December 4th to 10th by the Observatory staff and members of the Astronomical Society. A good orbit was computed by Mr. P. W. Glover.

Summer Time.

The Summer Time Act, 1927, provided for the time in New Zealand being one hour in advance of New Zealand standard time for the period beginning at 2 a.m., New Zealand standard time, on Sunday, 1927, November 6th, and ending at 2 a.m., New Zealand standard time, on Sunday, 1928, March 4th.

The only alteration necessary in the work of the Observatory was in the time at which the morning time signal was sent to the Post and Telegraph Department and to the Railway Department. The great advantage of summer time to the Observatory arose from the fact that the office opened in the morning early enough to receive the wireless time signal from the Paris Observatory.

SEISMOLOGY.

The Observatory has three seismographs in use—one Milne and two Milne-Shaws. These are all horizontal component machines, and with them very excellent records are obtained. The records from the twin-boom Milne seismograph at Suva, Fiji, are sent to this Observatory for working up, and are valuable in supplementing the records obtained at Wellington.

The number of earthquakes recorded on the Milne machine (east-west component) was 145; on the Milne-Shaw (north-south component), 150; and on the Milne-Shaw (east-west component) 149 earthquakes were recorded. Particulars of the numbers of the earthquakes registered on the three machines are given in the following table :—

1927.	Machine Milne.	Machine Milne-Shaw (N.–S.).	Machine Milne-Shaw (E.–W.).	Remarks.
January ..	20	20	20	
February ..	21	21	21	
March	14	15	15	
April	7	7	7	
May	9	11	11	
June	6	6	6	
July	5	5	5	
August ..	10	10	10	
September ..	8	8	8	
October ..	14	15	15	
November ..	20	21	21	
December ..	11	11	10	One lost on E.–W. through clock stopping.

Officers of the Post and Telegraph and Marine Departments and private observers have given valuable assistance in the reporting of earthquakes felt by them in New Zealand.

The total number of earthquake shocks felt in New Zealand for the year 1927 was 110; 84 of these were felt in the North Island and 16 in the South Island. In ten cases the same shock was felt in both Islands. The maximum intensity of the shocks felt in 1927 was 8 on the Rossi-Forel scale. The maximum intensity of shocks felt in 1921 and 1922 was 8; in 1923 was 6; in 1924 was 7; in 1925, 1926, and 1927 was 8 on the same scale.

Seventy-seven reports were received from officers of the Post and Telegraph Department, eleven from the Marine Department, thirty-nine from other observers, and 229 from the newspapers.

An article on "Earthquakes in New Zealand" was prepared for and published in the New Zealand Year-book. Maps have been prepared showing in considerable detail the distribution and intensity of the earthquake shocks felt in New Zealand; these are now being made ready for publication.

The work in seismology has increased very considerably since the new Milne-Shaw seismograph has been running, and a further addition to the work has been caused by the installation of the second Milne-Shaw seismograph. In addition to the technical reports on the earthquakes, contact prints are made of all important records and are sent to other observatories.

The old Milne machine has proved its usefulness in a number of cases where the local shocks have been strong enough to throw the Milne-Shaw machines out of action.

During the calendar year (1927) earthquake reports have been received from fifty-eight observatories.

Steps are now being taken with a view to obtaining seismographs suitable for recording local earthquakes. By means of these seismographs it is hoped that some precise knowledge of the origins of New Zealand earthquakes may be obtained.

General.

Observatory Committee.

In January, 1927, the Research Council appointed an Observatory Committee for the purpose of reporting to the Council on the programme of work to be submitted by the Director of the Observatory. The members of the committee are—The Naval Adviser; the Surveyor-General; the Engineer-in-Chief, Public Works Department; and four representatives of the New Zealand Institute. The four members of the New Zealand Institute are Professor C. Coleridge Farr, Christchurch; Professor D. M. Y. Sommerville, Wellington; Mr. A. C. Gifford Wellington; and Professor B. Burbidge, Auckland. This committee continues the work of the Government Observatory Advisory Board.

The first meeting of the committee was held on the 29th March, 1927, when Professor C. Coleridge Farr was elected Chairman. The committee dealt with the statement by the Government Astronomer on the proposed programme of work for the coming financial year. A number of the matters dealt with by the committee are included in this report.

The second meeting of the committee was held on Wednesday, 31st August, 1927, when it was resolved that (1) a number of selected sites be tested in the South Island as to their suitability for observatory work; (2) that a seismograph for recording local earthquakes be purchased; (3) that New Zealand become a member of the Astronomical Union of the International Research Council; (4) that if the Government is represented at the Pan-Pacific Conference at Java in May, 1929, one at least of its representatives should be an astronomer, who should also take part in the observations of the total eclipse of the sun to be observed at Sumatra on 9th May, 1929.

Publications.

The following Observatory publications have been issued during the year :—

Bulletin No. 64.—First Report of the Commission appointed to further the Study of Solar and Terrestrial Relationships. (Extract, *N.Z. Journal of Science and Technology*, Vol. 9, No. 2, 1927.)

Bulletin No. 65.—New Zealand Standard Time. (Wellington Philosophical Society, 1917.)

Bulletin No. 66.—The Longitude, Latitude, and Height of the Dominion Observatory, Wellington, New Zealand. (Extract, *Transactions of N.Z. Institute*, Vol. 47, 1914.)

Bulletin No. 67.—Report of the Dominion Astronomer and Seismologist, 1926–27.

E.–6.—Earthquake Reports for 1923, January–August.

As in past years, the Observatory is again indebted to individuals and to institutions for valuable gifts of publications. Some of these are presented in exchange for the bulletins. In particular,

reference should be made to the valuable gifts of cases of books forwarded to this Observatory by Dr. L. J. Comrie. These include publications from the Nautical Almanac Office, London; the Royal Astronomical Society, London; and the British Astronomical Association, London, and the Royal Observatory, Greenwich. A total of fourteen cases was received in this way.

A complete list of all the publications that have been purchased by the Observatory is attached to the report.

Meteorological Records, 1927.

The following are the meteorological records for 1927 :—

Barometer (height above sea-level, 415 ft.)—
Maximum reading, 30·23—1927, September 30.
Minimum reading, 28·78—1927, July 13.

Temperature (in transit-room)—
Maximum, 71·0° F., recorded 1927, February 13.
Minimum, 47·6° F., recorded 1927, June 19.

Temperature (in clock-room)—
Maximum, 70·2° F., recorded 1927, February 1.
Minimum, 52·0° F., recorded 1927, May 1 and June 20.

Humidity in new cellar—
Maximum reading, 100 per cent.
Minimum reading, 72 per cent.

Staff.

No changes in the staff took place during the year. The staff was constituted as follows: A. G. C. Crust, M.Sc., temporary professional assistant; T. S. Wyman, clerk. In addition, Mr. H. O. Belworthy, Internal Affairs Department, was attending to the Sunday duty till 7th August, after which date this work was taken over by the Observatory staff. Mr. B. L. Elphick, B.Sc., assisted with the seismological work for a total period of forty-seven days. Mr. R. D. Thompson, M.A., F.R.A.S., was assisting with the longitude work for a period of three months. Professor D. J. Richards was engaged on the seismological work for eight days.

My thanks are tendered to the staff for efficient and loyal service. The duties at the Observatory are exacting, and are discharged every day of the year, including Sundays and Government holidays. On no occasion has any essential duty ever been neglected.

C. E. Adams,
Dominion Astronomer and Seismologist.

REPORT OF PETROLOGICAL LABORATORY.

Much work has been done in the preparation of a bulletin on the building-stones of New Zealand. Many samples have been collected in the field, and others have been forwarded by J. Tait and Son, of Christchurch, and other workers in stone. Samples of all of these have been tested for specific gravity, absorption, and crushing-strength.

The greatest requirement of the building trade in New Zealand has been an easily-worked freestone which will resist the weathering action of the atmosphere. Numerous observations and tests have been made in connection with the vitric tuff which in various tones and grades has such a wide occurrence between Taumarunui on the south and Hinuera on the north. The stone can be easily and cheaply quarried, is extremely accessible, and possesses remarkable durability. Dressed samples have been shown to various architects in the North Island, and it is expected that this stone will soon be quarried and become available for building in all parts of the country. Since it has a pleasing tone, and is easily sawn, and can be obtained in stones of large dimensions, it can be employed for practically all architectural purposes. This rock has been the subject of a special report.

A special investigation was made in regard to the supposed discoloration of the Kairuru marble which has been used in Parliament Buildings and other large structures in Wellington and Auckland. Research was made in regard to each of the numerous theories that had been devised to account for this effect, but it was found that none of them had any real basis. Subsequently it was demonstrated that the dirty appearance that resulted on certain exposures of buildings was entirely due to the settlement and accumulation of wind-blown dust and soot. There is no doubt that a smoother dressing of the surface will reduce this effect to a great extent.

Samples have been collected from the marble of the Plumbago Valley, near Collingwood. Here there is a variety of mottled and figured marbles, first discovered by Mr. M. Ongley. In the majority of specimens the mottling is usually of a soft-pink colour (though yellow is frequent) and produces a pleasing effect. The locality is easily accessible, and a great variety of stone, which will take a high polish, can be obtained in any quantity and in large sizes.

It has lately been shown that tinted and coloured limestones which will take all the polish of marble can be obtained in any required quantity from Waro and several other localities near Whangarei. This rock when polished has various and pleasing shades of pink, and the softness of tone renders it most suitable for interior ornamentation. It has already been used with the most satisfactory results. It is hoped to complete the bulletin on building-stones shortly.

An investigation has been made into the nature and condition of beach abrasion, as information on this matter was urgently required in connection with many problems of marine engineering in New Zealand. Very unexpected results were obtained, and these were considered to be so promising that the investigations were carried to a considerable length and are still in active progress. Descriptions and results of the earlier of these experiments have already been published.

A number of tests of roadmaking-materials have been made. In connection with this gravels have been collected widely, and it is hoped before long to accumulate the information required to issue a bulletin of a gravel survey of New Zealand.

P. Marshall, Petrologist.

Approximate Cost of Paper.—Preparation, not given; printing (1,150 copies), £44.

By Authority: W. A. G. Skinner, Government Printer, Wellington.—1928.

Price 1s.]