1929.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(ANNUAL REPORT OF THE).

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

HON. HARRY ATMORE,— 25th September, 1929.

I have the honour to submit herewith the annual report of the Department for the year 1928–29.

E. MARSDEN.

ANNUAL REPORT.

The progress that has been made in the various activities of the Department during the past twelve months relates to the consolidation of the activities already organized, the co-ordinating, planning, and organizing of the necessary personnel and apparatus. Fair progress has been made in actual investigational work, and important results of no little economic value have been obtained; while, as a by-product, the various investigations have led to a healthy discussion of the problems involved, on a more factual basis. The results of investigations have been published in the form of bulletins or in the *Journal of Science and Technology* and *Journal of Agriculture*.

In the report that follows information is given as to what has been done and as to what it is proposed to do. Investigational work and results obtained therein are not discussed in detail, as information of that nature is given in the various publications referred to above. The annual reports of the Dominion Laboratory and Apia Observatory are published separately, as in previous years.

THE COUNCIL.

The Council has held regular meetings at two-monthly intervals, and, except where members were temporarily absent from the country, there have been full attendances. The members, originally appointed for a period of two years, were reappointed on the 15th February, 1929, as follows:—

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).

The activities of the Department are concerned with a wide range of problems, and to secure the efficient treatment of each it has been the policy of the Department to establish Advisory Committees comprised of representatives of the various industries and Government Departments, educational bodies, and others interested. To these Committees wide measures of direction and control are given, as it is considered that by this means investigations directed by those in whose direct interest they are being made, and who are themselves contributors, hold the greatest prospect of reaching both economic and scientific fruition. It is felt that by the adoption of this arrangement the closest measure of co-operation between science and industry will be maintained.

In the organization of researches the Council and Department have been fully alive to the necessity of co-operating with all Government Departments, Universities, and organizations already carrying out work in any particular field. In this regard it is pleasing to record the good general relations that exist; and I feel it my pleasant duty to express the Council's hearty appreciation of this co-operation and its gratitude to all concerned. During the year the value of this scientific team-work has been definitely apparent, and an endeavour has been made to promote direct free technical discussion of problems between scientific workers in different branches, institutions, and Departments. Very many cases during the year could be cited of the mutual help of real value readily given by all workers; and this is especially necessary in New Zealand, where small numbers of trained specialists are available. In this connection, the gathering-together in August, 1929, of all New Zealand scientists engaged on dairy-products testing and investigation should be productive of the best results.

As a result of the Imperial Agricultural Research Conference and the activities of the Empire Marketing Board, there has been considerable advance during the year in the linking-up of Empire research facilities, particularly in the primary industries. To take full advantage of these proposed schemes it will be necessary for New Zealand to financially contribute to the various research bureaux and information services set up as a result of the Imperial Agricultural Research Conference in 1928, so that it may take a fair share in research proposals, thus saving New Zealand much unnecessary repetitive research work, as well as indicating worth-while work, application, and local investigations, and helping to cut down to a minimum the period between discoveries elsewhere and their application in New Zealand. The British Department of Scientific and Industrial Research also has assisted, particularly in the direction of fuel, wool, and wheat researches. The Australian and Canadian Research Councils also have cordially co-operated, while the Bureau of Standards and the National Research Council in the United States have made every effort to answer inquiries and undertake work on our behalf.

The patenting by a United States research organization of the production of vitamin D by irradiation of certain compounds with ultra-violet light has raised the question of policy in regard to patenting of discoveries or suggestions of research officers. Hitherto, the policy of full publication of results has been followed, with little or no thought to patenting. It appears desirable, however, that, in the public interest, in many cases patents should be taken out in order to prevent fraud by those who exploit these results without giving the necessary scientific service. It is not suggested that profits from patents should be made in New Zealand, but that reputable companies be freely licensed to use patents, provided a genuine service is safe-guarded. This principle was followed in Canada in connection with the discovery of insulin in a laboratory supported by public funds.

During the past year the Secretary paid a brief visit to Canada and the United States for the purpose of studying organization of research and Government scientific services, and gleaning information on some of the problems before the Department.

Brief summaries of the various activities follow. Fuller reports by heads of branches are given later.

DOMINION LABORATORY.

It is pleasing to record a successful year's working of the Dominion Laboratory and its branches at Auckland, Christchurch, and Dunedin.

The Dominion Laboratory carries out the analytical and chemical work required by all Government Departments, with the exception of the Department of Agriculture. Owing to the increased degree to which chemical problems are entering into departmental and industrial questions, these services are yearly becoming of greater importance. For the successful administration of many Departments, and for the national interest generally, it is essential that the services of highly qualified chemists should be always available. The wide and varied nature of the problems that occur during the year require laboratory equipment of a comprehensive nature and a staff qualified to deal with chemical and analytical problems covering a wide range of subjects.

A number of Government Departments continually draw on the services of the Laboratory, the principal among these being Customs, Health, Police, Industries and Commerce, Post and Telegraph, and Public Works. In addition, the aggregate total individual inquiries made by other Departments also is large.

The staff and equipment complement of the Laboratory enables a maximum of organized scientific service to be rendered, and in addition to the ordinary routine work a considerable amount of research work into national problems has been initiated. Included in these is the extensive investigation into the incidence of goitre in New Zealand, carried out in collaboration with the Department of Health. A report on this work has been completed for publication. In this connection iodine determinations from soil and water supplies have been made over a number of selected areas in the Dominion, and these analyses have been associated with careful examinations by the Health Department of the school-children of these districts.

In association with the Geological Survey Branch a series of special investigations into the gold and silver content of sinters located in the Rotorua and Taupo districts has been completed. The technique of this work called for special manipulative skill.

It is the policy of the Laboratory not to undertake commercial analytical work unless such can not be carried out by private analysts. However, where the national interests are at stake—as, for instance, the possible development of new industries and utilization of waste products—investigations often are conducted by the Laboratory.

During the year work in this connection has been carried out in regard to bacon curing and wrapping, disinfection of meat-works, chemical and physical treatment of flax-fibre, manufacture of roofing-tiles, manufacture of soap, sand for glassmaking, tar for roading, water for industrial purposes, and zinc-plating. In addition, advice has been given in the numerous cases of inquiry from industry, and this service is being increasingly appreciated and taken advantage of.

In association with the Laboratory, and located adjacent to it, are two major industrial research laboratories—namely, the fuel-research laboratory and the leather-research laboratory.

In connection with this work for the secondary industries the need has arisen for tests of a physical nature apart from purely chemical investigations. Arrangements are in train for the co-ordination of the physical and engineering testing facilities of the Dominion and the establishment of a Standards laboratory for ultimate standards of electrical and other units, so that complete tests of New Zealand products may be made for comparison with standard specifications.

A large amount of work also is being carried out by way of standardizing and testing materials suitable for roadmaking. The staff of the Laboratory also have prepared abstracts of various scientific publications and made these available for general distribution through the Department's *Journal* and by means of bulletins.

GEOLOGICAL SURVEY OFFICE.

Since last year's report was presented the Geological Survey has issued an areal bulletin covering 1,284 square miles in the East Cape district. Detailed geological exploration is proceeding in an adjoining part of the same oil-bearing region, and in the Murchison district, where there are many gas-springs and oil-seeps. A large area near Te Kuiti is being mapped to provide data for a soil survey of extensive tracts of easy pastoral country on which stock do not thrive—probably owing to some mineral deficiency in the herbage. Another season's work should complete the mapping of the North Island volcanic zone, when the question of establishing a vulvanological observatory may be intelligently considered.

An accurate map is the basis of all geological work, as, indeed, it is of modern engineering and of scientific work in forestry and agriculture. Even after the Lands and Survey Department has supplied all available data, at least half of the geologist's time is taken up in completing a topographical map to the degree of precision required. A contoured map is highly desirable, but time enough for its preparation cannot be spared. During the last twenty-five years the Geological Survey has mapped in fair detail about one-quarter of New Zealand. If this work, absolutely essential in so many of the tasks confronting those engaged in developing the natural resources of the country, be they mineral, forest, agriculture, transport, or water for power or irrigation, is to be completed within reasonable time, it is urgent that the rate of mapping be greatly increased. Aerial mapping appears to be the cheapest and best way to do this. The methods are so well standardized and so flexible, and the advances made in the design and construction of cameras and the refinements of photographic films and papers, allow of the production of pictures of such remarkable clarity and detail as to have the very widest use. The Secretary of the Department made a special investigation of the extensive use of this method by the Geological Survey Offices of both Canada and the United States, and there would appear to be no reason why it should not be adopted in New Zealand, so that the geological-survey work may be expedited without increase of staff of expert geologists.

PETROLOGICAL LABORATORY.

A great deal of additional work has been carried out in connection with the collection of samples of New Zealand building-stones. Many different kinds of stones have been dressed, polished, and submitted to various tests by which their suitability for use in construction may be gauged. The work carried out indicates that there is in New Zealand a great variety of building-stones, in accessible localities, available for quarrying as soon as there is a sufficient demand for them.

The vitric tuff mentioned in the previous report has not yet been used for any considerable constructional purpose. This would appear to be due to a disinclination to incur the initial expense involved in the opening of a quarry until such time as a large demand is assured.

A question arose as to whether this rock would resist the chemical action of atmospheric acids in urban areas and on the sea-coast. Tests have indicated that the stone is unaffected by the action of strong mineral acids, even when immersed in boiling solutions.

An illustrated bulletin containing descriptions of New Zealand building-stones, their qualities and suitability for various constructional purposes, and their accessibility, is now in course of publication.

The research on the nature and abrasion of beach materials has been much extended. The object of this is to discover the source and movement of the materials that drift along the New Zealand coast in large quantities. These constitute a most formidable obstacle to the construction and maintenance of many harbours on the New Zealand coast. Large numbers of samples have been collected from rivers and beaches, and by dredging off the coast to a depth of 10 fathoms.

A further series of results and conclusions is now in course of publication. Much of the information that has been obtained should be of value to harbour engineers. Up to the present most of the work has been carried out on the beaches and in the water round Napier, though samples of sand for examination and grading have been obtained from many localities.

Many rock materials have been tested for their suitability for use in road-construction, particular attention is being paid to the deposits of gravel that extend so widely throughout the country; and the services of Dr. Marshall have been utilized on numerous occasions by the Public Works Department for special investigations.

METEOROLOGICAL OFFICE.

The function of the Meteorological Office is to co-ordinate meteorological effort in the Dominion and to provide, as far as possible, such information on the various weather factors as is required by different sections of the community according to their various avocations. The information provided falls under two heads: First, there is that regarding current weather, which is given by means of daily forecasts and reports of observations; and, second, the climatological data derived from the accumulated statistics of years.

The forecasting service arose out of the requirements of shipping. The importance to mariners of a knowledge of the nature of the weather to be expected on an inhospitable coast is obvious. It was relatively still more important when lighthouses and other aids to navigation were not so plentiful as now. Much of the activity of small shipping and of the work in partially protected or bar harbours is still conditioned by the weather. For mail-boats the value of the forecast lies in the increased speed with which a port can be approached if it is known that weather conditions are favourable, in enabling the proper precautions to be taken if the contrary is the case, in allowing the probable coal-consumption to be calculated, and occasionally in enabling a storm-centre to be avoided. During the year an attempt has been made to improve the forecasting service both from the point of view of increasing its accuracy and by obtaining more and better information on which to base it.

During the past year the evening forecast as broadcasted in Morse from the Wellington Radio Station has been amplified by the inclusion of reports from sixteen stations well distributed over the region extending from the Dominion to Chatham and Norfolk Islands and to Sydney and Hobart. The forecast includes an ocean forecast for the eastern half of the Tasman Sea, the western half being covered by Australian issues. The reports are sufficient to enable any one with an elementary knowledge of meteorology to draw his own weather chart. This is being done on an increasing number of ships.

Nowadays, however, the interest of the general community in the forecast is increasing rapidly. The principles of meteorology are being increasingly taught in the schools, and many people whose activities are affected by the weather are realizing the value of keeping a watch on its changes and taking advantage of the information conveyed in the official report.

It is probably persons engaged in agricultural pursuits who are most interested in the weather forecasts. There are many occasions on which large sums of money can be saved by proper provision for future weather in farming operations. Many sheep are lost, for instance, through being turned out after shearing in wet and cold weather. Many precautions can be taken during lambing against the effects of severe weather. Harvesting, fruit-picking, spraying, and other operations can be adjusted to weather conditions, with consequent saving of time and money. The same report as is issued in Morse from Wellington for the benefit of shipping is broadcasted nightly from the Radio Broadcasting Co.'s stations in each of the four main centres, and has proved a boon to farmers and the general public. During the Canterbury harvesting season, also, a special report was issued at midday giving the outlook for as far ahead as possible, and proved to be a success. There is, however, undoubtedly still much that can be done to improve the service to the farmer. For instance, the weather situation as defined by the Meteorologist could be analysed in a talk over the wireless by an officer with a knowledge of agriculture. The implications of the weather report could be explained in simple language, and practical advice given to farmers in various districts as to the best course to follow in their work. It is hoped that before long staff will be provided which would enable this service to be undertaken.

Aviation is still in the early stages of its development in New Zealand, but it is unnecessary to enlarge on the importance for any one undertaking a long journey by air of a knowledge of the wind, weather, and visibility he will meet with along his route. More frequent and more detailed information is required for aviation purposes than for the ordinary forecasting, and in the Dominion the supply will have, to a large extent, to follow the demand. At present forecasts are frequently supplied to aviators in response to telephoned or telegraphed requests, but arrangements are in hand, in co-operation with the Department of Civil Aviation, for a more complete organization, at least as regards inter-Island traffic. Before making the frequently somewhat hazardous crossing of Cook Strait a pilot will be given information regarding the wind at various heights, the nature and height of clouds, the weather, and the visibility.

The uses to which climatological information can be put are too numerous to mention in detail. Every person who makes his living from the soil wishes to know the average weather conditions he may expect and the extremes through which they vary. The purposes for which land should be employed and the fertilizer programme are determined very largely by rainfall and temperature. In this connection the whole of past rainfall data has been carefully sifted and analysed, and more accurate rainfall maps for both Islands are in course of publication. To a smaller extent the liability to gales, floods, frost, snow, hail, &c., is important. As an instance of the importance of climatic considerations, it may be mentioned that there are numbers of pests which are unable to pass through certain phases of their life-history unless the temperature rises above a certain value. Again, attempts have been made to grow fruit in districts where the frequency of frosts rendered it unprofitable. To engineers the most important climatic element is rainfall. They need to know not only the average yearly rainfall, but the intensity to be expected over various intervals. For a city drainage scheme, for instance, the provision to be made may depend on the amount of rain liable to occur within half an hour. In the case of rivers the height of a flood may depend on the accumulated rainfall of several days. There are many industrial avenues in which climatic data are of importance. Cold storage and certain manufactures, for example, require the humidity of the air to be controlled.

It should be the aim of the meteorological services to accumulate and classify data enabling all the above-mentioned requirements to be met. For the collection of this data the services are dependent mainly on the efforts of voluntary observers, to whom grateful acknowledgement is made. There are many investigations of a local nature, however, especially in connection with agriculture, which must of necessity be carried out by local organizations. In these cases the Meteorological Office is prepared to assist with advice and, so far as permissible, with the supply of equipment.

DOMINION OBSERVATORY.

The work of the Dominion Observatory comprises two distinct branches of science—astronomy and seismology. In astronomy the Observatory has the important duty of controlling the time of the Dominion, and it does this by the use of astronomical clocks which are rated and kept accurate by frequent astronomical observations and by the reception of wireless-telegraphy time signals from other observatories. From these clocks some hundreds of time signals are sent out every year by telegraphy, wireless telegraphy, &c., and time-ball and electric-light signals also are made.

With the exceptions of the small transit telescopes and small portable refractors, the Observatory has only limited equipment for astronomical observations. The policy in the development of the astronomical observatory is to undertake only those researches which the position of the Observatory in both latitude and longitude warrants. As the Observatory is nearly at the antipodes of Greenwich, it is important (1) to take daily photographs of the sun, to supplement those taken at Greenwich, thus keeping the sun under closer observation; (2) to undertake photographic zenith-telescope observations for variations of latitude; (3) to undertake variable-star observations with the photo-electric cell, &c.

Many other astronomical observations, such as variable stars, meteors, occultations, and planets, are carried out by members of the New Zealand Astronomical Society, and the results are forwarded to the Observatory.

In seismology the equipment comprises two Milne-Shaw and one Milne horizontal-component seismographs. These are chiefly used in the registration of distant earthquakes. At Suva, Fiji, there is a twin-boom Milne seismograph, the records of which are sent here; for local earthquakes adequate provision has not yet been made, but a comprehensive report on requirements has been prepared.

The records from New Zealand are forwarded to many seismological observatories, and appear in the International Seismological Summary. An addition to the staff of the Observatory would appear necessary if the records are to be adequately worked-up and plotted.

APIA OBSERVATORY.

During the past year the control of the Apia Observatory has been taken over by the Research Department, and the cost of upkeep is now included in this Department's estimates. Previously the Department's interest in the Observatory has been in a technical advisory capacity. A good year's work has been done, and the publications of the Observatory are receiving well-earned notice by workers throughout the world, as evidenced by offer of special instruments for trial, &c. The recently published monograph on upper-air currents is especially worthy of notice.

REPORTS OF THE RESEARCH COMMITTEES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

DAIRY RESEARCH.

Advisory Committee: Sir George Fowlds (Chairman), Mr. A. Morton, Mr. T. A. Winks, Mr. W. Iorns, Mr. Dynes Fulton, Mr. Q. Donald, Professor H. G. Denham, Dr. C. J. Reakes, Mr. W. Singleton. Director of Research: Professor W. Riddet.

The Dairy Research Institute has been established adjacent to the Massey Agricultural College at Palmerston North. Chemical and bacteriological laboratories have been completed and equipped during the year. The dairy factory erected by Massey College is available for research purposes, and is designed to make provision for the manufacture of butter, cheese, and other dairy-products. The College herds also have been availed of to provide material for factory and laboratory experimental work.

Arrangements have been made for co-operative investigations to be undertaken in association with the New Zealand Co-operative Dairy Co.'s laboratory at Hamilton, and with the Hawera laboratory of the Federation of Taranaki Dairy Factories.

Director's Report.

The Dairy Research Institute was brought into being about the end of March, 1927. The remainder of that year was taken up with arrangements for the provision of staff, laboratories, and dairy factory. While these arrangements were being completed investigations were necessarily restricted, so that the investigations undertaken in that year were limited to (*a*) a study of the daily variation in the production of fat and milk of the cows in the College herd, with a view to examining the extent of variation, and, as far as possible, the causes contributing thereto, with special reference to the effect of weather conditions; (*b*) a statistical examination of group herd-testing records, in order to obtain information upon the effect of the time of calving, age of animal, breed, and district upon fat-production.

I am glad to report that for the present year, ending 31st March, 1929, much more progress has to be recorded. When abroad, Dr. McDowall visited places of interest to dairying in England, Scotland, Ireland, Germany, Holland, Denmark, Sweden, Switzerland, France, and the United States of America. In all of these countries he made personal contact with the dairy research workers in the leading research institutions. He also gained some insight into dairy practices in these countries, and had an opportunity of discussing with various workers problems of peculiar interest to New Zealand. Amongst other details, he collected particular information relating to the pasteurization of milk for cheesemaking, the keeping-quality of unsalted butter, electric pasteurization of milk, sterile milk and ice-cream, packing of milk-powders, dairy sewerage, evaporation of whey and its utilization as an animal-food, the drying of buttermilk and outlets available for the sale of the product, the scientific control of dairy-produce in Holland, certified milk-production in Europe and America,

metals suitable for use in dairy machinery and utensils, new ideas in dairy machinery and dairy-flooring materials, cements suitable for joining tiles and whey-tanks, and the use of stainless steel for whey-storage vats. Reports on the electric pasteurization of milk, dairy-flooring materials, and the use of metals in dairy-machinery already have been published in the *New Zealand Journal of Science and Technology*, and others are to follow. The information obtained by Dr. McDowall and the contact made by him with fellow-workers in similar institutions abroad have provided a splendid background for the start of his dairy chemical research work in New Zealand, and the reports he has issued should be of great value to the dairy industry of the Dominion.

Mr. H. R. Whitehead studied methods of research in dairy bacteriology at the National Institute for Research in Dairying at Reading, England, and he also spent some time at the West of Scotland Dairy School, the Pasteur Institute, Paris, and the Dairy Research Institute at Kiel. At all of these places he made contact with fellow-workers and gained most useful up-to-date knowledge of modern methods of dairy bacteriological research. He has had the opportunity of studying methods of producing and distributing graded and pasteurized milk in England. This experience is invaluable to Mr. Whitehead and to the Institute in connection with similar work he is taking up in this country.

Both Dr. McDowall and Mr. Whitehead attended the World's Dairy Congress in July, 1928, where they met fellow-workers from all parts of the world. This personal contact is invaluable as a means of cementing co-operation with fellow-workers in other dairy laboratories.

When these two workers arrived, in October, their laboratories, which had been fitted in accordance with plans prepared by them in England, were finally completed and equipped with goods selected overseas. Thereafter an assistant and a laboratory boy were appointed to the chemical staff, and an assistant and two laboratory boys were attached to the bacteriological staff. Meanwhile the erection of the dairy factory was being proceeded with by the Massey Agricultural College. Some delay was experienced with the building in the course of erection, and it was not until January, 1929, that it could be brought into operation. Whilst this delay was certainly a matter of great concern to the Institute, it afforded the laboratory workers an opportunity of getting their laboratories and routine analyses into working-order before the whole team of laboratory and factory workers started in unison. The dairy factory provides facilities for practically all phases of research work in dairying. Accommodation is provided for the manufacture of butter, hard-pressed cheese of the Cheddar and similar types, fancy varieties of cheese, and casein. There is also sufficient accommodation for the pasteurization of milk and cream, the storage of butter and cheese, and the testing of dairy machinery. Whilst no provision has been initially made for dried and condensed milks, there is room for the installation of small experimental plants and the carrying-out of experiments connected therewith. The machinery installed is in keeping with the most modern types in use in New Zealand factories. Small-scale models were selected wherever possible, but these are sufficiently large to draw conclusions as to their usefulness on a commercial scale. As far as possible variety in metals was chosen, so that the usefulness of the newer metals could be tested out in practice. The opportunity was also taken of laying different types of flooring-material in the factory, so that these could be tried out under ordinary working-conditions. Mr. G. M. Valentine, of the Dairy Division, was appointed Dairy Factory Superintendent as the result of an agreement arrived at between the Dairy Research Management Committee, Department of Agriculture, and Massey Agricultural College. The Massey Agricultural College appointed a cheesemaker (Mr. E. Sawers), and a buttermaker (Mr. J. Stevenson).

The investigations carried out in the course of the year included the following:—

(1) *Daily Variations in Yield of Milk and Fat.*—The investigation concerning the daily variation in yield of fat and milk of the cows in the College herd, which was started in January, 1928, has been continued throughout the whole of the present year. Daily records of fifty-six cows have now been collected. Records also have been carefully kept of weather conditions recorded at the meteorological station, which is practically in the centre of the dairying-pastures on the College farm. In the course of this investigation the opportunity has been taken of studying a few facts of particular importance to herd-testing. These are: (*a*) The effect of milking cows early in the morning previous to the day of test, so that the recorded yields would represent the secretion of the animals for more than the usual twenty-four hours; (*b*) the effect of uneven intervals as compared with even intervals of milking upon the amount of fat and percentage of fat at each milking; (*c*) the effect of leaving strippings on the cow at one milking upon the test of fat and the secretion of fat at the subsequent milkings.

The amount of data collected is so great that it will take some considerable time to work up. With the data available it is possible to compare the accuracy of C.O.R. methods of recording and standard group herd-testing methods with actual production. A few points arising from this work can be recorded at this time. The prolonging of the test-day by an hour or so does not necessarily increase production of the cow for that particular day, particularly if the cow is in full milk: hence the statement often made in connection with herd-testing, that the animal can get abnormally high tests by milking specially early on the morning previous to test, is open to severe question. The leaving of strippings on the cow, however, has certainly an effect upon the subsequent test. It raises the test of the milk at the subsequent or following milking, and so produces an abnormally high result for that day; but it is not an economical practice, because the additional fat so recovered does not make up for the fat lost at the previous milking. When cows are milked at uneven intervals of milking the test at the milking after the long interval is higher than that after the short milking, but when milked at even intervals the tendency is for the test to be much the same at each; it would appear, however, that some cows give their higher test in the morning, while others have it in the evening.

A point with regard to the condition of animals at the time of calving was most clearly brought to our notice. It was shown that animals coming into profit in high condition secreted milk with a higher test than normal for about the first six weeks; they simultaneously lost condition. There is a clear example here of the necessity for the better feeding of stock in the winter dry period and of the profit derived therefrom.

(2) *Steam-production on the Farm.*—A means of producing steam on the dairy-farm has engaged the close attention of the Institute. It is well known that great difficulty is experienced in effectively sterilizing milk-cans on the farm. Whilst cream-cans can be washed and steamed at the factory, cans used for the taking of milk to cheese-factories cannot be similarly treated, because they are generally employed for the carting-back of whey to the farm; hence provision must be made to have them effectively sterilized there. A suitable simple steaming-device has been devised which can be made by any farmer at a cost of from £1 10s. to £2. It simply consists of a shallow basis (an old cream-raising basin), 4 in. deep by 30 in. wide, provided with a close-fitting lid to which are fitted three jets made of 1 in. water-pipe. This pan is set on a stand sufficiently high to be heated by a primus lamp. The lid of the pan and battens nailed on its upper surface around the spouts, so that the can when inverted over a spout will rest on these battens and thereby keep the mouth about an inch from the lid. Boiling water from an electric heater is poured into the pan until there is a layer of about 1 in. to 2 in. deep. The lid is then fitted on, and the primus lamp set alight underneath. In a short time steam emerges freely from the three jets, and the cans to be sterilized are inverted over these. They are kept inverted until the lip of the can is so hot that it can just be touched by the hand. This takes about eight minutes for a 10-gallon can. The can is then taken off and allowed to dry of its own accord. Such a can is just as effectively sterilized as is one by steam from a high-pressure boiler, if it is given the necessary time to heat. Cans treated in this way, of course, must be previously thoroughly washed. An adaptation of this can be made from an ordinary copper. If a copper be provided with a wooden lid and a piece of inch piping be inserted in the lid, a can may be steamed as described. The objection to the copper is that it is slow in action, because of the small evaporating-surface in relation to depth of water. The unit described can keep a worker busy washing and sterilizing cans, since with three spouts in operation he can remove one can every three minutes, which is just long enough to allow him to wash one ready for sterilizing. Can-lids, parts of the separator, and similar small fittings are sterilized in a box with a sparred batten fitted over the jets.

Another means of providing steam on the farm has been experimented with. This is a unit which aims at developing steam from electric energy. Heat from electricity is accumulated in a heavy lubricating-oil by keeping immersed in the oil an element through which electric current is constantly passing. When it is desired to generate steam by opening a valve, the hot oil is allowed to pass through a tube which is surrounded by a water jacket. The heat then passes from the oil to the water, and steam under pressure is generated. This unit is sold by a Wellington company who hold patent rights. The Institute has tested the efficiency of this machine under working-conditions. It has been proved that steam under pressure can be produced which can effectively sterilize all milking-shed equipment, but, so far, difficulty has been experienced with the regulation of the temperature of the oil. An improvement to meet this difficulty has been made, and a new unit is now under trial.

(3) *Methods of testing Milk for Butterfat.*—A series of trials was carried out to compare the relative accuracy and usefulness of the Babcock, Gerber, Morsin, and Hoyberg methods of testing milk for butterfat for herd-testing purposes. The Babcock test is most commonly used in New Zealand, but the others offer certain advantages. The Gerber is rather more mobile, in that the centrifuge employed is scarcely so heavy and bulky. The Morsin and Hoyberg tests are even more mobile than the other two, since they require no centrifuge for the separation of fat. They have also the advantage that they employ a non-corrosive liquid, in place of sulphuric acid, for dissolving of the milk solids. The trials carried out at the Institute show that the four methods of testing are equally reliable when fresh milk is employed. The Morsin and Hoyberg methods are not suitable for the testing of milk preservatized with potassium bichromate, formalin, or mercuric chloride. It was also shown that these tests may give rise to errors if care is not taken to keep the water-baths used for the separation of fat at a proper temperature; but this difficulty need not be experienced under working-conditions, on account of the ease in maintaining the temperature of the water-bath within the desired limits. Full details of this investigation are being published at an early date.

(4) *Openness in Cheese.*—Openness in cheese is reported to be the worst defect of New Zealand cheese at the present time. Accordingly an extended series of trials to inquire into the causes of openness were commenced in January, 1929, as soon as the factory could be brought into operation. The scheme of investigation was so set out as to admit of team-work between factory and laboratory workers. The greater part of the time has been devoted to investigating whether pasteurization of milk causes openness of cheese. Since pasteurization is so widely adopted in New Zealand, it seemed desirable to determine first of all whether it was a contributing cause before other phases of the work were tackled. Throughout the investigations cheeses have been made daily from raw and pasteurized milk, the same milk being divided into two portions for this purpose. Milk has been pasteurized by the flash method at temperatures varying from 145° F. to 175° F. by 5° F. At each temperature at least six cheeses were made. Experiments were also carried out with the pasteurization of milk by the Holding method at temperatures varying by 2° F. from 140° F. to 150° F. for thirty minutes. These cheeses were also made from milk divided into two portions, and raw-milk cheeses were made from the same milk to act as controls. The milk used in these experiments was produced by the College herd, and care was taken to secure as pure a supply as possible, so as to eliminate factors arising from bacterial contamination. Very detailed records were kept of the manufacture of each cheese, and the cheeses have been regularly examined at seven days old and fourteen days old. Thereafter, half of the total number were exported to Britain, and arrangements were made with the Director of the Dairy Division to have these examined in England and reports forwarded to the Institute, so that we can get information of their behaviour during transport. The other half of the total number has been kept in the cold-storage rooms of the dairy factory, so that these can be examined again when sixteen weeks old. Careful bacteriological and chemical analysis have been made of the milk and cheese during the course of the investigation, in order to collect as much information as possible

regarding the milk employed and the cheese manufactured therefrom. The information collected is possibly more comprehensive than any previously collected elsewhere regarding cheese-manufacture, since we have to complete manufacturing and analytical details from the point of production of the milk right through to the time of consumption of the cheese. No opinion can be offered regarding the effect of pasteurization until the cheeses have all been graded at sixteen weeks old. In addition to the series of trials connected with the effect of pasteurization, preliminary trials have also been carried out connected with modifications in the process of manufacture. These trials are to be regarded more in the light of indications than of definite information, because the number of cheeses made with each modification has been small on account of the limited time at our disposal. The reason for adopting this apparent chance method of investigation was that it was desired to get as wide a scope of suggestive causes as possible in the limited time at our disposal for the work before the close of the dairying season. The modifications in manufacture which have been introduced included—(*a*) Drying sweet compared with normal acidity at drying; (*b*) low cooking-temperature compared with normal cooking-temperature; (*c*) drying sweet and low cooking-temperature compared with normal procedure; (*d*) salting sweet compared with normal salting; (*e*) a combination of drying sweet, low cooking-temperature, and salting compared with normal procedure.

In addition to these dairy-factory investigations, Dr. McDowall and Mr. Whitehead have collected samples of milk and cheese from factories in the Manawatu district affected and non-affected with openness, with a view to ascertaining whether there was anything common to all affected factories. Nothing has been so far revealed; but it is apparent from Mr. Whitehead's bacteriological analyses that the purity of milk supplied to factories is far from satisfactory, and that factory water-supplies are not as pure as they ought to be. In view of this, factories should give close attention to the improvement of the purity of their water-supplies, and the question of milk-grading should be closely examined, as it appears that no method other than a penalty in payment will effectively improve the supply of milk delivered to factories. The chemical analyses suggest that the problem is closely bound up with complex chemistry of milk, and nothing definite can be stated till more detailed analyses are attempted. These are of an intricate nature, and will demand painstaking care and time.

Arising out of the work on openness in cheese, valuable information has been collected in connection with the production of milk by machinery. It was necessary to keep careful control over the purity of the milk produced, and, in the endeavours to keep it up to a high standard, a great deal of useful data has been collected concerning the matters of most importance in the milking of cows by machinery to produce a milk which will be as free as possible of germs.

(5) *Separated- and Whole-milk Starters.*—At the request of the Director of the Dairy Division a series of trials has been carried out using whole-milk and separated-milk starters respectively, in order to determine whether the use of whole-milk starters results in the loss of fat. This investigation was brought about by the recent regulation requiring all factories making whole-milk cheese to employ nothing but whole-milk starters. In the course of the investigation the amount of fat in the milks, starter whey, and cheese was carefully ascertained. The trials show that the use of whole-milk starter involves no additional loss of butterfat.

(6) *Separator Trials.*—Since the Institute offered to test dairy machines, subject to certain conditions, two separators have been submitted for trial. One of these has been reported upon as satisfactory.

(7) *Separating Milk at Varying Temperatures.*—Before the factory was brought into operation a series of experiments were carried out to determine the effect of separating milk at low temperatures, and to ascertain whether the fat normally lost at low separating temperatures can be economically avoided. It was shown that at temperatures of separation below 80° F. the loss of fat is fairly considerable, but not sufficient to merit the employment of expensive methods of heating. It was also shown that at low temperatures of separation the cream test was increased; further, the experiments prove that the loss is greatest when the cows are far advanced in their lactation period, hence the time at which farmers need to pay very particular attention to the temperature of their milk is towards the close of the dairying season, when cows are nearing the end of their lactations and atmospheric temperature is below normal.

(8) *The Effect of feeding Turnips upon Flavour of Milk and Cream.*—During the winter of 1928 two cows were fed Swedish turnips in varying quantities, starting with 20 lb. per head per day, and increasing at regular intervals by 5 lb. per head per day till the cows were receiving roots at the rate of 70 lb. per day. The turnips were fed in the first part of the trials immediately after milking, and, in the second part immediately before milking. In the first part no taint was produced, even at 70 lb. per day, when the milk was held for two days, but in the second part a taint appeared when the cows received 60 lb. per day. These good results were believed to be due to extremely clean methods of milking; but in view of the small number of cows their value was doubted. This experiment is being repeated at the time of writing, using soft turnips in place of Swedes.

(9) *Flooring-materials for Factories.*—As already indicated, types of flooring-materials are being experimented with in the dairy factory. These include a special type of aluminous cement called "ciment Fondu," and a bituminous compound, sold in the form of 12 in. squares, called "Prodorite." The latter is laid in special cementing-material. Small quantities of Prodorite have been supplied to several factories which are laying new floors, in order to get reports upon its usefulness under ordinary factory conditions.

(10) *Other Investigations.*—Other investigations which have recently been started include—(*a*) by Dr. McDowall, the preparation of dried and condensed products from buttermilk and whey, the usefulness of various metals (particularly chromium stainless steel) for the manufacture of dairy machinery, and the usefulness of special cements for tiled whey-tanks and the like; and (*b*), by Mr. Whitehead, the selection of special starters for the dairy industry, and points of most importance in the production of machine-drawn milk.

In accordance with arrangements made with the Federation of Taranaki Co-operative Dairy Factories and the New Zealand Co-operative Dairy Co., the Institute has collaborated with the laboratories belonging to these associations: since, contact has been maintained between the staffs concerned, and grants have been made to these district laboratories for special investigations. During the year the New Zealand Co-operative Dairy Co.'s laboratory at Hamilton has had under investigation the extent of loss of fat in buttermilk, and the causes contributing thereto; while the laboratory of the Federation of Taranaki Co-operative Dairy Factories has devoted special attention to methods of grading milk for cheesemaking. This co-ordination of research work between the central Research Institute and district laboratories is a gratifying feature of the Dominion's dairy research organization, which keeps all workers in closest touch with both central research and field activities.

Towards the close of the period under review a post-graduate student who holds the Gunson Scholarship in Agriculture of the Auckland University College, commenced special research work in the chemical laboratory. By offering such facilities to research scholars the industry benefits not only from the results of their work, but also from the interest that pure-science workers devote to dairying.

The nucleus of a good library has been obtained. Bulletins and reports pertaining to many aspects of dairying have been received from the leading dairy organizations and research institutes throughout the world. In addition, the leading journals relating to dairying are being received. It is hoped in the course of time to build up a comprehensive library in dairying which will act as a dairy reference library for all interested in the Dominion.

WHEAT RESEARCH.

Advisory Committee: Professor H. G. Denham (Chairman); Mr. C. H. Hewlett, Council of Scientific and Industrial Research; Mr. James Carr, Mr. W. W. Mulholland, and Mr. C. J. Talbot, representing the wheatgrowers; Mr. R. K. Ireland, Mr. R. J. Lyon, and Mr. W. S. Pratt, representing the flourmillers; Mr. C. E. Boon, Mr. F. H. Hawker, and Mr. T. S. Searle, representing the master bakers; Mr. J. W. Hadfield, Department of Agriculture; Mr. D. Colquhoun, Department of Industries and Commerce; Mr. A. Jones, representing the grain and produce merchants. Director of Wheat Research Institute: Dr. F. W. Hilgendorf.

The Wheat Research Institute commenced operations during the year. The activities of the Institute are concerned with (1) The breeding and selection of strains of wheat suitable for New Zealand conditions and possessed of the highest qualities for flour and breadmaking purposes; (2) cultural and manurial experimentation concerned with wheat; (3) certification of proved lines of seed wheat with a view to improving the standard of wheat grown; (4) chemical, physical, milling, and baking tests, and such investigations of wheat and flour as are likely to benefit growers, millers, bakers, and consumers.

Director's Report.

The object of the Institute is to forward the interests of all the parties interested in wheat—the farmer, the miller, the baker, and the consumer. Its funds are procured from a levy of 1½d. per 50 bushels of wheat or per ton of flour sold by the farmer, manufactured by the miller, and bought by the baker, together with a £1-for-£1 subsidy from the Department.

The Institute investigates wheats at every stage from the provision of seed grain till the delivery of the bread, and especially such problems as can be attacked by botany and chemistry. Its two chief officers are a chemist (Mr. H. E. West) and a plant-breeder (Dr. O. H. Frankel). The plant-breeder is engaged upon growing wheats collected from all parts of the world, and by means of crossing these with established New Zealand varieties it is hoped to produce wheats that will yield as well as the ordinary established varieties, but whose grain will possess higher milling and baking qualities. Some thousands of plants have been sown during the past autumn in the process of this investigation. Two crosses developed during the past two seasons are already showing some promise.

Pure lines of seed of the established varieties have been raised, and are being kept pure and available to farmers by means of a seed-certification scheme carried out by officers of the Department of Agriculture. A comprehensive series of wheat variety and manurial trials has also been conducted by the Department of Agriculture, and these have demonstrated the value of the use of phosphatic and nitrogenous fertilizers in increasing yields. With the laboratory facilities now available, the influence of manurial treatment on quality will be examined and ascertained.

A complete laboratory, at 295 Montreal Street, Christchurch, adjacent to Canterbury College, has been fitted up with experimental flour-mill, test baking-ovens, and the most modern chemical apparatus, in order to test the milling and baking quality of the wheats grown in New Zealand. Samples of all varieties have been collected from all localities, and all conditions of harvesting, and these are being tested to determine their qualities, so that they may be blended in such a way as to secure their best effect when made into flour. Various treatments of the wheat are being tried to secure the best possible product from the wheats available. An important part of the laboratory work consists in making tests of new strains of wheats raised at the Plant-breeding Station, in order to facilitate the selection of promising families. The proximity of the laboratory to the Chemical Department of Canterbury College is found to be of great advantage. The equipment of the laboratory has cost £2,400, and all the apparatus is giving complete satisfaction.

Good progress has been made with moisture and protein tests. Owing to an extremely favourable harvesting season, it was possible to use the combine thresher in a number of Canterbury crops. Tests of this grain compared very favourably in regard to their moisture content with others made with grain secured from threshing-mills, but, on account of the exceptionally good weather prevailing, these results must be accepted with caution. In the protein survey very wide divergences in the

protein content have been observed; and it has been found that in some instances a variety such as Tuscan, which is usually considered as being low in protein, is capable of approximating even Pearl in this respect. It is premature yet to base any conclusions on the work already completed, but the preliminary investigations indicate that systematic work on these lines will be productive of real economic advantage to the wheat industry.

In the baking section the action of different additives, such as milk, and the effects of different yeasts and of different methods of manufacture are being investigated, so as to guide bakers in securing the best bread from the flour produced in the Dominion.

Leading members of the milling and baking trades are taking a considerable interest in the work and are frequent visitors at the laboratory.

Affiliation has been arranged with the British Flour-millers Research Association, and by means of this co-ordination the Institute will receive invaluable assistance from those who for some years past have been engaged upon cereal investigations.

PLANT-BREEDING AND SEED RESEARCH.

Plant Research Station.

Advisory Committee: Mr. W. D. Hunt (Chairman) and Mr. C. H. Hewlett, representing the seed trade; the Hon. G. Fowlds and Professor G. S. Peren, representing the Massey Agricultural College; Dr. C. J. Reakes, representing the Department of Agriculture; Mr. Q. Donald and Mr. T. Rigg, representing the Council of Scientific and Industrial Research; Mr. W. Perry, representing the Board of Agriculture; Dr. F. W. Hilgendorf, representing the Wheat Research Institute. Director of Plant Research Station: Mr. A. H. Cockayne.

The sections of the Plant Research Station comprise the following: Administrative, Mycological, Seed-testing, Field Crop, Field Experimentation, Entomological, Grassland Investigations and Plant-breeding.

The Plant Research Station established during the year at Palmerston North consists of the specialist officers of the Fields Division of the Department of Agriculture, using the grant of the Empire Marketing Board, £2,000 per annum for five years, subsidized by the Department of Scientific and Industrial Research, to provide additional pure-research officers to complete a plant-research staff.

In the Director's report, which follows, work is described much of which belongs more properly to the Department of Agriculture, but which, by courtesy of the Director-General, is included here, since the more fundamental work of the Plant Research Station has been closely interwoven with the field-work of the officers of the Department of Agriculture.

Director's Report.

After negotiation between the Scientific and Industrial Research Department and the Department of Agriculture, the Plant Research Station at Palmerston North was established. In it have been incorporated the whole of the specialist and research officers of the Fields Division, and this staff has been strengthened by fresh appointments made by the Scientific and Industrial Research Department. The station is under the directorship of Mr. A. H. Cockayne, and administration funds are provided partly by the Department of Agriculture and partly by the Scientific and Industrial Research Department, in conjunction with moneys from the Empire Marketing Board. The special interests of the Scientific and Industrial Research Department are safeguarded by a special committee that has been set up by that Department; but, in addition to this, the whole of the work of the station, in so far as it affects both Departments, comes under review by that committee. The station in its present form has been in existence for only twelve months, and, as was to be expected, considerable preliminary work has to be carried out before it can be put in full working-order.

Buildings and Land.

An area of 14 acres adjacent to Massey Agricultural College has been secured for the location of laboratory and other buildings, and to provide experimental land for the research work undertaken. In addition, the experimental areas of the Department of Agriculture in various parts of New Zealand are at the disposal of the research staff for more comprehensive field-work, and the agricultural instruction staff of the Department of Agriculture work in co-operation with the specialist officers of the station in the general field and grass-crop experimental work of the Department.

Permanent laboratories and administrative offices have not yet been erected on the experimental grounds at Palmerston North, but efficient temporary laboratory accommodation for the various units of the station has been provided in the town itself. On the return of Dr. G. H. Cunningham from America and Europe comprehensive plans for permanent buildings will be brought forward. In the meantime, however, it can be said that the temporary provision already made has enabled the specialist staff to carry on under quite satisfactory conditions.

On the experimental area itself the only permanent buildings that have been erected are a range of greenhouses specially devoted to mycological investigations, and these are being added to at the present time to enable entomological work in connection with virus diseases of plants to be undertaken. During the year a chemist has been under special training at Cawthron Institute. Laboratory accommodation has now been provided for him at Palmerston North, so that the chemical end of the plant research work being undertaken can now be properly co-ordinated.

Mycological Investigations.

With land available and greenhouse accommodation, the following work has been undertaken during the period:—

Cereal Diseases.—Further bulk treatments have led to practically the whole of the malting-barley of Canterbury being rendered smut-free; and promising results have likewise been secured with smut-control of oats and wheat.

An extensive series of treatments has been undertaken with a view to providing nucleus lines of wheat seed free from wheat-scab, and barley free from barley-stripe; but as yet no successful treatment has been evolved.

Attempts at procuring take-all infection in the field, with a view to conducting persistence experiments, have not been successful, this being the third season in succession that negative results have been secured.

A commencement has been made with studies of biologic specialization of the cereal rusts, together with their methods of perpetuation, as a preparatory step to working out methods of control.

Potato Diseases.—Selections made by the Agronomist of most commercial lines of potatoes have been grown on the station farm, so that by the practice of rogueing we could render them free from certain diseases, as virus diseases, wilts, and early blight. All lines were treated before planting so as to render them free from corticium-disease. Many high-yielding lines were secured, but it is not possible to determine whether they are disease-free until they have been grown a second season. In addition, lines of commercially disease-free tubers have been secured from Scotland, England, and Ireland, and are at present being grown on the farm.

A commencement has been made with persistence studies on corticium-disease, approximately 1 acre being sown with infected tubers with a view to infecting the soil. Further experiments will be conducted in successive seasons to ascertain the period this organism remains in the soil, and, if so, whether any soil-treatment will tend to lessen this period or eradicate the disease.

Pea Diseases.—Selections made by the Agronomist of all garden peas cultivated in the Dominion have been grown on the farm. These were treated for collar-rot before being sown, and subsequently have been rogued repeatedly for this disease. Collar-rot was not eliminated by this method, however, so that a second sowing was made with selected seed. This second lot, if free from the disease and if it remains so, will supply sufficient clean seed for bulking.

Brassica Diseases.—Further work this season has been carried out with dry-rot, our objects being (1) to improve the technique of testing for the disease in seed; (2) to prove that the disease is seed-borne (for this purpose a special insect-proof series of cages has been erected); (3) to improve the method of treatment whereby diseased seed could be rendered dry-rot free; (4) to determine whether the disease carries over in the soil from one season to the next.

All attempts at perfecting a seed-treatment have so far failed, so that work is now concentrated on the production of disease-free lines of seed.

Club-root experiments have been designed to extend over a period of seven years. This work consists of (1) experiments to determine the period the disease persists in the soil; (2) whether any manurial, rotational, or cultural practice will lessen this period of persistence; (3) whether any brassicas are resistant or immune; (4) whether brassica weeds are hosts of the organism (and thus tend to carry the disease over indefinitely); (5) evolution of a technique for certain detection of club-root in the soil; (6) experiments to determine whether club-root is carried with the seed.

Other Investigations.—Lucerne-nodule organism: Considerable attention has been paid to the improvement of methods whereby lucerne-seed may be efficiently inoculated with the lucerne-nodule organism prior to sowing, and work conducted on the effects of manures on the organism has led to considerable modifications in the practice of establishing lucerne stands.

Fireblight: Owing to the outbreak of fireblight in the South Island, considerable additional work has had to be carried out with this disease, leading incidentally to the establishment of several previously unrecorded hosts.

Pine-disease: The cause of the dying of *Pinus radiata* throughout the Dominion has been under investigation, leading to the isolation of an organism common to all diseased trees. Experiments are at present under way to determine whether such is parasitic, and, if so, its method of dissemination.

Linseed-rust Control: Experiments, unfortunately unsuccessful, were conducted during the year to procure a treatment for the elimination of rust of linseed, which has been proved elsewhere to be carried with the seed. Further work is in progress.

Field Crop Investigations.

This work has for its objective crop and pasture improvement by the use of better seeds. The term "better seed" is used to cover freedom from disease, varietal purity, improved strains, and strains suited for particular purposes or environment. The organization falls into two closely associated divisions. On the one hand is the raising of improved seed for distribution, and on the other the organization for wider distribution from farm to farm and the certification of the seeds of those crops conforming to certain standards.

PRODUCTION OF IMPROVED SEED.

Seed of all the main farm crops is being raised by adopting pure-line selection. The work is carried out in close co-operation with the Mycologist, who undertakes the elimination of those diseases amenable to control, and the reduction of others by rogueing and the selection of disease-free lines. Nothing in the way of cross-breeding is being undertaken in the initial stages of this work, the view being held that there is ample scope for improvement in the standard varieties of proved value for local conditions.

Potatoes.—Commencing with tuber units of the more important varieties, there is now available sufficient seed for the planting of several acres. These selections will be multiplied as rapidly as possible and distributed to selected growers, who in turn will pass the seed into commerce, and be followed up by certification. Each year a fresh series of tuber units is being selected to replace the lines going into commerce, so that there will be a steady output annually of pure and healthy seed. Of

the original selections made, the stage has now been reached when the produce of next season's crop will be passed on to selected growers for increase and introduction into general commerce after the season 1932–33.

Wheat.—Pure lines have been raised of all standard varieties. The original selections are in the process of mutiplication, and further selections are being made annually to replace those going into the hands of growers. It will be two or three years before sufficient seed will be available for distribution of any one pure line, and in the meantime some of the varieties in commerce are badly sized and others are heavily infected with loose smut. To fill this immediate want, those pure lines which are not required for further selection, but which possess no serious defect, have been bulked. Sufficient seed of these bulked lines is now available for the sowing of nearly 100 acres, and tentative arrangements have been made with the Canterbury Seed Co. to grow these lines.

All seed distributed is smut-free, and the following varieties are represented: Solid-straw Tuscan, Velvet Ear, Major, Hunters, Dreadnought, Red Fife, Velvet Chaff, Marquis.

Peas.—Precisely similar methods are being adopted in the improvement of garden and field peas. Several hundred selections are being multiplied, and it is anticipated that the selection work in field peas will be of considerable value.

Malting-barley.—Pure lines of all the standard varieties of malting-barley have been raised, and sufficient seed, bulked from single-plant selections, is now available for the sowing out of about one acre of each. It will be a couple of years before pure-line seed is available. All lines produced are smut-free, and the work is being undertaken in co-operation with the Canterbury Seed Co. (N.Z.), Ltd.

Other Crops.—In co-operation with the New Zealand Cattle Cake and Oil Co., Ltd., selection work is being undertaken in the "Bill Moose" variety of linseed. This variety yields heavily on the better-class land, and the percentage of oil extracted is considerable higher than that obtained from the common variety. The shortness of straw, however, renders harvesting difficult, and the objective is to remedy this defect without sacrificing the other qualities. The work done so far would indicate ample scope for selection.

A very large proportion of the New Zealand onion crop is grown in the vicinity of Christchurch. The keeping-qualities of the varieties used leave much to be desired, although there are one or two notable exceptions. Selections from these long-keeping types have been seeded this season. In addition to this, the best-keeping English and American varieties are under trial, and seed will be raised from any which show promise. It is the practice of onion-growers to raise their own requirements in seed, so that if a superior type is produced its rapid distribution is assured.

A commencement is being made this season in the production of pure lines of oats.

CERTIFICATION.

It is essential that the production of pure lines should be closely interwoven with an organization for supervised distribution. This supervision is being effected by means of certification. Seed distributed is followed up by inspections, and while it remains pure and healthy the produce is hall-marked for seed purposes.

Potato-certification.—This has met with considerable support from both growers and merchants. Moreover, some very interesting and valuable evidence has been obtained and a great deal of constructional work undertaken by officers inspecting crops. There has been a very active decline in the number of crops rejected during this (the second) year, and a considerable increase in the area under certification. Approximately 1,000 acres have been entered in Canterbury, and this represents about 7 per cent. of the potato-growing area of that province and about 4 per cent. of the total area in potatoes in New Zealand.

Potato-certification is to be extended to the North Island next season, and it will then be possible to set Dominion standards for certified seed in respect to purity, disease, and grading.

Wheat-certification is undertaken in co-operation with the Wheat Research Institute, and is now in its second year of operation. Virtually all the improved seed wheat has in the past been produced by the Lincoln College, and probably all that accepted under certification has originated from that institution.

Solid-straw Tuscan and College Hunters were the only varieties found sufficiently pure for acceptance under certification. Of the others, nothing approaching pure seed is available in any quantity, but the selection work now under way by the Department should remedy this deficiency, and in a year or two seed of all the main varieties of sufficient purity for certification will be in distribution. Growers whose seed wheat is accepted are granted a bonus of 6d. per bushel above the ruling market-price for milling-wheat on the 31st March. This amount (and all expenses entailed in transport, dressing, commissioner, &c.) is charged forward. The bonus granted to growers is in the nature of a prize for efficient farm-management. Mr. Veitch, Government Grader, Christchurch, has been responsible for the grading and distribution of seed wheat, and most of the success must be attributed to his painstaking work.

White Clover.—A commencement has been made this season in the certification of old-pasture white-clover seed, mainly with a view to stimulating the export trade. A few acres have been accepted as a preliminary trial, the produce of which will be sealed and exported as "Certified New Zealand old-pasture white clover." Samples from each line will be tested out at various stations in Great Britain and also in this country, with a view to determining the relative value of white clover from pastures of different ages. It is hoped to extend this phase of the work in the near future.

Other Pasture-plants.—Work recently conducted by the Agrostologist has demonstrated very clearly the necessity for correct categorization of the various grass and clover seeds used for our pastures or exported overseas. Preliminary work is being undertaken with a view to future certification work, a certain amount of which will be inaugurated next season.

It seems possible that certification of grass and clover seeds is likely to develop into the most important phase of the work in its effect upon the export trade and the economic establishment of the pastures of the Dominion.

Field Crop Experiments.

A considerable extension of field experiments has been made in the past season. In the North Island the main extension has been along the lines of grazing trials on dairy farms. In the South Island a large number of pasture observation trials have been laid down and a considerable increase in the investigations on manuring of wheat, potatoes, turnips and swedes, and lucerne has taken place.

PASTURE INVESTIGATIONS.

(1) *Grazing Trials.*—About eighty dairy-farms were selected in the North Island with a view to determining the effect of intensive utilization of grass under phosphate in comparison with phosphate plus nitrogen. On each farm a uniform paddock was selected and divided into two equal parts. The treatments mentioned above were used, the nitrogen being applied in three, and sometimes four applications, at 1 cwt. per acre each time of application. Co-operating farmers are keeping records of grazing-days and a very good idea of the relative merits of the treatments is being gained. In some cases nitrogen had been an unqualified success, while in others no apparent difference in grazing-capacity can be determined. The results cannot be finalized for the year until the autumn grazing results are completed.

One very outstanding feature of the trials is the large carrying-capacity of paddocks intensively grazed. Some of the paddocks have already produced over 300 lb. of butterfat per acre. It appears that this figure is likely to be on the high side, on account of the fact that where the pastures are well managed there is a tendency to keep stock on paddocks longer than would be profitable under ordinary farming practice. No appreciable drop in production occurs under the system of having only two paddocks on a farm under such treatment, because the cows usually go back to good grass. It is likely that such high production could not be maintained over a whole grazing portion of a farm, as the effect of too frequent over-grazing and under-feeding would be reflected in the butterfat yield.

(2) *Farm under Intensive System.*—The intensive system of pasture management was commenced on Mr. J. Ward's farm at Manawatu in the 1927–28 season, and is being continued, with certain extensions and modifications, in the present season. Half the paddocks of the farm are under phosphate treatment, and half under phosphate and nitrogen. In spite of a heavy flood over the farm in September, the yield of butterfat will be higher than in the previous season.

(3) *Sheep-grazing Trial, Marton.*—A grazing trial with sheep has been started on the Marton Experimental Farm. The trial aims at a demonstration of the stock-carrying capacity at various seasons of the year when immediate and full utilization of grass by stock is observed. Two treatments are under trial, but nothing conclusive regarding their relative merits is likely to be available for at least another year.

(4) *Mowing Trial.*—This aims at the measurement of growth throughout the year from applications of super and slag applied at quarterly intervals. Valuable information is being gained regarding growth-rate of grass, response-rate of phosphates, and incidence of growth relative to time of application of manures. It is highly desirable that dry matter produced and chemical considerations should be investigated as soon as possible on this trial.

(5) *Haying Trials.*—Five investigations into the effect of fertilizers have been conducted in the North Island, four in Canterbury, and fifty in Otago and Southland. Most of these trials show a marked increase as a result of using phosphatic fertilizers—super as a general rule, especially in the South Island, proving a very satisfactory form.

(6) *Observation Trials.*—About twenty observation and demonstration plots have been laid down or are being continued from previous season in the North Island. In Canterbury about 180 small experiments have been distributed over as many soil-types as possible. Lime, phosphate, potash, and nitrogen are being used alone and in varying combinations. The object in laying down these trials was to get a rapid survey of as much land as possible, with the idea of determining what factors are mainly limiting production. The results more than justify the work at the present time, and, carried on for a few years, should be of great value. The striking feature of the trials is the comparatively widespread effect from lime. Phosphate response is often limited by the requirement of lime, and when used in conjunction with it is usually highly beneficial. Potash does not appear to be of any consequence except in one or two isolated cases. Nitrogen has almost invariably increased grass-growth, and where lime, phosphate, and nitrogen are used together the most marked improvement has taken place. Results indicate that nitrogen is highly important in the establishment and maintenance of rye and cocksfoot, which grasses almost always show a marked response. Grazing trials to test the economic value of response in a few places are being started this season. The arrangement of the plots is such as to demonstrate the effect of controlled grazing. Only a small percentage of farmers are carrying out good-management utilization of the grass produced, and in these cases improvement of the grass-sward, apart from applied manure, is greatly evident. In Otago about twelve areas are being used solely for observation. In the vicinity of Edendale good response to potash is occurring.

(7) *Cereals.*—A considerable extension of experiments in the manuring of wheat took place in the past season. This was rendered possible by the better threshing facilities provided by the up-to-date thresher mounted on a motor-lorry. In all, thirty-two trials were laid down, of which twenty-six were harvested. The remainder, in North Otago, were destroyed by hail. Superphosphate has established a definite superiority over slower-acting phosphates. The spring dressing with soluble nitrogen again proved to be highly beneficial in the main, the use of 1 cwt. of nitrate of soda causing an average increase of about 4½ bushels per acre. About two hundred small plots were laid down on roadside paddocks to focus farmers' attention on nitrogen and to get more general information regarding it. About sixty of these were harvested, and the general result was more or less in agreement with the results from the more carefully conducted trials mentioned above. Potash has not displayed any general advantageous results from its use.

(8) *Wheat-variety Trials.*—Three of these were sown in Canterbury. The results indicate a superiority of Tuscan as far as yield is concerned. Some fundamental work on rate of seeding is being done this year which it is expected will greatly simplify and increase the accuracy of these trials.

(9) *Effect of Disease-control Measures on Yields.*—Four experiments on wheat, two on barley, and one on oats were carried out to test the effect on yield of using disease-control measures. The results are not regarded as sufficiently conclusive this season, and the trials are being repeated in 1929–30 season.

(10) *Oat-manuring.*—Four trials conducted in Southland demonstrated the advantage of super over less-soluble phosphates, and a considerable increase in yield resulted from the use of nitrogen as an adjunct to phosphate.

(11) *Potato-manuring.*—The number of trials in Canterbury was increased to twelve in the past season, and three have been laid down in Otago and Southland, and one in Auckland. These trials are not yet harvested. The general and highly-paying response from superphosphate leaves no doubt as to its advantages. Potash and nitrogen are both inconsistent in response, and in some cases both have given increases where used singly with phosphate, but when used together the result is no better than where either is used as a single addition.

(12) *Swedes and Turnips Manuring.*—Seventeen trials in the South Island and two in the North are under way. They aim at the determination of the effect of various manures in relation to gemination and yield. The results of the previous season pointed very strongly to the advantages of super and lime in overcoming germination injury and in still maintaining the advantages of a readily available phosphate. Although scientifically the mixing of super and lime is a wrong practice, the results in practice are highly promising.

(13) *Lucerne.*—Experiments to test the effects of manure have been carried out in the North Island and Otago. While phosphates give good results almost invariably, the use of White Island fertilizer containing sulphur has been very beneficial to crops in Otago. In collaboration with the Mycological Section, various methods of applying soil and culture inoculations are under trial in an experiment in Canterbury, and in various places throughout New Zealand the use of the culture prepared at the mycological laboratory is giving excellent results. In some cases inoculation is so important as to cause the crop to fail entirely if it is not applied.

(14) *Rape.*—The work on rape has proceeded along the lines of previous seasons, and six trials were undertaken. Super, or a mixture of super and Ephos, are about equally effective. The top dressing of nitrate of soda at 1 cwt. per acre increases yield by about 15 cwt. to 1 ton, and may be considered just about paying. Farmers usually grow a superabundance of rape, so there does not appear to be any particular advantage in further stimulating yield, except where a shortage is likely to be experienced.

(15) *Peas.*—Work on peas has been conducted in two trials for the Field Mycologist. The object of the trials was to determine whether the reduction in incidence of collar-rot by using Semesan would materially affect the yield. Results are not yet to hand.

GENERAL REMARKS.

The energetic and careful way in which experiments have been conducted reflects greatly to the credit of the individual instructors concerned. Labouring under the temporary difficulty of insufficient technical assistance, many of these officers have had to devote long hours outside those ordinarily required of them to the work of experiments.

Grassland Investigations and Plant-breeding.

AGROSTOLOGY.

The transference of the agrostological unit from Wellington and the establishment as a member of the Plant Research Station at Palmerston North took place during the past year. Linked up intimately with the Fields Division extension and instructional service, conveniently placed in regard to the land, and facilitated enormously by car-transport, the outlook for extensive, sustained, and well-co-ordinated grassland research work never looked brighter. Two additional specialist officers have been added to the staff, and, in addition to these, Mr. William Davies, M.Sc., arrived on loan for two years from the Welsh Plant-breeding Station at Aberystwyth. Mr. Davies could not have come to New Zealand at a more opportune moment. We feel his sojourn in New Zealand will be of very great mutual benefit.

Broadly speaking, the threefold aim as a research station is—

(*a*) To know our grassland species and the exact niche into which each fits. Knowing the behaviour of each species and the requirements of each species, change in pasture-composition may be correctly interpreted. In other words, each grass and each clover is an indication of its sum environmental conditions. Species vary in habitat requirement and rearrange themselves in definite small or large association types, each association a contributor to a great mosaic grassland complex, the outcome of variation in condition of the habitat.

(*b*) To know type or strain within the species. While we are apt to visualize the species as stable or fixed, and to assert replacement and displacement, rise and fall of association types in response to the environment, yet there is unquestionably a species-variation, possibly a product of the environment. Danish cocksfoot differs in colour and form and in persistency from Akaroa cocksfoot; Kentish Wild White differs from Lodino or commercial Dutch White; Hawke's Bay rye-grass differs in growth-form, palatability, and persistency from Southland rye-grass; broad red clover differs greatly in form, persistency, and time of flowering from Cornish Marl or Montgomery red clover. Are these variants exploitable? Can we, as it were, by type or strain selection widen the habitat-range of

a species? Strain-selection has unconsciously gone on in all arable-land farming communities in New Zealand for the last four or five decades. Quick-maturing and free-seeding types of rye-grass, for example, have been harvested and sown; harvested and sown, over and over again. The slower-maturing, tardy seed-producing, leafy strain have figured in lesser and lesser amounts until to-day a free-seeding, rapidly maturing, more or less annual rye-grass type has been developed—the outcome of unconscious strain-selection. On the other hand, areas have remained in permanent grass for decades. These have been subjected to an entirely different set of environmental conditions, and survival of the sward-components has been determined by one or two things—(1) the ability to reseed, or (2) the ability to persist by vegetative spread, as by tillering.

(*c*) The third aim is to know how best to modify or change existing conditions on the farm so that the very best species and the very best strains of those species may be provided, and the wherewithal for their optimum growth and maximum development. No consideration of species or strain is of value apart from determination of the conditions necessary for maximum production by those species or strains.

This threefold aim constitues the fundamental grassland research work of the station.

Fundamental Grassland Research Areas.—Nine areas on widely different soil-types, situated respectively at Weraroa, Marton, Manaia, Katere, Stratford, Tutira, Pembroke, Gore, and Balclutha, have now been sown. On each area fifty-four different grasses and clovers, or strains of these, have been included in these trials, and differential top-dressing of these is being carried on to determine the reactions of each under the varying degrees of fertility-upkeep.

Strain Investigation.—The research work on hand has for its objective the testing-out of strain or type, and the reinstatement and perpetuation on the market of the persistent, leafy, and truly permanent strains of herbage plants. The main species at present under trial are (1) perennial rye-grass, (2) cocksfoot, (3) brown-top, (4) red-clover, (5) white clover.

Perennial Rye-grass: Over five hundred commercial lots are now under trial at the Plant Research Station at Palmerston North, and field-grazing trials of the more outstanding types are being conducted at Marton, Manaia, and Katere. Over two thousand plots of rye-grass alone have been laid down during the year. The trials up to the present indicate the necessity for differentiation between (1) those lots that are mixed with or are dominately Italian rye-grass; (2) those lots that are what may be called pseudo or false perennial; and (3) those that approximate to the true perennial, leafy, and persistent types.

The main projects are (1) to eliminate the Italian rye-grass lots; (2) to differentiate out as rapidly as possible the false perennial lots from the true perennial lots, and (3) to locate throughout New Zealand and get on to the market as rapidly as possible pedigree true perennial rye-grass strains. It is extremely gratifying to report that certain firms of the seed trade are taking the matter up in earnest, and are growing only approved genuine perennial rye-grass types, drawn largely from Hawke's Bay, and next year it is hoped there will appear on the market seed certified to by this Department as being the true perennial type.

White clover: Approximately 150 lines of white clover are now under test, and more are being secured for planting in the spring. There are probably numerous types of white clover in New Zealand, and much work is contemplated in classifying those white-clover crops which are harvested from districts that differ markedly in the type of agriculture practised. There are those crops harvested from permanent grassland and those harvested from volunteer white that comes away in the wheat stubble or after the laying-down of some temporary crop, no white-clover seed having been sown. It is not known at the present time how we should regard these volunteer and stubble whites, and it is felt that the time is ripe for a full investigation into those different New Zealand white-clover crops, to nip in the bud any tendency to production and perpetuation of short-lived white-clover strains in New Zealand.

Red clover: One hundred and four lots of red clover are now under test, belonging to four major red-clover groups—(1) Broad Red, (2) Late Red, (3) Late Late Red, and (4) Wild Red. The work to date has demonstrated that all New Zealand red-clover belongs to the Broad Red group. English experience has shown this group to be the least permanent of all the red-clover types, and there is a big possibility of introducing from one or other of the Late Red or Late Late Red groups a type of red clover that will conform more to the grazing-pasture type than do these reds of the Broad Red group.

Cocksfoot: Some 117 lots of cocksfoot are under trial, and these fall into two major types—(1) The New Zealand type, and (2) the Danish type. There is a very marked difference in these types. The Danish is broader in shoot and leaf, and the crown is comparatively few-tillered. In the true Akaroa type the shoots are not so broad or coarse, and the crown tends to being multi-tillered. The dense, finer-leaved, multi-tillered crown types conform more to the grazing-pasture type, and there is a big danger that, unless care is taken, the excellent New Zealand type may lose its identity, particularly as cocksfoot-seed production increases on the plains country and diminishes on the hills.

Brown-top: One hundred and four lots of brown-top are under trial, the main project here being to ascertain freedom or otherwise from red-top. All the lines sown are red-top free, but there exists a distinct type of brown-top which recent field-work has shown to be a type segregated out and confined to the poorer and drier soil type of the Canterbury plains country. The specific identity of this type and its behaviour under lawn conditions is being studied. Other species from different sources of origin under trial are: Crested dogstail, Timothy, Meadow Fescue, Chewings Fescue, Danthonia pilosa, Italian rye-grass, Western Wolths, rye-grass, and Phalaris bulbosa.

Rye-grassing Experiments: Secondary-growth Country.—The experiments on rye-grassing secondary growth have been continued, and some additional 30 acres have been sown. It is very gratifying to report that the species and mixtures of these recommended for these sowings are now being widely adopted by the hill-country farmer, and the work is really progressing of its own momentum. During the past year our attention has been focussed on the menace of hard-fern (*Psaesiar scaberula*). This

troublesome secondary growth defies the ordinary methods of control. Firing is not entirely effective owing to the green edge that will not burn unless the area has reverted to one entire sward of this fern. Crushing with cattle and hard grazing with sheep increases rather than decreases the amount of hard fern. Man's hands, wielding the slash-hook or grubber, are impotent against the spread. During the past three years spraying tests with arsenical compounds, mainly arsenic pentoxide (AS_2O_5), have been thoroughly tried out, and it is very gratifying to report a marked degree of success. In 1926 approximately $\frac{1}{4}$ acre was sprayed; in 1927–28 approximately 26 acres were successfully dealt with, and in 1928–29 over 100 acres have been treated. Experiments are now afoot to clean up some 200 acres in all, and to find out over a period of years the amount of spraying and cost to keep this area entirely free of hard-fern. Control of hard-fern will put quite a different complexion on the control of other secondary growths throughout the back Taranaki country at least. Crushing is absolutely essential to control bracken-fern and the menace of hard-fern induced as a result of hard crushing has been a big influence towards lighter stocking, and consequently has prolonged enormously the struggle against bracken. Hard-fern control assured will inspire more confidence in the regrassing of the country, and effective bracken-control methods may be vigorously applied.

PLANT-BREEDING.

Routine Work: Herbarium.—The old herbarium was gone through and put into order, much having to be discarded owing to the ravages of insects. Some two thousand additional specimens have been collected. Contributions have been made by Mr. H. Carse, of Auckland, and by other workers, while a number of species received for identification were incorporated. The whole have been prepared, mounted, and classified. The herbarium of introduced and indigenous species now contains some five thousand mounted sheets. By purchase from Mr. T. W. Kirk 407 sheets, mounted under glass, have also been added. A considerable amount of duplicate material is held for exchange purposes.

Contributions of exotic material, mainly selected for its bearing on New Zealand problems, have been received from the Herbarium of the Royal Botanic Gardens, Kew; the Herbarium of the Botanic Gardens, Sydney; the National Herbarium of Victoria, South Yarra; the Gray Herbarium, Harvard University; the Herbarium of the Bureau of Plant Industry, Washington; the Herbarium of the Botanic Gardens, Berlin; the Herbarium of the University of Palermo; the Herbarium of the University of Messina; the Herbarium of the University of Modena; the Herbarium of the University of Tomsk; the Herbarium of the University of Kiev. The collection of exotic specimens now numbers over two thousand sheets. Exchange parcels of specimens have been despatched.

The following localities have been visited for herbarium material and general botanic purposes: Neighbourhood of Dunedin, Central Otago, neighbourhood of Ashburton, the Wairarapa, Castle Point, New Plymouth, Mokau, Rotorua and volcanic plateau, the neighbourhood of Napier, Wairoa, Nuhaka, neighbourhood of Gisborne, Tolaga Bay, neighbourhood of Blenheim, Kainui, neighbourhood of Christchurch, Oamaru, Tapanui, Roxburgh, neighbourhood of Nelson, Mount Egmont, Mount Tongariro. Much local collection has also been done.

Some four hundred packets of seeds have been received from Europe and grown for comparison of European forms of species occurring as introduced plants in New Zealand. These mainly came by way of exchange with the Agricultural College of Voronesh.

Identification of Specimens.—Some six hundred specimens of plants have been received and reported on, with advice as to treatment where necessary. Several new records of introduced plants have resulted, some being of importance from the economic point of view.

Library.—The library has been gradually extended. Three instalments of the works given to the station by Dr. Cockayne, C.M.G., F.R.S. ("The Leonard Cockayne Collection") have been received and classified. The pamphlet section fills thirty-six boxes. Progress has been made with the indexing of these and of the plant-collections.

Investigational Work.—Special: The species of *Phalaris* occurring in New Zealand have been studied. The progress of this work awaits report on certain points submitted to Kew.

The weed "*Antholyza aethiopica*" has been shown to be a species of *Watsonia*, and its importance is under study.

The genus *Juncus* has been studied taxonomically, with full collecting, and a preliminary to economical work.

Gorse has been studied, especially in connection with its phenology, with the help of monthly reports from various officers and independent workers. Progress reports have been forwarded to the field entomologist, Cawthron Institute, to assist the work of control by *Apion* attack.

The distribution and taxonomy of *Hypericum perforatum* in New Zealand have been studied in connection with insect-control proposals, and herbarium and living material collected. Specimens of plants and seeds have been forwarded to Kew for report.

Special attention has been paid to the taxonomy of *Festuca*, *Danthonia*, and *Acaena*, both with herbarium and living material collected from various sources.

A seed-collection has been prepared to assist in identification work.

A number of miscellaneous taxonomic questions have received attention, especially with Gramineae.

Assistance has been given to other officers of the station when required.

Progress has been made in the study of the taxonomy and ecology of the introduced plants. The objective is the publication of a handbook of the introduced flora.

Collections of living plants have been made, with a view both to systematic study and the adornment of the station-grounds.

The following papers have been published :—

(1) Review of Cockayne's " The Vegetation of New Zealand " (in the *Journal of Agriculture*).
(2) Review of Cockayne and Turner's " New Zealand Trees " (in the *Journal of Agriculture*).
(3) " The F_2 Progeny of the Cross *Coprosma propinqua* g × *robusta* o " (in *Genetica*).
(4) Abstracts of various papers on New Zealand Botany (in Biological Abstracts).

A paper is in the press on hybridism among the introduced plants of New Zealand.
My assistant has a manuscript in an advanced state of preparation on " Sexuality in *Coprosma*."

Seed-testing Investigations.

For the calendar year 1928, 10,149 samples were received for testing purposes, representing a decrease of 619 on the number received the previous year. The reduction in the total is almost wholly accounted for by the lesser number of rye-grass, white clover, and red clovers submitted. Two hundred and six samples were received from sixty-five farmers and seed-growers. It is of interest to note that the greater number of samples submitted by farmers represented purchases made under the vendor's guarantee of purity and germination, which figure approximately 20 per cent. failed to reach.

The distribution of the samples received was as follows : Southland, 2,950 ; Wellington, 2,221 ; Auckland, 1,191 ; Canterbury, 1,189 ; Otago, 732 ; Taranaki, 328 ; Hawke's Bay, 238 ; Marlborough, 174 ; Gisborne, 23 ; Nelson, 13. The remainder of the total number was made up as follows : Seed-merchants, 8,509 ; Government Departments, 365 ; laboratory tests, 890 ; retests, 115 : the whole necessitating the making of 10,060 duplicate germination tests and 2,594 purity tests.

With the exception of rye-grass, the standard of purity and germination shown was very satisfactory. The depression in the germination of rye-grass has been marked for several seasons ; although in 1928 an improvement was shown in southern and Sandon seed, this improvement, in the general average, was offset by the depressions in Hawke's Bay and Canterbury seeds. Sandon rye-grass has, in most cases, for several seasons now failed to germinate up to a merchantable standard, and some attention has been given to seed-production in this district. The 1929 seed has in about 60 per cent. of the crops shown a decided improvement in growth, and where inquiries have been made it has been found that the higher-quality seed has been the result of a delayed cutting. This survey of all the areas harvested this year is being continued, and with the data collected covering crops harvested in previous years it is thought that it will be shown that in the majority of cases the unsatisfactory germination is due primarily to immaturity at times of harvest—that is, under average climatic conditions.

Two thousand five hundred and eleven tons of grass and clover seeds were exported during 1928, a reduction of 2,000 tons on the quantity for the previous year, which, on account of the heavy exportation of rye-grass, was a record year. Taking the export figures over the four years 1925–28, substantial decreases for 1928 were shown in rye-grass, red clover, and white clover ; while the quantity of brown-top shipped has been more than doubled.

The experiments commenced in 1928 in dusting Chewings fescue with Semesan to overcome loss in vitality are being continued, six parcels having been sent to Washington and Cambridge during the twelve months. Tests made at those places and at the New Zealand station have shown that, to date, the treatment has in no way checked losses in vitality.

A number of white-clover samples collected from the various seed-production districts have been examined, and indices of dominance, frequency, and constancy of occurrence of the individual species of impurities tabulated.

Laboratory experiments, designed to test the effect of atmospheres of different degrees of humidity, the rates of adsorption, and loss of moisture on stored seeds are being carried out.

With the present organization and accommodation, research work bearing on seeds and seed-production is necessarily limited.

From the commencement of the year 1929 all brown-top samples have been tested under the proposed international testing system, as were all samples of seed certified under the recently introduced system of seed-certification. It has been repeatedly shown during the year that the retention of the almost obsolete testing system in New Zealand has been the direct cause of many disputes in the seed trade, both import and export seeds being involved. It was mainly for this reason that the Continental system was adopted for brown-top. It is to be hoped that in the interests of the seed trade and in the seed-testing station itself opportunity will, in the near future, be provided for the complete reorganization of the station so that it may give the full services required of it. It may be added that the adherence of the New Zealand station to the Irish system was a subject of discussion at the Conference of the International Seed-traders' Association and the International Seed-testing Association at Bologna and Rome respectively during 1928.

The tabulation and issue to the trade of periodic reports covering average purity and germination percentages have been continued, for which general appreciation has been shown. The station has acted in an advisory capacity in connection with trade disputes, quality standards, seed-production, identification of seeds, seed storage and shipment, &c. A large number of tests (approximately six hundred) have been made on behalf of the Mycological Section in connection with its investigation into the control of seed-borne diseases, and approximately two hundred for the Agrostological Section.

Entomological Investigations.

A certain amount of dislocation in connection with entomological work was inevitable consequent on Dr. Miller's resignation at the commencement of the year and the transfer of this section to Palmerston North. Apart from the above, however, the work for the past year, though necessarily curtailed, has proceeded as usual. For convenience the past year's activities are dealt with under two heads—(*a*) Routine, (*b*) research.

Routine.—This involved (1) the identification of numerous insects sent in, and supplying all available information as to their economic significance and methods of control, where known ; (2) the

investigation of minor problems in the field as they are brought under our notice from time to time; (3) attention to and care of departmental collection, and indexing and classification of certain classes of literature.

Research.—The amount of work necessary under this head is to all intents and purposes unlimited, but, necessarily, only problems of immediate or major importance received consideration. These are briefly outlined and dealt with under their respective headings:—

(1) Diamond-backed moth (*Plutella maculipennis*): The larvæ of this moth are particularly destructive in the numerous cruciferous crops grown throughout the country. With a view to the biological control of this pest it was deemed essential to ascertain the different species of parasites and hyperparasites (if any) already here. This phase of the work is now well advanced, and specimens of the parasites obtained have already been forwarded to the Imperial Bureau of Entomology, London, for specific identification. The life-history of the above moth is also being studied.

(2) Biological control of the "Pear-midge" (*Perrisia pyri*): The work under this head has consisted mainly in rearing to the adult stage midges and their parasites from material sent in from various orchardists.

(3) Virus diseases of potatoes: This apparently, though primarily a question for the Mycological Section, also involves entomology, inasmuch as insects are vectors in the dissemination of the disease. A survey of the potato-growing areas representative of the South Island was accordingly undertaken. Various species of insects infesting the potatoes were collected and are being classified, while preparations to ascertain what part these insects play in the transference of the disease are in train.

(4) Brief field survey in regard to the incidence of eel-worm as it affects the potato-grower, and experiments to determine broadly the types of soil most conducive or otherwise to the welfare of this pest has been undertaken, but much remains to be done.

(5) Survey to determine the food habits of the pukeko: Numerous pukeko-stomachs are sent in from time to time from variously selected localities. These stomachs are analysed and the food contents noted.

(6) Aphis control: Though admittedly a question of primary importance, comparatively little work has yet been done on it; primarily, perhaps, because the subject is involved and difficult, and its successful undertaking is no light consideration. Parasites of this pest have been reared and identified, however, while some still remain for identification.

NOXIOUS-WEEDS-CONTROL RESEARCH.

Advisory Committee: Professor H. B. Kirk (Chairman), Mr. Q. Donald, Dr. F. W. Hilgendorf, Mr. A. H. Cockayne. Director of Research: Dr. David Miller.

The funds for this research are provided by annual grants of £2,000 received from the Empire Marketing Board. These are supplemented by a similar grant from the Department, while the Cawthron Trust Board makes available portion of its services to facilitate the investigations. £1,000 of the Empire Marketing Board's grant is being expended in Great Britain. This amount, previously apportioned between Dr. Imms, of Rothamsted, and Dr. Heslop Harrison, of Durham, for the collection and forwarding to the Dominion of suitable parasites, has during the year been allocated to the Empire Marketing Board's Entomological Station at Farnham Royal. On the 1st May, 1928, Dr. D. Miller took up his position as Director of Research in succession to Dr. R. J. Tillyard.

Report of Director on Progress of Researches.

Equipment.

An automatic cool-store plant was erected in the general laboratory, and is utilized for keeping insects in a dormant state until required. Towards the close of the year a specially designed heated glasshouse was erected, in order that certain insects may be experimented with throughout the winter months.

Blackberry.

Two insects have been tested out in connection with blackberry—(*a*) *Coraebus rubi*; (*b*) *Bembecia marginata.*

(*a*) *Coraebus rubi.*—A consignment of rose stocks infested with the larvæ of *Coraebus rubi* was received during April from the south of France. Periodically in May, July, and August this consignment was removed from cool storage and planted in the insectary in order to give the insects every chance of emerging in time for spring and summer work on the control of blackberry. Although the rose stocks sprouted after planting, no beetles had emerged by the end of December; however, from an examination of some of the stocks, emergences are expected in January, 1929, when the researches on blackberry-control will commence.

(*b*) *Bembecia marginata.*—From the consignments sent from North America last year twelve moths were secured; but the eggs laid by the females were found to be sterile. Owing to this difficulty and to the fact that *B. marginata* damages raspberries, it was deemed advisable to discontinue work with this insect and concentrate on *Coraebus rubi.*

Ragwort.

Three insects parasitical to ragwort have been tested:—

(*a*) *Tyria jacobaeae.*—Progress with this insect has been extremely satisfactory, and, before last winter, having reached a stage when the tests had shown the insect to be a safe one to liberate, a Government permit was secured.

Tests with this insect have proved successful, and, in consequence, about 500,000 specimens were liberated in ragwort-infested areas in the Bay of Plenty, King-country, Taranaki, Southland, and Nelson districts. This liberation was for the purpose of testing out the adaptability of the insect

in the climatic conditions prevailing in these districts, and to ascertain its capacity for over-wintering. Reports indicate that it has apparently become successfully established where liberated; and if this proves true, then it is hoped that generous supplies will be available for wholesale distribution in all of the main ragwort areas of the Dominion next summer, so that a reasonable effect may be obtained before the insect becomes too heavily parasitized.

(*b*) *Homoeosoma vagella.*—This insect was secured from Australia, but was found to be well established in New Zealand, where, though at times temporarily checking ragwort, it did not act as an efficient control and was subject to severe parasitism. The work with this insect has been discontinued.

(*c*) *Gortyna ochracea.*—Tests with the larvæ of this insect showed that they damage the foliage of tomato and potato. In consequence, all the stocks were destroyed.

Gorse.

During the year five consignments of *Apion* were received. From the experiences gained from the researches during the year there is no doubt that the acclimatization of *A. ulicis* in New Zealand will prove a difficult problem. The two main difficulties are: (1) The flowering of gorse out of season in most parts of New Zealand, and (2) the high percentage of sterility among the weevils on arrival in the Dominion. As it was found that gorse flowered according to season in the neighbourhood of Dunedin, a field station was established there and some better results secured. It is intended to carry on the work with flowering gorse during the winter in the new heated glasshouse just erected. Experiments are being undertaken to ascertain, if possible, the cause of sterility. Another difficulty is due to the necessity of keeping the weevils on gorse under close confinement to prevent their escape, and there is no doubt that this has an ill effect on both the insect and the host plant.

Piripiri.

A correspondent in Chile has sent word that he has located the larvæ of a saw-fly that does considerable damage to Chilian species of *Acaena*. The correspondent has been engaged in working out the life-history of this insect and in making tests on its food range; he found that it did not attack strawberries, which is an important point. He has sent two consignments (one received during October and the other in November), but, owing to faulty packing, the material did not arrive in good condition. However, better arrangements are being made, and this insect will probably be of great value in the attempt to control piripiri. The insect has been identified as *Antholcus varinervis*.

Foxglove.

Although it has been decided to discontinue the work with foxglove, a very small unsolicited consignment of two species of insects—*Eupithecia pulchellata* and *E. pyrreneata*—were received during December. These are being kept under observation, but no adults have so far emerged.

MINERAL CONTENT OF PASTURES RESEARCH.

Advisory Committee: Professor H. G. Denham (Chairman); Mr. Q. Donald; Mr. S. Fletcher; Professor W. Riddet; Mr. Bruce Levy. Directors of Research: Mr. B. C. Aston and Mr. T. Rigg.

Systematic investigations into the mineral deficiencies recognized as appearing in the pastures of the Dominion were commenced in April, 1928. The work has been confined to the Auckland and Nelson Provinces. In the Rotorua, Waikato, and King-country districts, as the result of deficiencies in iron, phosphorus, calcium, and, possibly, other essential mineral ingredients of animal diet, various forms of stock unthriftiness and diseases appear. In most cases the cause of the complaint is obscure, and can be ascertained only by a carefully planned series of field trials and laboratory experiments conducted over a period of several years. Throughout these areas, therefore, and on top-dressed areas in the same localities, numerous samples of pastures and soils are being analysed. In the Nelson area somewhat similar deficiencies occur, but in some respects these are markedly different from those occurring in the Auckland District. The most remarkable characteristic of the disease in the Nelson District is the occurrence of large granular masses—xanthine calculi—which are found in the kidneys of sheep that have grazed on deficient areas. In this district soil and pasture analyses are also being combined with stock-feeding experiments.

The funds for this research are provided as follows: Empire Marketing Board, £2,000 for five 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. Advice has been received from the Empire Marketing Board that its grant, originally made for a period of two years, has been extended for a further term of three years. The Cawthron Trust Board, through the services of its staff and laboratory, has been actively associated with and has co-operated in this research in the Nelson District. The grant received from the Empire Marketing Board and from the Department of Scientific and Industrial Research, together totalling £3,000, is apportioned to the Department of Agriculture and Cawthron Institute in the ratio of 2 : 1.

During the past year Dr. J. B. Orr, Director of the Rowett Institute, Aberdeen, paid a short visit to the Dominion, and, after visiting some of the areas where inspections were being made, furnished a helpful report. Dr. Orr's visit also has rendered possible a greater degree of co-ordination with similar investigations being conducted at Rowett Institute. The establishment of a Bureau of Animal Nutrition, with its headquarters at Rowett Institute, will enable the Dominion to participate further in the advantages secured from an Empire-organized attack upon the very difficult problems of animal nutrition.

The following are the reports of the Director and associated Director of the Mineral Contents of Pastures Research :—

Director's Report.

Historical.

In October, 1926, an offer was received from the Empire Marketing Board, through the High Commissioner for New Zealand, advising that a grant would be made by the Board towards work on the mineral content of pastures in New Zealand, provided that such a grant could be supplemented by others from New Zealand sources. Subsequent negotiations resulted in the Empire Marketing Board agreeing to a grant of £2,000 a year, on the understanding that the New Zealand Government would increase its grant of £1,000 (which was already being expended on this class of work through the Department of Agriculture) by another £1,000. Accordingly £4,000 became available for mineral content of pastures investigations, which were to be carried out under the direction of the Chief Chemist (Mr. B. C. Aston), of the Department of Agriculture, in association with the Cawthron Institute. It was agreed that the work should be under the general control of an Advisory Committee of the Council for Scientific and Industrial Research. Accordingly a Mineral Content of Pastures Committee was constituted by the Council.

This committee made the recommendation that the funds available from the Empire Marketing Board and the £1,000 received from the New Zealand Government through the Department of Scientific and Industrial Research should be allocated for the purposes of the researches, as follows : Department of Agriculture, £2,000 ; Cawthron Institute, £1,000—and this suggestion has been adopted and followed out since the definite institution of the research on the 1st April, 1928.

All the investigations are being carried out under general directions laid down by Dr. Orr, Director of the Rowett Institute. These are briefly as follows :—

(1) That any scheme of work adopted should be in general accord with similar schemes which are being operated in similar parts of the Empire on this problem ; such technical work or other as could not be done in the country where the investigation is being carried out would be carried out at the Rowett Institute.

(2) To ensure that the data from the different parts of the Empire will be comparable, it is necessary that the analytical methods, and as far as possible the experimental methods employed at different centres, should be uniform.

(3) For this reason it was asked that one of the chemists and one of the workers engaged in feeding-tests should have a training for six months in the same laboratory where the other workers have been trained, and that the training should include—(*a*) The analysis of samples of pastures, and, where considered desirable, of soils, to determine the mineral content of pastures in different areas and in different seasons ; (*b*) the correlation of the minerals with the other constituents and with the nutritive value of the pasture as determined by its carrying-capacity, and the health, rate of growth, and production of the animals grazing on it ; (*c*) feeding-tests to determine the effect of feeding to grazing-animals mixtures of mineral salts or foodstuffs rich in minerals found to be deficient in the pastures.

Dr. Orr then made proposals referring to the ways and means of carrying out this part of the programme, which were discussed by the Scientific and Industrial Research Council and the Cawthron Institute. It was finally agreed that Mr. T. Rigg, M.Sc., F.I.C., Agricultural Chemist to the Cawthron Institute, should spend some months at the Rowett Institute, and that Mr. R. E. R. Grimmett, M.Sc., who had been in charge of field-work and experiments with animals for over a year at Rotorua, and had been employed in the Chemical Laboratory for some years previous to this, should at once proceed to the Rowett Institute for a six-months course of training there. This arrangement was duly carried out. Dr. Orr, in the same letter, laid down the broad principles governing the investigation into the nutritive value of pastures, as follows : "The first work to be undertaken is the analysis of samples of pastures and the collection of information on the nutritive value of the pastures on the grazing-ground sampled. The samples should be collected by the method described in the paper by Godden (*Journal of Agricultural Science*, Vol. 16, Part 1). Two whole-time chemists and two whole-time field-workers will be required to begin the work. There will be an exchange between the various centres of experimental data and other information bearing on the subject. The Rowett Institute, for the time being, is acting as the collecting and distributing centre."

At a subsequent meeting of the Research Council on the 19th April, 1927, it was agreed that no utilization of the Empire Marketing Board's funds other than those expended in sending Messrs. Rigg and Grimmett to the Rowett Institute should take place until these workers returned to New Zealand. This date of commencement was afterwards fixed at the 1st April, 1928, so that the following report is for the year's work from that date. A scheme for work on the mineral content of pastures for 1927–28 was drawn up and submitted to both Dr. Orr and the New Zealand Research Council. The salient features of this scheme were :—

(1) *Iron Starvation* (*Bush Sickness*).—Work on pasture and soil analysis to be continued, and the staff and equipment engaged to be increased ; work determining the effect of the various top-dressings of pasture to be continued.
(2) *Phosphorus-deficiency Diseases.*—Analysis of pasture samples to be undertaken when possible.
(3) *Mortality from Renal Congestion in Young Lambs.*—(This was subsequently deleted from the programme as not coming within the scope of the investigation.)
(4) *Calcium Starvation.*—Analysis of soils and pastures to be continued in districts where marked deficiency exists, resulting in sheep mortality.

Dr. Orr (in a letter of the 13th May, 1927) approved of this programme of work and of the two men selected to go abroad, and expressed pleasure that preference should be given to analysis of pasture upon which deficiency diseases occur, and hoped that feeding-tests with cattle to determine whether supplementary feeding of mineral salts will prevent the occurrence of deficiency diseases would be successful. He suggested that the work on soils should be developed according to local requirements.

A list of the areas upon which mineral deficiencies were known to occur was drawn up and submitted to the Research Council, as follows:—

(1) Pongaroa district, on East Coast: Well-marked phosphate deficiency.
(2) North Taranaki and Norsewood (Hawke's Bay) districts, where "Waihi" disease in dairy cows occurs; also referable to phosphate deficiency.
(3) A large area suspected or known to be affected with iron deficiency (bush sickness) in the Rotorua, Tauranga, and Matamata Counties.
(4) An area in the King-country exhibiting marked lime deficiency accompanied by some phosphate deficiency, and affected by a malnutrition in sheep, suspected to be due to calcium starvation.
(5) Areas in the Nelson District near Glenhope, Sherry River, French Pass, and West Wanganui Inlet, where conditions similar to bush sickness occur in sheep.
(6) Areas in the South Island at Ashburton and the coastal districts of Southland, where a condition in cattle arises similar to the "Waihi" disease of the North Island.

Distinguished Visitors.

As a result of Dr. Orr's brief visit to New Zealand in June, 1928, it was agreed that certain work should be done in connection with the pastures on which temporary sterility and more or less allied diseases in cattle and unusual mortality in sheep occurred. That an exchange of one of the workers from the Rowett Research Institute and the Department's laboratory would be arranged, if possible, and that an attempt be made to have the period of the investigation increased from two to five years if the Empire Marketing Board could extend their contribution for that period. All of these three matters have been successfully initiated. Miss Simpson arrived here in exchange in January, 1928, and Mr. I. J. Cunningham left in March, 1929, to take up work at Rowett. The extension of the grant from two to five years has been agreed to by the Empire Marketing Board, and certain work has been begun in connection with temporary sterility and other diseases not strictly within the scope of the term "mineral deficiency" disease, but which, nevertheless, may be influenced by the nature of the food supply.

The visit of Dr. Orr and Sir John Russell to the Australian States and New Zealand had a very salutary effect on the recognition of the importance of chemistry in agriculture.

Personnel of Staff.

The officers whose salaries are wholly or in part paid out of the Empire Marketing Board's grant for research into the mineral content of pastures, for the agreed contribution from the New Zealand Government supplementing it, are as follows: Empire Marketing Board's grant—Mr. R. E. R, Grimmett, analyst (part paid); Mr. C. M. Wright, country analyst; Mr. E. C. Boulton, assistant to country analyst; Mr. P. H. Sykes and Mr. F. Thompson, laboratory cadets (part paid); Director of New Zealand grant (part paid). New Zealand contribution—Mr. R. E. R. Grimmett, and Mr. I. J. Cunningham, analysts (part paid).

Mr. Theo. Rigg is making a separate report on the grant to the Cawthron Institute, Nelson (see *N.Z. Journal of Agriculture*, Vol. 38, No. 5, May, 1929—"Mineral Contents of some Typical Pastures in Waimea County").

Mr. Grimmett has been engaged for a great portion of his time in the field, during portion of which he was collecting soil-samples in the pumice lands between Rotorua and Taupo Lakes. He was provided with an assistant, paid out of other funds. It was thought that his salary in future had better be paid out of the General Government fund, although much of his work will be in connection with mineral-contents work; and his salary and expenses will accordingly not be charged against the Marketing Board's grant. Mr. Wright and his assistant, Mr. Boulton, have devoted all their time to the Mairoa and pumice-lands field experiments in connection with malnutrition diseases due to suspected deficiency in pasture. Their salaries and expenses are entirely charged to the grant.

Miss Simpson, of the Rowett Institute, arriving in New Zealand in January, 1929, has been particularly occupied with the analysis of plant and animal specimens with a view to ascertaining whether low iodine content is associated with malnutrition. Samples of thyroids, milk, blood, pasture, &c., are being examined. The average iodine content of twenty-five samples of milk was found to be 44 ν per 100 c.c. The work has not yet been in progress long enough to enable any general report to be made on this aspect of the research.

Soil Research.

In addition to the work more immediately concerned with the composition of pastures, must be mentioned the soil-analyses supervised by Mr. F. J. A. Brogan. Samples have been taken in furtherance of the extension of the soil survey of Rotorua and Taupo Counties, and two papers have been prepared for publication.* This work of classification of the soils will no doubt assist in demarking the boundaries of the bush-sick areas, and so is connected with the work of malnutrition due to pasture deficiency. No part of the expense of this soil-work has been charged against the Marketing Board's grant or the subsidies.

Cases where the pasture has been killed out by poisonous salts in the soil have been investigated, and one paper prepared for publication†; another is in preparation.

The work for the past year has provided additional evidence that where deficiency diseases in stock occur it is not possible to tell by mere inspection of the pasture whether it will or will not support stock in a healthy condition over lengthy periods, although stock may be kept healthy, and even, under certain conditions, fattened, if the period of grazing is restricted to a few months.

* Since published in *N.Z. Journal of Agriculture*, May and June, 1929.
† Since published in *N.Z. Journal of Agriculture*, April, 1929.

The three outstanding instances of this deceptive nature of the pasture are (*a*) "bush sickness," or iron starvation in sheep and cattle; (*b*) "dopiness" in sheep, or calcium starvation; (*c*) "Waihi disease" in cattle, or phosphorus starvation. (It is possible that this phosphorus deficiency may occur in sheep also in some localities.)

The bush-sick pasture has not only misled hundreds of practical farmers by its apparent normality and luxuriance of growth, but quite recently two eminent British authorities have failed to *see* anything abnormal in the appearance of the pastures. The Mairoa "dopiness" pasture after treatment with a calcium salt is still a poor-looking feed, yet the addition of calcium has enabled a flock of young sheep to be maintained in health for eighteen months where previously the mortality would have been heavy. Some cow-pastures in the upper Wairarapa district carrying a fair proportion of clovers and having good lime percentages are yet extremely deficient in phosphorus—none worse, indeed, has yet been found in New Zealand. Other areas are affording similar evidence, but sufficient work has not been done to enable much to be said on the composition of their soils or pastures.

The remedy for each of the three troubles in stock mentioned is different; but it may be at once said that, as all North Island soils are deficient in phosphate and give a liberal growth-response to phosphatic treatment, each of these deficiency diseases is benefited to a certain extent by phosphate dressings. Indeed, it would be an extraordinary thing if it were not so, seeing that phosphates have such a stimulating action on all plant-life—increasing the root-development and the consequent ability of the plant to search further afield for plant-food, and increasing the proportion of clovers in the pasture, thereby increasing the calcium content. Also it must not be forgotten that in the case of superphosphate other mineral foods besides phosphorus are supplied, chiefly calcium sulphate (supplying Ca and S); while in the case of basic slag there are supplied iron, manganese, silicon, calcium, and magnesium. All deficiency areas are therefore likely to respond to liberal phosphatic manuring, and especially to treatment with a basic-slag and superphosphate mixture in equal amounts. It may be noted that basic slag is the only commercial phosphate which contains iron in appreciable quantity.

In regard to calcium deficiency, there are cases where the application of lime or calcium salts does not increase to the same extent as phosphates the carrying-capacity of the pasture (Wallaceville experiments gave evidence to the contrary), yet it undoubtedly makes it more palatable and has a great influence in rendering stock more resistent to disease; therefore calcium salts or lime may well be advocated as a pasture-dressing. The administration of licks to combat calcium deficiency is still in the experimental stage.

One of the greatest difficulties met with in the progress of this investigation has been that of obtaining samples of pasture which adequately represent what the animal is actually eating. The most misleading results may be obtained from pasture gathered in the field on which stock are actually grazing.

Mamaku Experimental Farm.

Field experiments under the direction of the resident overseer of the Mamaku Farm, which is situated in the centre of the bush-sick area of the Rotorua district, have been continued, and the results are summarized as follows:—

Experiment 1 was to determine to what extent frequent top-dressings with iron phosphatic manures would enable the sandy-silt soil of the Mamaku area to maintain sheep successfully. On the 23rd November, 1927, ten vigorous large-framed type wethers in very forward condition and fit for slaughter were put on No. 11 paddock (27 acres), which had previously been top-dressed with sulphate of iron ½ cwt. per acre, gypsum 2¼ cwt. per acre, and superphosphate 1¼ cwt. per acre. An additional top-dressing of ½ cwt. of Ferrous sulphate per acre was applied in 1928. The sheep did quite well up till the 4th February, 1929, when one died in good condition, the cause of death not being ascertained. The remaining nine sheep were transferred to a young-grass paddock free from ragwort, and a commencement was made with the feeding of pellets to all the sheep except one, which, being poorer in condition, was drenched with 1½ oz. 6 per cent. solution of Ferri ammon. cit. As late as June, 1929, it was reported that the sheep, although poor in condition, were bright enough, and were taking the pellets readily. The composition of the pellets is as follows: Iron ammonium citrate, 2 lb. 8 oz.; copra, 24 lb.; flour, 16 lb. 4 oz.; peanut-meal, 9 lb.; cod-liver oil, 2 lb. 8 oz.; anise, to flavour.

The efficiency of iron sulphate as a dressing for coarse pumice soils to supply deficient iron is very questionable under soil conditions of high aeration and low humus content. In other cultivated soils, more compacted and containing more organic matter, ferrous sulphate appears to give better results, as a pasture-dressing, on the health of the stock.

Experiment 2: An experiment with steers on the same paddock as the sheep gave results which indicated that some unusual influence was at work which militated against the proper development of the cattle. The new factor was suspected to be poisoning due to ragwort, as the animals had been observed eating that plant. The matter is now being tested by a straight-out experiment.

Pellet-making.

The two experiments in which the feeding of pellets (consisting of half oily meal and half mineral foods) to sheep were successful in restoring bush-sick sheep to health having proved the efficacy and adaptability of the method, the use of this has been extended. During the year over 12 cwt. has been made up and despatched for various experiments in the country. It is anticipated that this method of combating deficiency disease in sheep will prove superior to others in the case of animals grazed on broken or hilly land of a character similar to that of parts of Scotland where the method was first successfully used by the Rowett Institute in the cure of sheep suffering from mineral deficiency in their natural food—poor pasture. In New Zealand sheep have in the past been found to be particularly difficult to treat for bush sickness, being far more susceptible than cattle to this form of malnutrition, and, when found to be suffering, are usually too far gone to drive long distances to change paddocks on healthy country, while drenching a large number of animals daily for a few weeks is not practicable.

Investigation is being made into more efficient and economical methods of producing the pellets.

Curative Treatment with Iron Medicines.

During the year a large amount of ferric ammonium citrate (some 13 cwt., an amount equivalent to 18,600 cattle doses) has been sold in 1 lb. lots to farmers in the pumice lands affected with bush sickness. Farmers, as a rule, do not readily commit their thoughts and experience to paper, but those who have replied to the circular asking for their opinion have generally given replies very favourable to the use of the drug. The area over which these farmers are working is a very wide one, extending on the coast from the Bay of Plenty in the north to Whakatane in the south, and inland to Putaruru. Some of the farmers have been using the drug for several years (one for seven), so that this method of combating the bush sickness bids fair to become a recognized practice in the agriculture of the pumice lands. The remarkable fact to be noted is that the use of the iron ammonium citrate is increasing more in the border-line farms which are not recognized as having more than a slight tendency towards the malnutrition in the cows. It is becoming recognized that the iron treatment increases the yield of milk and enables the cow to rear healthy offspring under conditions which previously resulted in failure.

The treatment of cattle for bush sickness appears to be an easy matter compared with treatment of sheep. For these animals the pellet method had given a striking success in two experiments, in each of which a small flock of sheep were used. This method involves the use of the deficient mineral mixed with about 50 per cent. of oily meals, and the mixture made into small cubical pellets and baked to a dry hard state. It is hoped shortly to arrange for a large-scale experiment with sheep.

A New Cure for Bush Sickness.

Seeking for a form of iron which would have all the advantages of the double citrate and none of its disadvantages, experiments have been made with a native carbonate of iron (spathic iron, or "siderite" of the mineralogists) which was obtained from a quarry near Auckland. This has the advantage that it is insoluble and not likely to have such ill effects on the animal when taken in excess. The difficulty was to grind the singularly hard, tough boulders into a very fine powder. This was eventually accomplished with the aid of a paint-manufacturers' mill (by the kindness of Jackson and Co., Wellington) on a small scale, and, finally, by the phosphate-mill of the Challenge Phosphate Co., Auckland, on a much larger scale. To both of these firms the Department is much indebted and tender them hearty thanks. A farmer then tried the material mixed with common salt in the bails of three bush-sick cows, which recovered under the treatment. He then tried it on the herd in the field, and found that all (a majority of the herd) those which would take the lick improved under the treatment compared with those few which refused to take it. The experiments are accordingly being extended.

"Dopiness," or Calcium Starvation, in Sheep.

A type of air-borne volcanic soil differing greatly in response to fertilizers and in agricultural value from the coarser pumiceous sandy and sandy-silt soils of the central district of the North Island is the volcanic andesitic loam of what is known as the King-country. This loam has been derived by weathering from showers of fine volcanic dust or mud, and is described by Henderson and Ongley (Bull. Geol. Survey, No. 24, p. 56). The analytical examination of this type of soil and of the pasture growing upon it has been the subject of recent investigation. In August, 1926, the writer was first consulted regarding a loam soil which, with its subsoil, showed a very characteristic section in the road-cuttings—a brown loamy face which cracks up in summer, then appearing as a much-fissured surface exactly similar to that described by Henderson and Ongley.

This type is abundantly distributed in the Mairoa Riding of Waitomo County, about 15 miles west of Te Kuiti, at an elevation of about 1,000 ft. above sea-level. The local rainfall is a heavy and well-distributed one; the surface features show what the farmer would call "easy country"; and the native vegetation originally consisted of forest and shrubs of a type which might be called mixed rimu-tawa forest, which indicates good soil rather than bad. On many farms the forest had been burnt off over twenty years previously, and, generally speaking, the whole area consisted of surface-sown pasture, a good deal of which had reverted to fern and second growth. Where the pasture was still maintained it had reverted from the ordinary grasses sown on the burn, including rye-grass, cocksfoot, and clovers, to *Danthonia*, Yorkshire fog, and brown-top. The complaint one had to investigate was not so much the fact of decreased carrying-capacity of pastures which had for their first seven or eight years after the burn carried one and a half ewes to the acre, and now carried only less than one dry sheep, but that even with that diminished stocking the animals did not thrive, and the number of culls in the flock greatly diminished or altogether extinguished the profit. There was very little cultivation practised, and club-root (finger-and-toe) disease in cruciferous crops grown in field or garden was alleged to be an invariable occurrence.

Dr. J. B. Orr, Director of the Rowett Research Institute, visited this area when on his visit to New Zealand in August, 1928, and approved of experiments being conducted to determine the cause and remedy of this form of malnutrition. A certain amount of progress had been made at the time of Dr. Orr's visit, indicating that the deficient element responsible was calcium. The reasons which led the writer to the adoption of this hypothesis may briefly be mentioned:—

(1) Excessively high "lime requirement" figure of the soils.
(2) Non success with phosphates in eliminating the disease.
(3) Presence of club-root in cruciferous crops.
(4) Excessive moss in the pasture in winter seen in top-dressed land.
(5) Absence of clovers and other Leguminosæ in the pastures.

(6) Lightness of the bones of dead animals. Although the bones are light, there are no cases where bone-lesions have been observed, such as occur in phosphate-deficient areas in cattle; neither do the bones break easily, as has been found in sheep in an osseous cachexia case (Reid and Aston, reported in *N.Z Journal of Agriculture*, 15th November, 1910, page 422). The writer regards this absence of bone-lesions as confirmatory evidence of calcium deficiency, as Theiler was unable to produce bone-malnutrition by deficient calcium diet, only general emaciation.
(7) Botanical composition of pastures showing moss, *Danthonia*, Yorkshire fog, and brown-top (*Agrostis*)—species that love sour soils.
(8) Preference of sheep for limes over unlimed pasture.
(9) The fact that the land after a forest-burn was highly productive, but after some years deteriorated rapidly, indicated that something was being leached out of the soil, assisted by the heavy rainfall of this upland locality, that had been contributed by the ashes of the bush-burn. The only element which could answer to this description was calcium. Phosphates are not leached out of the soil.

Work during the year has been largely concentrated in the field experiments. Mr. C. M. Wright, a farmer with chemical training, and an assistant, also a farmer, have been busily engaged in supervising extensive trials with various top-dressings on pasture on which sheep were used to determine the effect of the dressings in ameliorating the malnutrition. The results of the year's work have confirmed the first prediction, that calcium is the deficient element, or, to put it in Mr. Wright's words, "lime is the limiting factor" in farming these King-country volcanic loams, and it would seem that a mixture of 5 cwt. of ground limestone and 2 cwt. of superphosphate, which would supply 12 parts of calcium to 1 part of phosphorus, is likely to be a dressing which will enable the settlers to overcome their present difficulties. One may say that the farming community of the districts in which the experiments have been carried out seem to be convinced of the correctness of the conclusion that some form of calcium is necessary to bring the land back to its former productiveness.

The local officers of the Chemistry Section of the Department have had the whole-hearted support of the settlers. The two lime companies operating in the district—Wilsons' Lime Co. and the Hangatiki Lime Co.—have supplied a very large quantity of lime (50 tons each) at cost price, and the Challenge Phosphate Co., of Auckland, has donated a truck of superphosphate. The Australian companies have given or promised to give consignments of some tons of gypsum (sulphate of lime), and the Golden Bay Cement Co. and the Milburn Lime and Cement Co. have also enabled the Department to obtain gypsum from their stores.

That the rehabilitation of this fine type of country, now classed as "deteriorated," is now only a matter of time and the granting of reasonable financial facilities, is the opinion of the writer.

Summary of Mairoa Experiments.

Area.	Treatment.	Grazing.	Pastures.	Results.
20	2 tons ground limestone, Jan., 1928	40 cull hoggets, Feb., 1928, and cattle	Originally tawa-rimu; grassed twenty years—run-out *Danthonia* and *Lotus major*; now much healthier and clover showing	Sheep have done well.
5	4 cwt. gypsum, Oct., 1928	8 hoggets, 3 cows and calves, Nov., 1928	Improved in appearance	Sheep satisfactory; weight increased.
7	Control	10 hoggets, Nov., 1928 ..	..	Sheep holding their own.
35	Field divided in two; No. 21 $CaCO_3$ pellets used	38 ewes and 1 ram, Mar., 1929	..	..
10	1½ tons limestone, Jan., 1928	11 cull ewes	..	Ewes did well—7 lambs; also night paddock for cows.
20	5 cwt. limestone and 2 cwt. super., April, 1928	April, 1928, heavily stocked with cattle and sheep	Better soil than elsewhere; heavy fern crushed out by top-dressing in fern	No grazing records kept.
11	5 cwt. limestone and 2 cwt. super., May, 1928	11 sheep, mixed sexes ..	Originally fern-manuka and now greatly improved	Now possible rear young sheep. One strip limed only neglected by stock.
10	1 ton limestone, Jan, 1928; 2 cwt. basic super., Aug., 1928	No records kept; owner considers lime-phosphate dressing suitable	Originally fern-manuka, but grassed fifteen years; badly run out	No grazing on area where basic super. not used.
13	2 tons limestone, Mar., 1928; 2 cwt. super., spring, 1928	No records kept ..	Twelve-year-old pasture liberally phosphated without result; improved in appearance	Stock doing better after lime treatment.
		Waitangururu.		
20	5–2 limestone-super, June, 1928	20 cows, 18 ewes, 16 lambs	Originally tawa-rimu bush, grassed eighteen years	Previous great trouble with sheep now averted; lambs ceased dying from malnutrition and now killed fat.
		Ngapaenga.		
4 5	5–2 limestone-super, Aug., 1928	..	Seven-year-old run-out pasture; now improved	Now available to improve cull sheep.

Mr. Wright, Country Analyst, reports as follows :—

The results obtained by running sheep on pasture that has been top-dressed with lime and phosphate mixed at the rate of 5 cwt. ground limestone and 2 cwt. of superphosphate per acre, have given further proof that lime is the limiting factor.

Previous experience with superphosphate straight and with basic superphosphate showed that the curing of the malnutrition troubles by means of the usual 2–2½ cwt. dressing of the above manures was not possible in one year. What the results would be had the pastures been regularly dressed as above for some time and then sheep put on to graze has not been determined, as none of the farmers have been top-dressing for a sufficiently long period and running sheep to enable one to get reliable information, and no farmer has been able to carry his sheep over successfully on a super or basic-super dressed pasture with a single application of the manure. The point is that, on the one hand, it is quite possible that with time and a sufficient number of top-dressings with super or basic super a healthy pasture might be obtained ; but no farmer can afford to wait, when, on the other hand, with a top-dressing of lime and superphosphate in the proportion of 5 cwt. ground limestone and 2 cwt. superphosphate per acre the desired results can be obtained and the sheep kept healthy over the usually bad period. Four trials with the 5–2 mixture were made, but in only one case was a weighing-test conducted. It is not suggested that the 5–2 mixture is the cheapest or best. It was used in that strength because it was evident from the results from the use of basic superphosphate that there was not enough lime in the latter and it was decided to increase the lime content for a trial. It is now proposed to establish further experiments to determine the best and cheapest mixture. The key to the whole problem at Mairoa now is the production of lime at a lower cost. At present the cost of ground carbonate is 19s. per ton net, and the average cost of carting would be about £1 2s. 6d. per ton, and this would mean that the cost of the 5–2 top-dressing mixture would be about £1 3s. per acre, exclusive of the labour of spreading. It will also be determined, if possible, whether sheep can be kept healthy by periodically running them on the top-dressed pasture, and, if this is successful, it will mean, of course, that the area that will be required to be top-dressed will be limited, and the dressing of the whole of a farmer's property may then proceed as finance will allow.

If satisfactory arrangements could be made for the grinding of some of the millions of tons of limestone in the district so that it could be put on the farms at about £1 per ton, it would, of course, substantially reduce the cost per acre ; and the settlers are endeavouring to have this done.

In the seventh experiment listed above the sheep were weighed at intervals between July, 1928, and February, 1929. In all, six weighings were made in this period. The results were as follows :—

	Average Gain in Weight.	Average Weight of Wool shorn.
	lb.	lb.
Eleven sheep, mixed sexes from 5–2 lime-super top-dressed area	51·21	7·71
Ten ewes (control)	23·61	5·31

It was apparent from the weighings that the gain in weight was small in the summer. It has been observed that the sheep generally start to go back from November onwards, which seems to point to the generally known fact that in malnutrition areas the trouble increases as the feed gets away, and, in the above case it was not possible for the farmer to buy more stock to keep his pasture short. The average gain in weight has been quite satisfactory on the lime-and-super paddock, being more than double the gain in the control. The sheep have kept healthy, and certainly show their better treatment when compared with the control sheep. The average weight of wool from lime-and-super paddock (7·7 lb.) and from the control (5·5 lb.), a difference of 2·2 lb., or approximately a 40-per-cent. increase, is very satisfactory.

On another farm, about two miles away towards the south-west of the previous one, an area of 20 acres was top-dressed with 5–2 lime and super in June, 1928. This is hill country, and had previously been very unhealthy for sheep. The farmer has been milking cows, and the increase of ragwort is forcing him to change over to sheep. Unless country could be made healthy for the sheep, this man would have to abandon his farm after having felled the bush on it and improving it, mainly by his own efforts, after nearly twenty years of work. The sheep on this area were not weighed, as it was thought unnecessary, because formerly they could not be held.

The farmer's experience on this area had been most unfortunate. Four years ago, out of 162 rams reared on the place only 100 survived, forty-five of which were marketed in fair condition and fifty-five were culls. Since then the trouble has been accentuated, and sheep would commence to go off six weeks to two months after being placed on the farm. The ewes in these flocks rapidly grew thinner and wasted away.

On a paddock of 37 acres the back portion, of 20 acres, was top-dressed about June, 1928, with 5 cwt. lime and 2 cwt. super ; 17 acres were unmanured. It was noticeable that the cows always passed over these 17 acres and grazed on the top-dressed area. Eighteen ewes and sixteen lambs have also grazed this top-dressed portion, not one of which have shown the slightest sign of trouble, the lambs being ready for killing at Christmas, giving weights ranging from 45 lb. to 53 lb. Clovers, rye-grass, and dogstail showed up readily after the top-dressing. So satisfied was the farmer with the results secured on this area that he has bought 30 tons of lime and 4 tons of super to extend the benefits to other portions of his farm.

On another farm, where the experimental paddock showed a lime requirement of 67 tons per acre, about 20 acres that had reverted to fern was top-dressed with the 5–2 lime-and-super mixture. The paddock has been stocked with cattle, and eight months after this treatment the fern was almost all dead, while the grass is looking healthy. On this farm last year thirty wethers were sold fat, while this year 130, which had grazed mostly on the top-dressed paddock, were sold at top prices.

On another farm, at Ngapaenga, with a lime deficiency of 9 to 10 tons per acre, six-year-old pasture which had previously been top-dressed with 3 cwt. super and kainit, but in which the grass was showing very poorly, with a large predominance of weeds, the result of an October, 1928, dressing of the 5–2

lime-super mixture has effected a striking improvement on the clover and cocksfoot content of pastures, particularly on the sloping ground. The paddock top-dressed has been used as a hospital paddock, and has carried cull sheep very well. The experience of these farmers who have written letters appreciative of the value of the 5–2 lime-super mixture indicates that it is proving efficacious for dealing with the deficiency problems at Mairoa.

Although calcium is undoubtedly the element the deficiency of which is responsible for the Mairoa malnutrition in sheep, it would appear that the amount of lime needed, where it is used alone, may be too large to be practicable in general sheep-farming. Where a small quantity of phosphate is mixed with the lime it will probably stimulate the root action of pasture plants and enable them to range over a greater area and so absorb more calcium. That a mixture which contains such a preponderating amount of calcium as 12 parts calcium to 1 part phosphorus, as in the 5 cwt. lime to 2 cwt. super mixture, is found to give excellent results in combating the malnutrition is evidence of the importance of the addition of phosphate.

On carefully reading Mr. Wright's report it will be readily seen that neither phosphate by itself nor lime by itself will give the optimum results on Mairoa pastures.

When phosphates are liberally applied, and on a portion of the top-dressed land lime is also applied, the stock will generally be found grazing on the limed area. On the other hand, when the area is limed and a portion of the limed area top-dressed with phosphates, stock will forsake the portion which has been limed only in favour of that both phosphated and limed.

Wairarapa Phosphate Deficiency.

Work on this area has been continued during the year, and the results already obtained have been confirmed, that the poorer pastures of this district are among the lowest in phosphorus content that have been encountered in the course of this research, a fact especially notorious when it is considered that they are cow-pastures. The farming public and the agricultural officials in that district have been warned that the deficiency is serious. The content of manganese is in some pastures unusually high, approaching 0·1 per cent Mn_3O_4 on the dried sample. Pastures which have been top-dressed with superphosphate compared with the non-phosphated land on the same farm show great superiority in phosphorus content.

Thus at Mauriceville the pasture on non-phosphated areas averaged 0·43 per cent. phosphoric acid, and on the phosphated fields it was 0·62 per cent. phosphoric acid. At Hamua it was 0·48 per cent. phosphoric acid, as against 0·61 per cent. phosphoric acid. At Hukanui the non-phosphated land gave pasture which varied from 0·2 per cent. to 0·48 per cent. phosphoric acid, as against 0·7 per cent. phosphoric acid for the phosphated land. At Masterton the non-phosphated pasture yielded 0·38 per cent. phosphoric acid, and the phosphated land 0·62 per cent. phosphoric acid.

As bearing on the incidence of disease and low phosphate content of the pastures, it will be noted that at Te Parae, Masterton, there was as little as 0·27 per cent. of phosphoric acid in the non-phosphated pasture, and that " sleepy " sickness in ewes occurs here.

The non-phosphated pastures on a farm at Hukanui where " Waihi disease " occurs in cows had only 0·2 per cent. of phosphoric acid.

It will be noted that the amount of calcium of these pastures was much higher in every case than that of the phosphoric acid ; and there is apparently no great deficiency of this element in the pastures that one may complain of as having any adverse influence in the health of stock. This is as one would expect from the high clover content of most of the pasture.

Hamua.

Six soil-samples from this district show distinctly the low content of phosphoric acid, except where phosphate applications have recently formed part of farm practice.

Samples of soils and pastures from the following localities in the Wairarapa district have been analysed : Hukanui, Eketahuna, Kaituna, Dalefield, Greytown, Belvedere, Featherston, Masterton, Mangamahoe, and Mauriceville. Marked phosphate deficiency is common throughout these samples, and in some cases lime also is lacking. The botanical composition of the pastures also shows striking differences in so far as the clover content is concerned. Bone-malnutrition and temporary sterility of cows are associated with these deficiencies throughout the district.

Summary.

A review of the year's work shows that work has gone steadily forward in several directions, where the conditions are extremely diverse, the following practical results being achieved :—

In the " bush sickness " (iron deficiency) in sheep and cattle experiments the entrance of a new factor—the ingestion of a poisonous plant, ragwort (*Senecio jacobaea*) by the cattle—is likely to prove an interfering element in the work with cattle, rendering them unresponsive to the accepted curative treatment.

The successful use of the Rowett Institute method of pellet-feeding deficient minerals to bush-sick sheep is a distinct step forward into unknown territory—the treatment of a species which has hitherto not been possible to attempt with the accepted remedy for cattle. The method is practicable and comparatively inexpensive.

In regard to " dopiness " (calcium starvation) in sheep, the experiments have reached a stage in which the paramount importance of calcium in the treatment of pastures on which the disease develops is generally accepted by farmers and officials.

In the areas of the Wellington Provincial District the cattle-pasture of which showed it to be highly deficient in phosphorus the analysis of a further series of samples has confirmed the correctness of the former opinion, that certain areas are so deficient in phosphorus that stock are suffering. For dairying pastures the phosphorus content is the lowest yet met with in New Zealand, and advice to manure liberally with phosphates has been given.

Mineral Contents of Pastures Investigation at the Cawthron Institute.—First Annual Report for Year ended 31st March, 1929.

Introduction.

Early in April, 1928, a detailed scheme for the investigation of the mineral contents of Nelson pastures was submitted to the New Zealand Research Council's committee for pasture investigations. The scheme was approved by the Committee and active work was at once commenced at the Cawthron Institute. Dr. Askew was appointed analyst in charge of the chemical work. Mr. J. A. Bruce, of the Cawthron Institute, was delegated for special work as fields officer in connection with the investigation. Mr. L. Hodgson was appointed as cadet in the laboratory. The work undertaken at the Cawthron Institute in connection with the mineral contents of pastures investigation has included (1) a systematic examination of the mineral status of typical pastures in the Waimea County, Nelson; (2) detailed studies of both stock conditions and pastures in certain localities where serious mortality of stock has frequently occurred; (3) the value of bone-meal "licks" for stock on mineral-deficient pastures; and (4) the influence of season on the mineral contents of selected pastures manured in different ways.

The Waimea County possesses several features of unusual interest in connection with soil and pasture studies. The county has a highly diversified geology, embracing ultra-basic, basic, and acid igneous rocks, besides several older sedimentary and Pleistocene deposits. As might be inferred from the varied geology of the county, striking differences in soil characteristics are encountered. Some soils are exceedingly poor, and deficient in mineral plant-foods; others have earned a local reputation for their high-productive capacity and excellent qualities.

Serious losses in stock have been reported from different parts of the county, while large areas give unsatisfactory returns with stock.

Under these circumstances it was anticipated that a systematic study of the mineral contents of typical pastures in the county would give much valuable information concerning soil and pasture relationships. It was hoped that the chemical analyses of pastures associated with high stock mortality would reveal the causes of loss and of inferior results with stock.

Some results of the investigations concerning the Waimea pastures have been published in the *Journal of Agriculture*, May, 1929, in a paper entitled "Mineral Contents of some Typical Pastures in the Waimea County." Another paper bearing on a widespread occurrence of xanthin calculi in sheep is now in the press.

Some of the more important aspects of, and conclusions derived from, the investigations are set out below.

I. Influence of Soil-type on Pasture.

For the purpose of this study typical pastures located on six soil-types derived from different parent rocks were selected. As far as could be ascertained, no manurial treatment had been given the pastures since their establishment decades ago. The pastures showed great variation both in flora and in carrying-capacity. A similar variation in the percentages of mineral constituents was likewise found, indicating that the nature of the parent rock from which the soils have been derived exercises a profound influence on both quality of pasture and its mineral composition. The following table (Table 1) illustrates the great variation in the composition of typical pastures associated with four soil-types derived from different parent material.

Table 1.—Analyses of General Pasture-samples from Hill-soil Types of Different Geological Origin.

Soil-type (Geological Origin).	Moutere Hills (Pleistocene Gravels).	Orinoco (Hornblende Gneiss).	Kaiteriteri (Granite).	Pikikiruna (Limestone).
CaO	0·61	0·82	0·56	0·98
P_2O_5	0·63	0·94	0·64	0·95
K_2O	3·19	4·44	2·93	4·02
Na_2O	0·12	0·12	0·19	0·26
Cl	1·07	1·54	1·00	1·03
N	3·43	4·92	3·32	5·02
S	0·33	0·35	0·24	0·35
Fe	0·011	0·045	0·016	0·016
Mn	0·052	0·038	0·042	0·018
Total ash	11·67	12·07	10·63	11·11
Soluble ash	6·15	8·70	5·99	8·25
Insoluble ash	5·52	3·37	4·64	2·86

All determinations expressed as percentages of dry matter.

Note.—Pastures on the Orinoco and Pikikiruna soil maintain one and a half sheep per acre; those on the Moutere Hills and Kaiteriteri soils less than half a sheep per acre.

Although the pastures associated with soil-types possessing great variation in properties also vary greatly in their value for stock, the mineral composition of the pasture does not show as great a variation as might have been expected from a consideration of the analytical data obtained by the usual methods of soil-examination. A high deficiency of phosphate in the soil is invariably reflected in a low percentage of phosphate in the pasture. When the percentage of available phosphoric acid

in the soil rises above a certain level comparatively little variation in the phosphate content of the grass-samples have been found. The lime content of the pastures has shown but little relationship to the lime requirement of the soils as determined by laboratory methods.

II. Nelson Pastures giving Good Results with Stock.

A number of selected pastures on different soil-types have been analysed. These pastures in many cases have been treated with lime and phosphate or are located on soils known to be rich in mineral constituents. Farmers speak highly of them, and praise their milk-producing or fattening qualities.

In Table 2 the average chemical composition of eight good pastures in the Nelson District is compared with average data published by Godden* for English cultivated pastures.

Table 2.—Pastures giving Good Results with Stock.

	Nelson Pastures (Average of Eight Samples).	English Cultivated Pastures (Average—Godden).
CaO	0·83	1·00
P_2O_5	1·06	0·74
K_2O	3·96	3·18
Na_2O	0·49	0·25
Cl	1·45	0·95
N	5·34	2·83
S	0·43	..
Fe	0·038	..
Mn	0·017	..
Total ash	11·69	9·79
Soluble ash	9·10	6·64
Insoluble ash	2·59	3·15

All determinations expressed as percentages of dry matter.

The analytical data presented in Table 2 show that Nelson pastures considered good by stockmen differ in many respects from the English cultivated pastures analysed by Godden. In the Nelson pastures the average phosphoric acid content is considerably higher than that of the lime, a reverse order to that found by Godden. The figures for potash, chlorine, nitrogen, total ash, and soluble ash are greater than Godden's average figures. The most striking result is the very high percentage of crude protein found in these New Zealand pastures. This far outstrips any of the available English figures, in one sample analysed the remarkably high figure of 36 per cent. was attained. The main constituents of the Nelson pastures have been perennial rye and white clover, a mixture considered to be ideal for pastures.

III. Pastures giving Poor or Indifferent Results with Stock.

A number of districts in the Waimea County are characterized by their poor results with stock. It is probable that a number of factors are operating as will be seen from a consideration of the data set out below.

(*a*) *Suspected "Bush-sick" Pastures at Glenhope.*—In the case of certain pastures located on granite soils in the vicinity of the Hope and Sherry Rivers serious losses in stock have occurred whenever the grazing has been restricted to particular areas. Owners of properties located on these soils state that symptoms of ill health are apparent within three weeks if sheep are grazed exclusively on affected pastures. Death of the animals frequently ensues within six to nine months from the commencement of grazing. The symptoms of affected sheep correspond closely to those noted by B. C. Aston in connection with the "bush sickness" of the Rotorua District.

Chemical analyses of pasture samples taken from affected areas reveal a great deficiency of iron. This is well illustrated by the data presented in Table 3, comparing analyses of healthy and affected pastures.

Table 3.—Analyses of Pasture-samples from Suspected Bush-sick Area, Glenhope.

——	Autumn (Average of Three Samples).	Spring (Average of Three Samples).	Adjoining Healthy Country, Spring Sample (Average of Two Samples).
CaO	0·62	..	..
P_2O_5	0·71	..	..
Fe	0·013	0·013	0·04
Mn	0·033	0·026	0·02

The percentage of iron in the pastures of adjoining country known to be healthy for stock is three times greater than that in the affected pastures.

The low percentage of iron and the lack of improvement affected by liming or top-dressing with phosphates supports strongly the theory of bush-sickness as enunciated by B. C. Aston† from observations in the Rotorua District.

* Jour. Agric. Sci., 1926, Vol. xvi, Pt. 1, p. 81.
† Jour. N.Z. Dept. Agric., Vol. 29, p. 87.

(*b*) *Occurrence of Xanthin Calculi in Sheep.*—During the course of our investigations numerous instances of calculi in the kidneys of sheep grazing on the Moutere Hills type of soil were brought to our notice. The calculi were not confined to sheep on any one property, but cases from several parts of the district within the limits of the extensive area of Moutere Hills country were observed. On one farm alone as many as twelve sheep which had died or had been killed for post-mortem examination during a period of six months were found to have greatly enlarged kidneys, containing a large quantity of stones, gravel, and powder. On examination, the stones proved in every case to be xanthin—a very rare form of urinary calculus.

The occurrence of xanthin calculi, although many inquiries have been made, has not been reported in sheep grazing on other soil pasture associations in the Waimea County. The fact that the Moutere Hills soil is of very low fertility, and that various stock ailments are common among sheep and cattle grazing the poor pastures on this soil-type, suggest that xanthin-calculus formation may be caused by deficiencies in the Moutere Hills pastures.

Chemical analysis of the Moutere Hills soil has shown that it is highly deficient in nitrogen, lime, and phosphate. Field experiments with many crops have already shown the great importance of both lime and phosphate in securing optimum crop-production.

The pastures on the Moutere Hills soil have greatly deteriorated on many farms. The English grasses and clovers have long ago disappeared, being replaced by *Danthonia*, sweet vernal, and *Agrostis* sp.

Analyses of pasture-samples collected from farms where calculus-formation frequently occurs show that great deficiencies of mineral constituents and protein occur in the pastures. This is well illustrated by reference to Table 4, comparing analyses of Moutere Hills pastures with the average for good Nelson pastures.

Table 4.—Analysis of Moutere Hills Pastures.

	Moutere Hills, Autumn Growth (Average of Five Samples).	Moutere Hills, Spring Growth.*	Good Nelson Pastures, Autumn Growth (Average).
CaO	0·61	0·49	0·80
P_2O_5	0·63	0·56	1·06
K_2O	3·19	1·64	3·81
Na_2O	0·12	0·31	0·49
Cl	1·07	0·42	1·45
N	3·43	2·01	5·23
S	0·33	0·22	0·42
Fe	0·011	0·03	0·026
Mn	0·052	0·016	0·019
Total ash	11·67	10·40	11·51
Soluble ash	6·15	3·81	9·02
Insoluble ash ..	5·52	6·59	2·49

All determinations expressed as percentages of dry matter.

The outstanding features of the analytical data are the low content of (1) nitrogen, (2) soluble ash, (3) lime, and (4) phosphate in all samples from the Moutere Hills. Despite the fact that samples of pasture were collected at the same stage of growth-development in both cases, the percentages of lime and phosphate in the spring samples from the Moutere Hills are little more than 50 per cent. of those in the good Nelson pastures. In the case of nitrogen the percentage in the Moutere Hills pastures falls as low as 38 per cent. of that in the good pastures.

The analyses of Moutere Hills soil and pasture suggest that a lack of minerals is responsible for the poor results frequently obtained by farmers with stock on extensive areas of this country. Confirmation of this is afforded by the fact that on a number of farms bone-meal "lick" is taken eagerly by stock, with beneficial results. There is, however, not sufficient information available to explain the occurrence of xanthin calculi in sheep on this country. The whole matter is now being carefully investigated with a view to determining what factors operate in calculus-formation and how the difficulty can be overcome.

(*c*) *Other Abnormal Pastures in the Waimea County.*—Certain pastures located on fine sandy soils in the Motueka Valley give very poor growth, and even with light stocking are not able to maintain stock in a healthy condition. The soils are derived mainly from the detritus of serpentine and peridotite rocks in the watershed of the Motueka River. Analyses of pasture-samples show that they have a very low percentage (0·23) of lime. The percentages of magnesia and silica are considerably higher than those found in good pastures. It appears likely that the low percentage of lime in the pasture, combined, possibly, with a rather high percentage of magnesia, is responsible for the poor results with stock on these pastures.

Other pastures located on the Tahuna sands are associated with "pica" and poor stock results, unless top-dressing of pastures is undertaken. These pastures are deficient in lime and phosphate, the percentage of lime being particularly low.

* Collected from a farm where many calculi have been found.

IV. Experiments with Bone-meal "Licks."

In view of the striking deficiencies of both lime and phosphate found in the pastures of certain soils of the Waimea County, and of the difficulties associated with liming or manuring somewhat unaccessible hill country, experiments have been commenced with the use of bone-meal "licks." On a number of farms on poor country where deficiencies of minerals occur no great difficulty has been experienced in getting stock to eat a "lick" of bone-meal and rock-salt. In certain cases large quantities have been greedily eaten by both sheep and cattle. A noticeable improvement in the condition of stock has resulted from the use of the bone-meal "lick." Cattle, in particular, have improved wonderfully in appearance, losing their rough coats and listlessness. More carefully controlled experiments are now in progress, and exact information should be available at the conclusion of the present season concerning the value of bone-meal "licks" on a typical mineral-deficient pasture.

V. Effect of Season and Manuring on the Mineral Composition of Pastures.

The analyses of pasture-samples which have already been made have shown that a considerable variation in the amounts of iron and other minerals may occur in certain pastures at different times of the year. With a view to collecting more information on the seasonal variation in typical Nelson pastures, and to studying more closely the influence of manurial treatment on the mineral composition, samples of green growth have been collected from three selected pasture areas throughout the whole of the growing season. In one case mowings of a series of plots treated in different ways have been made at fortnightly intervals throughout the season. Dry weight determinations in addition to hay and aftermath weights have been made in connection with this experiment. The chemical analyses of the pasture-samples are now being undertaken, and much valuable information should be secured from the investigation.

In concluding this report of the mineral contents of pastures investigation at the Cawthron Institute, mention must be made of the assistance which has been given by farmers throughout the district in supplying information in connection with stock ailments. Much valuable help on various aspects of the investigations has been given by Professor Easterfield, the Director of the Institute. Mr. L. Bishop has assisted in the collection of pasture-samples, and Mr. W. C. Davies has supplied excellent photographs illustrative of the work in progress.

T. Rigg,
Officer in Charge Mineral Contents of Pastures Investigation at the Cawthron Institute.

Appendix to Report of Mineral Content of Pastures Investigation.

The Mineral Contents of Lucerne and the Value of Sulphur for its Fertilization.

In conjunction with the Plant Station at Palmerston North, an investigation of the mineral contents of lucerne and of the value of sulphur for manuring of this crop has been carried out by Mr. B. W. Doak, who has been temporarily attached to the Cawthron Institute for this work. The investigation has shown that an increase in the sulphur content of lucerne frequently takes place when different sulphur-containing compounds are used for manuring. On two soils an increase in yield was obtained by the use of sulphur fertilizers, indicating that sulphur was required as a plant-food on these soils. It seems probable that the wonderful improvement effected by superphosphate when used for top-dressing lucerne and pastures results in part from the large percentage of gypsum contained in this manure. It would appear probable that direct sulphur fertilization of the crop is seldom required if superphosphate is used for top-dressing.

Analyses of lucerne cut at the hay stage show that very large quantities of plant-food are removed from the soil by its growth. The following shows the extent of the annual removal of plant-foods from the soil in the case of a lucerne crop on a stony loam in the Nelson District.

The crop was top-dressed with a mixture of lime, superphosphate, and sulphate of potash, and gave a yield of 84·6 cwt. of hay per acre. This crop removed per acre the following amounts:—

Lime (CaO), 212 lb., equivalent to 380 lb. calcium carbonate; phosphoric acid (P_2O_5), 59 lb., equivalent to 246 lb. 44–46 per cent. superphosphate; potash (K_2O), 147 lb., equivalent to 272 lb. sulphate of potash; sulphur (S) = 35 lb.

The investigations have shown that the mineral content of lucerne is considerably affected by treatment with fertilizers. The mineral composition is profoundly influenced by seasonal conditions. Very dry weather has increased greatly the percentage of lime in the leaves and has caused a reduction in the amount of phosphoric acid in comparison with the quantities present in a season of normal rainfall.

Lucerne in the young growth stage has been compared with good pasture at approximately the same stage of growth-development. The lucerne has been found to be little superior to pasture either in protein or carbohydrates. Lucerne contained less potash, chlorine, and insoluble ash than pasture. As far as bone-forming materials were concerned, lucerne was superior to good green pasture solely in its high content of lime (1·91 per cent. against 0·87 per cent. found as the average for good Nelson pastures).

PHORMIUM RESEARCH.

Advisory Committee: Mr. A. Seifert (Chairman), Mr. H. A. Seifert, Mr. H. Greig, Mr. E. Frost, Professor G. S. Peren, Mr. A. H. Cockayne, Mr. H. Vickerman, Dr. J. S. Maclaurin, Professor T. H. Easterfield.

Investigations connected with phormium research were placed on an established basis during the year, when the committee was constituted and arrangements made to secure funds by placing a levy of 2d. per bale on hemp and 1d. per bale on tow exported. The estimated revenue from this source amounts to about £740 per annum, which is supplemented by a grant of £1 for £1 by the Department. Additional contributions are being arranged from flax-planting companies and organizations at a rate of 1s. per acre upon all established areas until such time as these reach maturity.

At the present time the phormium industry appears to be in that transitory stage when it seems possible that future supplies of fibre will be drawn from artificially-established areas, rather than from native sources as hitherto. Projects for planting considerable areas are now under consideration throughout the Dominion, and the need is urgent for supplying those interested in these plantations with the best possible advice in order that serious mistakes may be avoided and the future of the industry made more assured. Consequently a survey of the main flax areas and plantations has been made with a view to ascertaining the practices and conditions that have been successful. It is proposed to embody in a bulletin the information gleaned from this survey.

More attention has been devoted to the discovery of new uses for phormium-fibre overseas. . For this purpose consignments of flax have been forwarded to the Imperial Institute ; the British Admiralty ; the Plymouth Cordage Co., Boston, U.S.A. ; Dr. Possaner von Ehrenthal ; Imperial Chemical Industries ; Spectrum Dyes, Ltd. ; and the Bureau of Standards, Washington. These consignments will be tested for their suitability for a number of purposes, including paper, rope, and cordage, and cellulose and fabric manufacture. The hope that phormium-fibre might be used for the manufacture of artificial silk has not yet been realized.

It is gratifying to note that a considerable amount of local experimentation is being conducted by various enthusiasts throughout the Dominion, and during the year the committee has investigated a number of processes designed to effect improvements in flax-treatment.

Mr. P. W. Aitken has continued his investigations into the chemistry of phormium. The work dealing with the use of chemicals for fibre-bleaching purposes has been completed, and results indicate that only the cheapest of chemicals—viz., permanganate of potash and sodium hyposulphite—could be economically used for this purpose. With the knowledge of chemical bleaches now available, there yet remain to be developed suitable mechanical devices which will enable these to be put into practice

It has been found that impurities occurring in the water-supplies available at flax-mills have been responsible for poor colour being secured in connection with the fibre. In consequence a large number of water-analyses have been made throughout the Dominion, and this information has been made available to flax-millers themselves.

Investigations dealing with the influence of various machines—strippers, scutchers, &c.—upon the chemical and physical properties of phormium also have been commenced. It would appear from strength-tests carried out with a specially devised machine that the mechanical processes through which phormium-fibre passes at present are responsible for considerable reduction in its tensile strength.

Phormium investigations under the supervision of the Research Committee are at present being conducted as follows :—

(1) Chemical and mechanical researches by Mr. P. W. Aitken and Mr. C. R. Barnicoat.
(2) Botanical and cultural researches by Dr. J. S. Yeates, at Massey Agricultural College.
(3) Utilization investigations overseas at the Imperial Institute, London ; the Admiralty ; Plymouth Cordage Co., Boston, U.S.A. ; Bureau of Standards, Washington ; Dr. Possaner von Ehrenthal, Gothen, Germany ; Spectrum Dyes, Ltd., Melbourne.

Report on Breeding, Selection, and Cultivation of Phormium.

By Dr. J. S. Yeates, Massey Agricultural College.

(*a*) *General.*—During the past year it has been found possible to travel fairly extensively in both Islands on phormium work. Visits have been paid to all the important flax growing and milling districts, except the extreme north of the North Auckland District and Otago-Southland area. The objects of such travelling were several. First and foremost was the collection of material of phormium varieties, and also a preliminary study of the distribution of the main types of phormium. A secondary object was to secure first-hand acquaintance with the industry under all conditions, and to establish with millers and growers that personal contact which is necessary to the success of work of this type. Although a good deal of material was obtained in this way, it must be understood that on a lengthy and somewhat hurried tour much was left undone. It was, however, necessary to secure a general knowledge of all districts as a preliminary. In future years it is hoped to concentrate on a small area each year.

(*b*) *Progress of Plants Collected During the Previous Year.*—The "fans" of selected plants have now been planted for about twelve months in a small area at the Batchelar homestead. The growth has been quite satisfactory, although slow in beginning, on account of the severe treatment received in transplanting. Since most of the fans have to be carried long distances by motor-car, the roots and leaves need to be trimmed back very close to save carrying too much weight.

(*c*) *Growth of Pedigree and Hybrid Seedlings.*—(1) Pedigree seedlings : These are called pedigree seedlings to denote that each batch of them has been grown from a single pod of one bush, fans of which have been planted in the nursery. Wherever possible, several batches are grown from each bush, and a total of some twenty bushes was treated in this way last year. The growing of these pedigree seedlings is regarded as the most important aspect of the work. The immediate aim is to find bushes the seed of which produces a high percentage of vigorous seedlings of uniform milling-qualities. In other words, the object of this part of the work is to find varieties which will provide the best available seedling plants for commercial planting. Further than that, a great deal of valuable information will in time be obtained on the breeding behaviour of phormium, information which is necessary for systematic hybridization to procure improved strains. The seedlings under this heading have grown very well.

(2) Hybrids: Crosses were made between several varieties in December, 1927, and January, 1928. The crossing was done in Mr. A. Seifert's nursery at Shannon. The parents were chosen for particular excellence in one or more respects. The following were crossed (Mr. Seifert's number for each variety is used here):—

SS: An upright plant with leaves which strip excellently, yielding fibre of good colour and great strength; a good disease-resistant plant. The height is not sufficient to produce a good crop.

13 K: A tall-growing variety of high cropping-capacity and good general qualities, but slightly lacking in strength.

21 H: An exceedingly-rigid-leaved variety, yielding fibre of particularly good colour, but lacking in strength.

37 A: A very heavy cropping variety of good general quality.

The variety SS was crossed with each of the others, so that seed of the following hybrids was secured: SS × 13 K, SS × 21 H, SS × 37 A. The hybrids SS × 21 H, and SS × 37 A have grown quite satisfactorily, but it is too early yet to say whether or not they will have the desired combinations of characters. The cross 13 K × SS has produced seedlings which in habit of growth and colour are intermediate to seedlings of the parent varieties. The most noticeable feature is, however, the vigorous growth of these seedlings as compared with seedlings of the parents. The accompanying photographs (figs. 1 and 2) illustrate this point. This hybrid vigour is, of course, well known in both animal and plant crosses. It seems feasible to use this vigour in commercial phormium-plantations in order to hasten maturity and increase the yield per acre. Before large numbers of hybrids can be provided it will, however, be necessary to develop methods of crossing on a large scale. This work is to be prosecuted vigorously in the next flowering season. It must be remembered that hybrid vigour is important from the point of view of disease (*e.g.*, yellow leaf). As a rule, hybrid vigour means also resistance to disease.

(*d*) *Collection of Varieties in Past Year.*—A total of 220 strains has now been collected. For convenience these are referred to as varieties. There is no doubt that the majority will be distinct from one another. The centres from which fairly large collections of varieties have been obtained are as follows: Martinborough, 37; Wellington (Palliser Bay), 7; Waverley (Taranaki), 8; Blenheim, 18; South Westland, 12. Many other varieties have been obtained from North Auckland-Kaingaroa, Whangaroa, Bay of Islands, Waikato, Bay of Plenty, and other localities in both Islands. Wherever time and opportunity allowed, the collection has included five fans and also seed of each variety. Exact written notes have been made to enable the precise bush to be found again. In most cases photographs have been taken to illustrate the locality and the characteristics of the variety. Obviously, seed could not be taken from all varieties, because seed was ripe only towards the end of the time spent in the field. Seed was, however, collected and sown pod by pod from more than one hundred of the varieties collected this year. This seed is already growing. The fans collected in this way have mostly been planted on the 20-acre plot set aside for phormium-cultivation. Seed-capsules of each variety are being kept wherever possible. These capsules, or "pods," are valuable features in distinguishing varieties otherwise very similar in appearance. Photographs and capsules of each strain will be filed permanently for reference purposes.

(*e*) *Experimental Area of Uniform Plants.*—It was considered most desirable that an area of about 1 acre should be planted with plants of one variety for experimental purposes. No variety is yet known which produces seedlings of sufficient uniformity for this purpose, so that planting by fans was necessary. The problem of securing enough fans (about one thousand) of one variety was expected to be very difficult. Fortunately, the required number was obtained from Maori plantations of a very good variety. These plants are now set out on the 20-acre experimental area. The variety concerned is a hybrid of the same nature as the cross SS × 13 K mentioned above. The growth is most vigorous, and the fibre of excellent quality. Seedlings of this hybrid naturally show a "breaking-up" of the hybrid strain, so that propagation by fans is necessary. A careful genetical analysis of this hybrid will be made to find if it can readily be increased by seed on a commercial scale. The acre of this hybrid now planted will, in any case, be available for increase by fans if such a course proves desirable.

(*f*) *Yellow-leaf Disease: Mr. Meadows's appointment.*—In February of this year Mr. L. Meadows, of Canterbury College, was appointed to this College by arrangement with the Scientific and Industrial Research Department. Mr. Meadows was appointed chiefly in view of the urgent necessity for some work on yellow-leaf disease. The attack on the yellow-leaf problem is being made in general along the following lines:—

(1) Field observations of its occurrence on various soil-types and under different conditions of soil moisture, &c.

(2) Root excavations of diseased and healthy plants to determine if the disease can be correlated with any features noted in this way. Mr. Meadows has done extensive work on the excavations and careful mapping of root-systems. The results as yet cast no light on yellow-leaf disease, but represent a distinct gain in our knowledge of the root-system of the plant.

(3) The selection and breeding of resistant strains of phormium is regarded as the policy which will ultimately be the most successful. As noted under section (*c*) hybrid vigour frequently renders plants immune to disease. Selection of resistant strains is being given particular attention. A question which must be answered is to what extent seedling plants inherit resistance from the resistant parent. An area of land very susceptible to the disease will be needed at some time in order to answer such questions.

(4) Manurial trials are to be undertaken as soon as trial areas can be arranged. Mr. T. Rigg, of the Cawthron Institute, has given many helpful suggestions for work along these lines.

(*g*) *Strength-testing.*—During the year some work was done in conjunction with Dr. M. A. F. Barnett, on the strength of phormium-fibre. It was found, as would be expected, that hand-stripped fibre, weight for weight, was much stronger than machine-stripped. A strength-testing machine was designed by Dr. Barnett as an outcome of the above work. The machine is being constructed in Wellington, and is now completed. A fibre conditioning and testing room has been fitted up, in which temperature and humidity can be regulated.

(*h*) *Laboratory Estimation of Fibre Content.*—A promising beginning has been made in the development of a method for determination of fibre-percentage in the laboratory. It is considered that the method in question should give a reliable guide as to quantity and strength of fibre. The purchase of equipment, costing several pounds, will be necessary before these experiments can be completed.

(*i*) *Development of Main Flax Area.*—The development of the main trial area is proceeding. Twelve acres have so far been stumped and ploughed. A crop of rape has been taken off the greater portion. Three acres have been subsoiled.

(*j*) *Co-operative Trials of Varieties.*—Arrangements have been made with two growers (one at Hamilton, one in Canterbury) to set aside small areas for the planting of fans from varieties grown also at Massey Agricultural College. Some varieties have already been sent to these areas, and more are yet to be sent. In addition, exchange of fans of special varieties have been arranged with various growers. This work is necessary in order to find the effect of various conditions of growth on known varieties.

(*k*) *Manurial Experiments.*—Manurial experiments to test the effects of various manures on the growth of seedlings have been instituted. Although differences between the plots are visible already, it is much too soon to give any conclusions.

(*l*) *Records of Commercial Planting.*—In the course of the summer's travelling particular attention has been given to newly planted commercial areas and to nursery practice where seedlings are grown. A good number of photographs are being filed as records of the development in the various commercial plantations. It is hoped to keep photographic records showing the progress in these areas from time to time.

The work has at all times been rendered very pleasant by keen interest and readiness to help on the part of flax-millers and flax-growers in all parts of the country. Officers of the Department of Agriculture have likewise given practical evidence of their desire to help the progress of the work.

PIG-INDUSTRY INVESTIGATIONS.

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

As a result of the special grant of £1,775 made in order to facilitate investigations connected with the feeding and management of pigs, three recording groups were put into operation in the Waikato, Manawatu, and Canterbury districts, attached to the Waikato Group Herd-testing Association, and to Massey and Canterbury (Lincoln) Agricultural Colleges respectively. The data secured have provided a valuable record of the actual conditions prevailing in the pig industry to-day. An interim summary of the results indicates—

(1) That much greater attention should be devoted to securing pigs that will produce a high litter-weight. In every case high litter-weights have been associated with economy of production.

(2) The great importance of the economic value of proper management has been emphasized. On one farm, where general conditions and feeding were on good lines, a net return of £5 18s. per cow was secured from pigs fed on skim-milk. The lowest return in a number of farms where the recording system was introduced showed a return of £1 16s. per cow. On farms where whey was used returns were not so good, but it would appear that from £1 10s. to £2 12s. per cow could be secured from pigs fed on whey.

(3) By recording the weight of litters at birth and at four weeks it is possible to accurately forecast their weight at eight weeks of age. This fact provides means for reducing very considerably the cost and trouble involved in pig-recording. Further, litters that are heavy at eight weeks of age can be fed 50 per cent. more profitably than light ones of the same age.

(4) Litter-weights at eight weeks have been found to range from 100 lb. to 450 lb., while only 8 per cent. of the total litters recorded exceeded 300 lb. This reveals the need for culling among breeding sows and boars in order that the low producers may be eliminated and increased attention to feeding during the winter months.

(5) It has been found that the inauguration of pig-recording has aroused a very real interest among farmers maintaining pigs. The scheme has been responsible for the introduction of pedigree stock to replace others of lower productivity.

Pig-feeds.

The preliminary trials started last year at Canterbury (Lincoln) and Massey Agricultural Colleges in connection with whey-paste proved sufficiently promising, although the first paste was contaminated with impurities, to warrant more extended trials with paste of better quality. These trials have shown that it is possible to use concentrated whey as a basic diet for pigs. Even when used alone the paste proves a satisfactory pig-feed, but, as with other milk feeds, its value is immensely increased when small quantities of cereal or meat-meals are fed in conjunction with it.

In the search for supplies of suitable pig-feeds to supplement the basic ration of skim-milk and whey now so commonly used throughout the dairying districts, samples of meat-meals have been subjected to fundamental feeding-tests at Otago Medical School. The results of these researches, using the meals in feeding small animals, have now been published in the Department's Bulletin No. 12—"Report on the Nuritive Values of Meat-meals," by Miss E. A. Pope, M.Sc.—and these will provide basic information for trials to be conducted with pigs themselves.

PORK AND BACON RESEARCH.

The Department has secured detailed particulars of the preparation of pork and bacon as manufactured overseas. This information has been passed on to local bacon-manufacturers, who are members of the Bacon Research Association. In addition, samples of ham and bacon have been imported from overseas for purposes of comparison, and a number of tests in connection with salt-penetration, moisture content, &c., have been carried out on these samples. Problems such as fly and mould infections of bacon, suitable wrapping-materials, and various manufacturing difficulties have been under constant investigation, and reports in regard to these have been issued.

Work now has been commenced upon the influence of feeds upon bacon quality and structure, particular attention being devoted to the occurrence of deleterious taints and flavours which allegedly are due to feeding practices. One of the difficulties confronting investigators is the fact that very little research has been carried out upon the fundamentals of bacon-curing. Relief from this difficulty now may be secured as the result of the proposed establishment of a Bacon Research Institute, to be under the direction of Dr. Callow, of the Cambridge Low-temperature Research Station in Great Britain, and steps already have been taken to ensure co-operation with the work of this Institute.

WOOL RESEARCH.

Advisory Committee: Dr. C. J. Reakes (Chairman), Mr. W. Perry, Professor G. S. Peren, Mr. R. E. Alexander, Mr. E. Short, Dr. Dry, Mr. Q. Donald, Mr. A. H. Cockayne.

During the year the microscopical examination of a number of New Zealand wool-fibres, undertaken as a result of a special contribution of £100 received from the Romney Marsh Sheep-breeders' Association, was continued and brought to a state of partial completion. The results of numerous microscopical and weight determinations were embodied in Bulletin No. 7—"New Zealand Wool-fibres," by E. F. Northcroft, M.Sc. This examination brought into prominence to a greater extent than ever before certain peculiarities of Romney-wool fibres, and will form the basis of further experimental work on the animals themselves.

The Council of Scientific and Industrial Research gave the matter of wool research careful consideration during the year, and decided that the problems confronting the wool industry were of sufficient importance to warrant the establishment of a Wool Research Committee. This committee, representative as it is of all wool interests, has very carefully surveyed the position as it exists in New Zealand, and in dealing with the main points to receive attention has had the advantage of consultation with Dr. J. E. Nichols, of the staff of the British Research Association for the Woollen and Worsted Industries, Torridon, Leeds.

As the result of this examination the complexity of the problems affecting the wool industry have become more apparent, and it has been decided to gradually build up a proper organization to cope with the situation. Pending this establishment, sectional investigations have been commenced at Massey Agricultural College, Dr. Dry undertaking investigations on the growth and development of the wool-fibre, and Mr. Scrivener examination of the wool-grease and its relation to fibre-nourishment. At the same time a limited number of breeding and management investigations will be conducted at both Canterbury (Lincoln) and Massey Agricultural Colleges.

In order that the best results may be secured, co-operation with investigations at present proceeding in Great Britain would appear very necessary, and proposals to raise the necessary funds to deal adequately with wool problems are now receiving consideration.

FUEL RESEARCH.

Fuel Research Committee: Colonel W. D. Holgate (Chairman), Professor H. G. Denham, Mr. W. A. Flavell, Mr. A. H. Kimbell, Mr. Robert Lee, Dr. J. S. Maclaurin, Mr. H. Vickerman, Dr. E. Marsden (Secretary).

Staff.—Mr. S. W. McIntosh, on completion of his investigation on coal-dust in mines, resigned in August, 1928.

The present staff comprises Mr. W. A. Joiner (Chemist in Charge), W. G. Hughson, and A. K. R. McDowell (Assistant Chemists). The work is carried out under the general supervision of the Director of the Dominion Laboratory, Dr. J. S. Maclaurin.

Laboratory.—The laboratory consists of three rooms, suitably equipped, at the rear of the Dominion Laboratory, Wellington. For the study of low-temperature carbonization of sub-bituminous coals a Fischer retort to take a charge of 30 lb. of coal was installed. As it was desired to examine the products in considerable detail, some modifications and adjustments were required: the oil-condensers were made gastight; a pump was installed to draw the vapours from the retort and through the condensers; provision was made for stripping the gas of light oil by means of absorbent charcoal; a gas-holder was constructed to collect and store the gas, and a meter to measure the quantity; a thermocouple was obtained to replace the mercury thermometer provided with the retort.

Work.—Waikato coal has been carbonized at temperatures of 550° and 600° C., and yields of residue, tar-oil, light oil, and gas determined. The tar-oil has been examined by fractional distillation.

Numerous coal-samples have been analysed and subjected to Gray King assay. Current literature on fuel has been indexed, and abstracts prepared when required.

The carbonization of South Island sub-bituminous coals in the Fischer retort is now proceeding, and small laboratory trials are being made preparatory to the carbonization of West Coast bituminous coals.

Bulletins.—Bulletins issued during the year comprise—

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

"Summary of Investigations on New Zealand Coal," prepared by W. Donovan.

"Low-temperature Carbonization of blended New Zealand Coals," by W. G. Hughson.

A bulletin dealing with Waikato coals is in course of publication, and bulletins on southern brown coals and on Westport coals are in preparation.

Reports.—Reports on coal-dust in various mines, prepared by S. W. McIntosh, have been forwarded to the mines concerned.

Progress reports of the work have been furnished to the Advisory Committee from time to time.

The following abstracts and descriptions of processes have been prepared either for circulation to members of the Fuel Committee or for publication in the *Journal of Science and Technology*:—

(1) Developments in the Braunkohle Industry in Germany.
(2) Reactivity of Cokes (Technical Paper 18, Fuel Research Board).
(3) Fifth Annual Report, Safety in Mines Research Board.
(4) Inflammation of Coal-dusts. (Maron and Wheeler.)
(5) The Hird Process.
(6) New British Short-flame Burner for Pulverized Fuel.
(7) Report on Pulverized Fuel.
(8) Absorption of Oxygen by Pre-heated Coal.
(9) Plassmann Process.
(10) K.S.G. Process.
(11) Report on Utilization of Slack from the Ohai Coalfields.

Investigation Abroad.—During the year Mr. W. Donovan, Assistant Dominion Analyst, visited Canada on behalf of the Waikato Coal-mine Owners' Association to inspect and report on the operation of the Lurgi process at Bienfait, Saskatchewan. Opportunity was taken to inspect also the K.S.G. plant recently erected at New Brunswick, New Jersey.

FRUIT RESEARCH.

A grant of £150 made to the New Zealand Institute of Horticulture for bud and stock selection in connection with citrus fruits has been used for the introduction and establishment in a nursery in the neighbourhood of Auckland City of a number of standardized Californian and Australian lemon and orange trees. On this area one thousand citrus stocks will be available for working with the varieties introduced. This stock consists of sweet orange, citronelle, trifoliata, and Florida sour-orange varieties. The growth and development of the buds and trees in this nursery will be carefully watched, as it is realized that the future success of the New Zealand citrus industry is largely dependent upon the adoption of the best type of lemon and orange trees suitable for local conditions.

At the same time a survey of the citrus areas of the North Island has been in progress, and a large amount of detailed information gathered regarding the growth, development, and fruiting-qualities of the oranges and lemons already established in various districts.

COLD-STORAGE RESEARCH.

During the year the Department has co-operated with the Department of Agriculture, Cawthron Institute, and the Cambridge Low-temperature Research Station in a series of investigations connected with the preservation of fruit in cold storage during transport to Great Britain, and in regard to the keeping-qualities of fruit held in local land stores. The experiments were designed upon lines suggested by Dr. Franklin Kidd subsequent to his examination of the previous season's shipments of apples and pears from New Zealand. Six of the main export varieties of apples and pears were subjected to investigation. Experimental consignments were sent forward, accompanied by recording thermometers, in twelve vessels during the fruit-export season. The fruit so despatched had been collected throughout the orchard areas in accordance with a carefully designed plan, and with each shipment a detailed history-chart giving the fullest particulars of the condition in which it was grown, packed, stored, &c., accompanied the fruit. On arrival in Great Britain, the fruit consignments were immediately examined by officers of the Cambridge Low-temperature Research Station, who in due course will furnish a report upon their condition. The information gleaned from last year's experiments indicates the necessity of reducing temperature of fruit consignments to the degree appropriate for cooling, either before shipment or as soon as possible after the departure of the vessel.

The major portion of the wastage last year, being occasioned by fungal rots, indicates the need for further care in handling, orchard treatment, and storage. It is gratifying to record that these experiments have been greatly facilitated by the sympathetic attitude adopted by the various shipping companies. Steps already are being taken by these companies to effect improvements in their vessels, which improvements will permit of better conditions being maintained for fruit during the voyage to Great Britain.

At the Cawthron Institute experiments have been conducted in connection with the holding of fruit in land stores, where study has been made of the influence of temperature and humidity upon the main export varieties of fruit gathered from specified areas.

From the work in this connection already carried out it is apparent that the keeping of fruit in good condition is materially affected by the conditions under which it is grown. The beneficial effects of certain fertilizers in this connection have now been almost conclusively proved. The importance of this research from the point of view of the marketing of our fruit overseas will be obvious.

While cold-storage investigations during the year have been limited to fruit, arrangements now are in hand to extend these to both dairy-produce and meat during the coming season. In the first year the work on dairy-produce will be confined to cheese, and the actual experiments will be conducted in association with the Dairy Research Institute.

A special committee has been set up in collaboration with the New Zealand Meat-producers' Board to co-operate with visiting officers from the Cambridge Low-temperature Research Station of the British Department of Scientific and Industrial Research in a series of investigations into cold-storage problems in so far as they affect New Zealand meat. Two of the Department's technical officers have been attached to this Committee.

A series of investigations on the keeping-qualities of onions, also, has been carried out in association with the Department of Agriculture. The onions were placed in a specially arranged cold store in Christchurch, and after storage for a number of months were shipped for sale in Wellington and Auckland. While improvement was apparent in the keeping-qualities of the onions, the trial was started too late in the season to warrant any definite conclusions being drawn as to the feasibility of keeping onions in cold storage. The experiment has indicated the necessity of fuller examination from the mycological point of view and the control of humidity in storage.

Investigations at Cawthron Institute.

In the present incompleted state of the special cold-storage research work which is being undertaken it is not possible to do much more than outline the scheme and some of the methods which are being used to carry out the work.

It was considered that the line of work which would prove of greatest value to the industry would be a careful study of the effect of storage temperature on the keeping-quality of the six varieties of apples first in order of importance in the New Zealand export trade during a storage period equal to that occupied on the voyage from New Zealand to England. Owing to the necessity for keeping the size of the experiment within reasonable limits, it was decided to confine attention to fruit grown on one type of soil. By far the largest single uniform area of land exporting fruit in New Zealand is the Moutere Hills district, which includes not only the Hills district proper but also the Tasman, Mapua, Mahana, and Mariri areas. Fruit from this area was therefore selected for the work. Arrangements were made with the executors of the estate of the late Mr. E. H. Bisley to secure the necessary fruit from their Mildura orchards, with the exception of the Statesman variety, which they do not grow. This was secured from the orchard of Messrs. Hurst and Stewart of Redwood's Valley.

The method of picking and sampling was that employed in our own cold-storage work of previous years. A picking is taken over the whole of a block of trees, and the sampling is arranged so as to ensure that each case will have fruit in it from every tree. All fruit is picked as nearly as possible of uniform maturity and size, and is wrapped and packed in the standard Canadian case exactly as for export.

A period of four days was allowed to elapse between picking and storing the fruit, to correspond with the average length of time occupied by export fruit on its way to the stores where it is held prior to loading. No export fruit is likely to be more than eight weeks in the ship's hold on the voyage from New Zealand to England, and this was therefore fixed as the length of storage to be adopted in the experiment. At the end of the storage period the fruit is removed from store and is divided into two lots. One lot is examined at the end of three days, during which period it has been held at ordinary cool-room temperatures. This examination is designed to indicate the condition in which the fruit opens up when it is offered for sale in the London market. It is quite possible that fruit will not be sold by the retailer till three weeks after it has left the ship, and consequently the second half of each lot of fruit is left out of store for a period of three weeks before it is examined. This will then give an indication of the condition in which the fruit is likely to be when it reaches the consumer, and will provide a record of the extent to which breakdown and other diseases develop after removal of fruit from cool storage. Storage was arranged with the Nelson Freezing Co., Ltd., Stoke, and three rooms were utilized. One of these was already in operation for the storage of pears, and provided a flesh-temperature of about 35° F. A temperature of 38° F. was obtained in our small experimental room, and for securing a low temperature (32° F.), a commercial chamber of approximately 1,500-case capacity was hired. A charge of 10s. per day was made by the company to cover both rental of the rooms and cost of operating extra machinery. It was not possible in the work of this season to take into consideration the effect of the relative moisture content of the store-air, and consequently all rooms had to be so run as to produce as nearly as possible the same drying-effect at each temperature. The commercial room in which the pears were stored was not subject to our control and had to be taken as the standard. In it the humidity ranged from about 85 per cent. to 90 per cent. In the low-temperature (32° F.) room it was not possible to raise the humidity quite to this figure. The room was very large and practically empty, and in consequence the battery maintained the room at a very low humidity. Wet sawdust was spread out in the room and wet sacks were laid over the stack of fruit in an attempt to raise the humidity nearer the desired figure, but, on account of the freezing of the water, only a small measure of success was attained. Up till the time when a commercial room run at 32° F. became available the humidity averaged about 75 to 80 per cent. In the small room at 38° F., a similar difficulty was met with, but was entirely obviated by the use of wet sacks in the room. A further difficulty, again attributable to the storage of a very small quantity of fruit in a large room, was experienced in the 32° F. room. This was a marked flesh-temperature rise during the period when the plant was not running. The temperature rose about 2½° or 3° F. at first, and a jacket consisting of benzine-tins filled with water and stacked in boxes over the whole of the outside of the fruit-stack was therefore tried out as a remedy. By this means it was found possible to reduce the rise to about 1° F. It would appear that, in the absence of special stores or small chambers, such difficulties cannot be avoided, and must always detract to some extent from the value of tests on the early varieties of apples.

As far as the experiments have gone at present, the one outstanding fact brought to light is the extreme sensitiveness of the Cox's Orange variety. From the results obtained it appears that

there must be very heavy depreciation in the quality of many shipments, and that a more detailed study of the behaviour of the variety is needed. Even in the best keeping line, that held at 38° F., there was as much as 12 per cent. of breakdown of sufficient severity to spoil the commercial value of the fruit. At the end of three weeks after removal from storage this figure had increased to 16. A picking taken just previous to the export closing date of the variety showed 16 per cent. of moderate to severe breakdown on removal from store and 37 per cent. at the end of three weeks. In addition to the damage directly attributable to breakdown, there was a very considerable depreciation in the quality and palatability of the variety. In the early picking a considerable percentage of bitter-pit developed, but there was practically none in the late picking.

Dunn's Favourite has so far showed little trouble at any temperature. As far as the work has gone, 35° F. seems to be the temperature which produces the most desirable apple at the termination of the storage period.

Breakdown has not proved serious in the Jonathan. The most striking fact so far brought to light with this variety is that deep scald—an irregular, sharply outlined browning of the skin of the apple, associated almost invariably with browning of the underlying tissue—is found to be almost entirely confined to apples stored at 32° F. It is evident that if this trouble is to be avoided the Jonathan must not have its temperature lowered below 35° F.

The Delicious, as may possibly have been anticipated, did not develop breakdown at any storage temperature. The deciding factor influencing the choice of storage temperature for this variety is the flavour and general eating-quality of the fruit. With the early picking, a temperature of 32° F. prevented any ripening process taking place and gave a much inferior result to that obtained at 35° F., while this in turn was not as good as at 38° F. No sign of mealiness was in evidence at any temperature.

The above notes cover only a few of the more striking points so far brought out, and until the examinations are completed it will not be possible to view the data in proper perspective and draw reliable conclusions as to the best treatment to be accorded to any one variety.

INVESTIGATIONS OF THE UTILIZATION OF PAKIHI LANDS.

The land known as pakihi covers a large area in the Nelson and Hokitika Survey Districts. Statistics supplied by Mr. A. F. Waters, Commissioner of Crown Lands, Nelson, and by Mr. W. T. Morpeth, Commissioner of Crown Lands, Hokitika, show that in the Takaka, Collingwood, Buller, Inangahua, Grey, and Westland Counties the area classed as pakihi covers approximately 200,000 acres.

The pakihi land consists largely of flat or gently sloping terraces, and is, in general, easy of access, and much of it consists of natural clearing. For the most part the land is unproductive, and large areas have been let on lease at 3d. per acre per annum. There is a widespread opinion that these lands can never be made productive except at prohibitive cost. The usual soil on the pakihis is a fine silt loam, well supplied with organic matter and waterlogged except in dry weather. As the rainfall in the pakihi areas is from 80 in. to 100 in. per annum, swamp conditions prevail, and this is reflected in the flora, which consists largely of dwarf umbrella-fern (*Gleichenia dicarpa*), a small rush (*Juncus planifolius*), a rush-like sedge (*Cladium teretefolium*), lycopodium, and sundews. The vegetation supports a few bullocks and dry cows for limited periods of the year. The general absence of bracken, gorse, blackberry, and phormium on the wet pakihi is very noticeable.

In general the pakihis are underlaid by very coarse gravels, often consisting almost entirely of granite boulders and detritus. The junction between the granite and the pakihi silt is usually cemented into a pan which varies greatly in thickness. In some areas the pan is met 9 in. or less below the surface; in others it may be more than 3 ft. underground. The presence of the pan has generally been regarded as an insuperable obstacle to drainage, and if the utilization of pakihi land presupposed the general breaking-up of the pan the cost would certainly be very great. The pan is brown in colour, and is usually supposed to be ferruginous; the colour is, however, largely due to organic matter, and in many cases the amount of iron oxide is negligible.

Another objectionable feature is the large number of tree-roots usually present in the soil; they mostly belong to the Westland pine (*Dacrydium Colensoi*), and show extraordinary durability. These roots add considerably to the expense of initial ploughing, though a stump-jump plough might get over the difficulty. The lack of fertility of the soil is sometimes attributed to the "poisonous" action of these tree-roots, but there is no evidence to support this contention.

Valuable laboratory-work upon the pakihi soil has been done in the past by Mr. B. C. Aston, Chief Chemist to the Department of Agriculture, and very useful field experiments have been carried out by Fields Instructor Mr. G. de S. Bayliss. Other field or plot experiments which have come under our notice were carried out by Messrs. Falla, Dixon, and Egan.

Work on the breaking-up of the pakihi pan by explosives was carried out by Mr. Leggo, representing the Nobel Explosive Co. An account of this work is recorded by Mr. McPherson in the *Journal of Agriculture*.

The officers of the Cawthron Institute have examined the field plots upon which these earlier experiments were carried out, and are able to report that, though nothing has been done to them since the initial treatments some twenty years ago, the land has in no case gone back into pakihi condition. When top-dressed with basic slag without any fresh seed the plots showed a most wonderful response.

In 1923 the Buller Progress League forwarded to the Cawthron Institute 1 ton of typical pakihi soil taken from an area selected by Mr. Rigg, Chief Agriculturist to the Institute. This was thoroughly mixed and used for pot and cylinder experiments, which showed (1) that the soil was very infertile, even when well drained; (2) that lime alone gave but little improvement; (3) that great improvement resulted from the employment of lime with superphosphate, with basic slag alone, and with Nauru phosphate alone. The experiments were carried out with oats, rye-grass, and with mixtures of grass and clover.

A careful examination of the field conditions led the officers of the Institute to the conclusion that the swampy nature of the pakihis is at least as much due to the spongy and colloidal nature of the soil as to the presence of the pan itself. This is illustrated by the fact that the pakihi soil retains its ordinary character in the immediate neighbourhood of open drains.

Following a representation made to the Hon. the Minister of Railways by the Hon. W. H. McIntyre in 1926, an offer was made to the Cawthron Institute Trust Board of a twenty-one-years lease, without rental, for experimental purposes, of a considerable area of pakihi land, the property of the Department of Railways, at Sergeant's Hill, Westport. The offer was accepted, and in April, 1927, a number of plots were marked off for experiment by Mr. Rigg. A lock-up shed for storing tools and fertilizers was erected, and certain sections were ploughed by tractor, others by horse; others, again, were merely disked. An adjoining 1-acre section, upon which the explosion experiments of the Department of Agriculture were carried out in 1912, was also secured and fenced in. Flax-fans were planted on a section which had been thrown up into ridges to receive the plants, the fans receiving different manurial treatments on different ridges. In the following spring young flax-plants were planted on another plot. The planting was followed by an exceptional period of drought, which appeared to have killed the plants, but with the arrival of rain in the late summer the flax made a wonderful recovery. Quite recently flax-seedlings of six different varieties, presented by Mr. Alfred Seifert, of Palmerston North, have been planted.

During the parliamentary session of 1927 legislation was passed allowing the Buller County Council and the Westport Borough Council to contribute funds towards the pakihi experiments of the Cawthron Institute, such contributions to be subsidized at a £2-per-£1 rate by the Department of Scientific and Industrial Research. £300 per annum has thus become available for the cost of the experiments.

In April, 1928, a number of the plots were sown with mixed grasses and clovers, different fertilizers at different rates being used upon the plots, the fertilizers employed being lime, basic slag, superphosphate, and Nauru phosphate, alone and in combination. In November the growth under several of the treatments was so satisfactory that a public field demonstration was held, at which the farmers spoke with enthusiasm of the results obtained. At a later date the experimental area was examined by officers of the Fields Division of the New Zealand Department of Agriculture, who reported favourably at headquarters upon the results obtained. The results may be summarized as follows:—

(1) Plots ploughed in winter and fallowed during summer worked down to a better seed-bed than land ploughed and worked in autumn and sown directly afterwards. The fallowed land accordingly showed a much more even take of grasses and clovers.

(2) Almost as good a growth of grasses and clovers has been obtained upon land which has been thoroughly disked as was obtained on the fallowed ploughed land.

(3) Simple burning of the pakihi vegetation, followed by treatment with lime and basic slag, harrowing, at once, and then sowing grasses and clovers, gave a result which was little inferior to the best plots obtained by the ploughing and fallowing treatment. This treatment, which is inexpensive, is now being repeated on an extended scale.

(4) Plots receiving lime alone proved total failures; those receiving superphosphate alone were very poor. Nauru phosphate or basic slag alone gave better but still poor results. Where lime and basic slag, or lime and superphosphate, were applied together, very satisfactory crops of grass and clover resulted.

(5) On the ploughed and fallowed land the use of 1 ton of lime per acre with 5 cwt. of super or basic slag gave as good results as were obtained when the quantity of lime was doubled. Basic slag and super proved equally effective.

(6) Seven months after sowing, the crop of mixed hay approximated to 1 ton on the plots referred to in (5). Three months later a second crop of 2 tons of hay per acre was obtained. The appearance of the plots suggests that there will be great improvement in the second season.

(7) Areas of pakihi which received lime treatment fourteen years ago have responded wonderfully to either basic slag or superphosphate.

(8) In the first season rye-grass, Yorkshire fog, *Lotus angustissimus*, and red clover have been very vigorous in their growth. Paspalum, cocksfoot, and red clover are now showing up well.

(9) The texture of the soil which has received the lime and phosphatic treatment has become open and granular, and quite different from the ordinary pakihi; even in very wet weather it shows no tendency to remain sodden. The increase in the bacterial population of this soil has been extraordinary.

(10) *Phormium tenax* has made satisfactory root and leaf growth on plots treated with Nauru phosphate. No advantage has so far followed the throwing of the land into ridges. It is, however, too early to make any definite pronouncement about the success of this plant until the crop is ready to cut.

LEATHER RESEARCH ASSOCIATION.

Report for the Period 1st January to 31st March, 1929.

Advisory Committee: Messrs. J. E. Astley, A. E. Lawry, D. Phillips, A. M. Wright, and Dr. J. S. Maclaurin. Research Chemist, Mr. P. White.

The preliminary work of establishing and equipping the Leather Research Laboratory was carried out as expeditiously as possible. During this period contact was effected with the tanneries, boot-factories, and Government institutions using leather.

On the whole, the boot-manufacturers were buying New Zealand leather; however, attention was drawn to certain defects, such as bad colour, inability to scour the leather, and undue softness. In consequence, suggestions were made to the tanners whereby their leather might be improved and these defects overcome, and the result of their putting into practice these suggestions has been to give satisfaction to the boot-manufacturers.

In the past, Government institutions had not used New Zealand leather to a great extent. In the main, this was due to the fact that the tanner did not know the requirements of the institution, and the latter took it for granted that the tanner was unable to produce the goods required. All of the institutions visited in New Zealand are now using New Zealand leather.

At first the main object of visiting the tanneries was to get in touch with local conditions. Various problems were submitted on such subjects as chemical control of tan-liquors, retanning of sole-leather, growth of moulds on leather, and methods of finishing sole-leather. Suggestions to suit local conditions were made, and in most cases the results have been satisfactory.

Analyses have been made of the leather produced in all of the tanneries of members of the Leather Research Association. The chief defect, if it may be called a defect, disclosed by the analyses has been the low yield of leather. By this is meant the amount of leather produced from the actual weight of the hide. A general improvement in this respect has been made, and the result is that the tanner is now receiving a better return on his input and at the same time giving more satisfaction to his customers.

Tests with the wear-testing machine have been carried out. So far these tests have shown that the leather produced in New Zealand compares very favourably with English leather. On each test carried out a New Zealand leather has proved to be the superior article, and average of New Zealand leathers is higher than an imported leather tested.

The water-absorption of New Zealand leathers is much less than that of English leathers, and, at the same time, the water is taken up more slowly. From the wearer's point of view, this is a valuable asset. Also, New Zealand leathers when wet will dry out more quickly.

Samples of wattle-bark, as used in the tanneries, have been analysed. New Zealand wattle-bark is quite up to the average, and investigations are in progress for the development, if possible, of a supply of locally-grown tannin materials.

Each tannery is now equipped with a method of testing the pH (acidity) of the tan-liquors. At any time check tests can be made by the Government Analyst at Auckland or Dunedin. This system of control will have very beneficial results in the future.

Each month a circular letter is sent out dealing with problems of interest to the man who actually controls the processes. These letters are intended for the foremen as well as the managers. Incorporated in them are the results of the latest research published in various journals. In this way contact with other workers is maintained which otherwise would not be the case.

STANDARDS AND STANDARDIZATION.

Weights and Measures.—During the year the Labour Department received the new sets of primary standard weights and measures, and our Department's Physicist has co-operated with officers of the Labour Department in carrying out a verification of the departmental standards. This work at present is in progress.

Proposed Standards Laboratory.—The need for providing basic standards for New Zealand, particularly engineering and electrical standards, has been increasingly felt, and during the year a special committee was set up to consider this question. The personnel of this committee is as follows: Dr. C. C. Farr, F.R.S., Mr. A. Gibbs, Mr. P. R. Angus, Mr. F. T. M. Kissel, Mr. H. Vickerman, Dr. E. Marsden. The committee has recommended the establishment of a Dominion Laboratory for Physical Standards, and has drawn up detailed recommendations and estimates therefor. The New Zealand Manufacturers' Association, the New Zealand Society of Civil Engineers, and the Electric-supply Authority Engineers' Association have strongly supported these proposals; and it is felt that the establishment of a central standards laboratory should make for increased efficiency and economy in the various Government Departments which have to maintain substandards of various types, as well as supplying a public service which is urgently required by providing facilities for tests of manufactured products.

RADIO RESEARCH.

Advisory Committee: Professor P. W. Burbidge, Mr. J. M. Bingham, Mr. A. Gibbs, Dr. M. A. F. Barnett.

During the year a Radio Research Committee was set up with the object of co-ordinating and facilitating radio research work in New Zealand. Steps have been taken to arrange co-operation with the Radio Research Boards in England and in Australia.

Arrangements have been made with the New Zealand Association of Radio Transmitters for the collection of special data relating to the variation in the strength of signals from the Byrd Antarctic Expedition, and it is hoped that valuable information may be obtained in this way. In due course it is intended to initiate further work on the intensity of signals under various conditions.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

To enable the prosecution of various forms of agricultural research to be conducted at Lincoln College, an annual statutory grant of £3,700 is made to this institution. The work provided for by this grant embraces plant-breeding, potato-improvement, wheat-manuring, pig-feeding, farm economics, and sheep investigations. Detailed reports of the activities under these various sections are received at half-yearly intervals.

The plant-breeding work at the present time affects wheat, oats, cocksfoot, rye-grass, and red clover.

Wheat investigations are conducted in conjunction with the Wheat Research Institute. In connection with oats, a number of crosses—Algerian × Gartons and Algerians × Duns—have been carried on into the third year, while some thirty samples of oats derived from overseas have been tested. One strain of selected Algerians is now available for general distribution, and has shown an improved yield over the previous best strain issued.

Considerable work is being carried out on various strains of cocksfoot, and an area of about 1½ acres of the best strain so far isolated has been vegetatively established and will be used for securing further supplies of this strain. Trial plots of cocksfoot have been established over a wide area on

different soil-types and under different climatic conditions throughout the South Island. On these various selected cocksfoots are being grown in order to ascertain their adaptability to different environments. It is considered that by selection of cocksfoots suitable to any particular environment great improvement can be effected in the sheep-pastures of the Dominion.

Associated with cocksfoot is similar work dealing with rye-grass. Some five hundred strains have been under test at the College, and a similar number distributed throughout the best areas in the other provinces of the South Island. Very striking differences have been noticed in the resistance to drought and disease displayed by these strains of rye-grass.

One hundred and ten strains of red clover are now growing at the College, and are kept under special observation in regard to growth-form, proportion of leaf to stem, bulk of feed, depth of crown, date of flowering, and rapidity of recovery after feeding-off.

Pig-feeding trials have also been in progress during the year, particular attention being devoted to the value of whey-paste and meat-meals as pig-feeds.

The preparation of a sound system of farm accounts appropriate to Canterbury farming-conditions is also being dealt with.

Experiments are in progress concerning the yield of wool from sheep fed on definite diets. At the same time intensive grazing experiments have been carried out, and have shown that this system of utilization of farm pasture grass has great possibilities in the direction of increasing the carrying-capacity of grassland.

Special grants were made during the year to enable preliminary investigations to be commenced into pulpy-kidney disease of sheep in the Methven district. A good deal of valuable information as to its nature and incidence has been secured from the work done during the year.

In view of the hopeful preliminary results secured from intensive pasture-management trials on the experimental fields of the College, it was decided to enlarge the scope of this work consequent upon an offer being received from Canterbury stock and station agent firms of certain farms which would be placed entirely under the supervision of the College for a number of years in order that the results of these preliminary experiments might be tested out on a farm scale. A supervisor for this work has been appointed, whose duty it is to regularly visit these farms and give directions as to their management in accordance with the programme of intensive grazing, pasture-cultivation, and manuring.

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 achievements give promise of their being able to conduct useful research work in various industries. The awards made this year are as follows:—

Name.	Research to be undertaken.
L. H. Briggs, Hastings ..	"Constitution of Septospermol and Aromandrene, the Latter Compound also probably being a Constituent of Manuka-oil."
H. A. A. Aitken, Dunedin ..	"The Sulphur Content and Sulphur Compounds of New Zealand Pasture Grasses."
T. H. McCombs, Christchurch ..	"An Investigation into the Essential Oils of *Pinus insignis* and other Pines."
F. W. G. White, Wellington ..	"Preliminary Measurements of the Dispersion of Ultrasonic Waves in Air."

Mr. Briggs subsequently resigned his scholarship owing to his taking up another scholarship at Massey Agricultural College. The scholarship was accordingly transferred to Mr. G. A. Peddie for statistical investigations connected with the yield of dairy cows, yields of cheese, &c.

Mr. F. W. G. White, after carrying out a portion of his investigations, was awarded a University Travelling Scholarship. The scholarship accordingly has been transferred to Mr. J. W. Harding, who will continue the investigations commenced by Mr. White.

"JOURNAL OF SCIENCE AND TECHNOLOGY."

The *Journal* now acts as the official organ of the Department of Scientific and Industrial Research, and its pages are used for the publication of the results of various researches conducted throughout New Zealand. The *Journal* is also used to record scientific advances made overseas the results of which may be of importance to the Dominion.

PUBLICATIONS.

During the year the series of bulletins has been extended, six additional bulletins having been published, viz.:—

Bulletin No. 6: "Report of the Fischer Process," by Dr. H. O. Askew.
Bulletin No. 7: "New Zealand Wool-fibres," by E. F. Northcroft.
Bulletin No. 8: "Summary of Investigations of New Zealand Coal," by W. Donovan.
Bulletin No. 9: "The Relative Values of High and Low Testing Milk for Cheesemaking in New Zealand," by P. O. Veale.
Bulletin No. 10: "Low-temperature Carbonization of Blended New Zealand Coals," by W. G. Hughson.
Bulletin No. 11: "The Building-stones of New Zealand," by Dr. P. Marshall.
Bulletin No. 12: "Report on the Nutritive Values of Meat-meals," by Miss E. A. Pope.
Bulletin No. 13: "The Yield of Cheese per Pound of Butterfat," by P. O. Veale.

Further bulletins are now in the press and will be issued during the coming year.

REPORTS FROM BRANCH DEPARTMENTS.

DOMINION LABORATORY.

REPORT OF THE DIRECTOR.

THE work during the year has consisted almost entirely of chemical analyses and examinations carried out on behalf of Government Departments. The number of samples received from the various Departments was as follows: Customs, 461; Justice (Police), 42; Geological Survey, 147; Main Highways Board, 228; Mines (including prospectors' samples), 303; Post and Telegraph, 114; Health, 3,621; Public Works, 31; public bodies, 28; Railways, 79; Stores Control Board, 66; other Departments, 120; miscellaneous, 215: total, 5,455. Health includes—Milks of Wellington City supply, 1,716; milks from country districts, 870; human milks (Plunket Society), 308; soils and waters for goitre research, 231; foodstuffs, waters, &c., 496. Miscellaneous includes—Samples for leather research, 57; packing-industry research, 47; other, 111.

The total number of samples examined shows an increase of 369 compared with the previous year.

Customs.—The number of samples submitted by the Customs Department (461) was much greater than that for the previous year (334 samples). Most of these samples were examined in order to determine their classification for tariff purposes, but some to ascertain whether they complied with the regulations under the Sale of Food and Drugs Act. The latter included a number of flours which were examined for artificial bleaching. The result of this action has been that imported flour is now free from chemical bleaching.

Justice.—The Superintendent of Police submitted a much larger number of samples than in previous years. These comprised medicines, rat-poison, "Meta" fuel tablets, and exhibits relating to cases of suspected poisoning. The medicines consisted of acetylsalicylic acid, chloral, bromide, ergot, bismuth carbonate, and tincture of nux-vomica. Poisons found in the exhibits were strychnine, chloral hydrate, barium carbonate, potassium oxalate, oxalic acid, and powdered glass. In view of possible grave danger to children, the desirability of a clear indication as to the poisonous properties of "Meta" fuel tablets was brought under the notice of the Director-General of Health.

Geological Survey.—The samples submitted included clay, bentonite, diatomite, glauconitic shell-rock, graphite, gas-samples, incrusting salts, mineral waters, pumice, rocks for superior analyses, schist silt, sinter, water, and ores for gold and silver assay. The results of these investigations will be published in bulletins of the Geological Survey.

Main Highways Board.—The number of samples dealt with during the year shows a large increase over the previous year's figures. The use of hot trichlor-ethylene as a solvent to replace chloroform in the extraction of bituminous concretes has effected an economy in costs and time, while improved methods of solvent-recovery, storage, and circulation have also contributed to this end. The samples examined consisted chiefly of sheet asphalt, bitumen, bituminous concrete, bituminous emulsion "Distar" spray emulsion, road-oil and pumice, road asphaltic oil, pavement, tar, and Australian redistilled tar.

Mines.—The samples examined included coals, lignite, oil-shale, fireclay, clays, limestone, mica, antimony, copper and mercury ores, samples for tin, sand for rare earths, mine-airs, and numerous assays for gold, silver, and other metals.

Post and Telegraph Department.—The samples examined included alloy wire, aviation spirit, beeswax, bronze wire, carbon tetrachloride, resin-core solder, fire-extinguisher, gold wire, greases, green dye, jointer's metal, "Joy" cleanser, kerosene, scrap lead, lead sheathing for telephone-cables, lineman's solder, motor-spirits, oils, steel piping, rectified spirits, shellac, sealing-wax, soap, soldering-fluid, sulphuric acid, and zinc rods.

Health.—As in the previous years, a very great variety of substances, principally foodstuffs, were examined. They include air from bitumen plant, aspirin, butter, bacon, brandy, beer, ginger-beer, hop-beer, wholemeal bread, bath-enamel, brine and pickle from bacon-factory, cream, cheese, cocoa, corned beef and pork, deposit of scum on Petone Beach, smoked fish, gin, ice-cream, lemon-squash and orange-squash, metal lid for confectionery-container, mince-meat, nitrous oxide, oranges, peanut-cheese, pepper, pickled pork, rum, radox bath-salts, sausages, sugar of milk, schnapps, soap, soda-water, tin piping, water, whisky, &c.

The foodstuffs, on the whole, complied well with the regulations.

Of the butters, five samples contained excessive amounts of water, and two contained boric acid, which is now prohibited.

Of the beers, one contained an excessive amount of sodium chloride (common salt).

A large number of sausages, corned meats, &c., were examined for boric acid, in all cases with negative results.

Of the fifty-five ice-creams examined, five were deficient in milk-fat.

A considerable number of soda-waters were examined for traces of lead. It was found that in many cases lead was present. The makers were notified by the Department of Health, and took steps to ensure the purity of their products.

Several samples of imported sugar of milk were examined, as well as some of New Zealand manufacture. It was found that with the exception of one imported sample they were all of good quality and that the New Zealand product compared well with the imported sugar of milk.

A number of transparent toilet soaps were examined, and it was found that, with one exception, these soaps are low in actual soap content.

Of the liquors submitted, refilling was proved in five cases while three had been diluted with water.

Milk.—Wellington City: The number of milk samples taken in Wellington during the year was 1,716. Of these five were deficient in fat; six contained added water. Warnings were recommended in six cases slightly below standard, and in seventeen cases when the milk was not fresh. As in other recent years, the condition of Wellington's milk supply must be regarded as most satisfactory.

Country districts under control of Medical Officers of Health—Wellington, Gisborne, and New Plymouth: 870 milk-samples were examined; of these, nine were deficient in fat, eight contained added water and five were slightly below standard. As in the case of Wellington City, this discloses a very satisfactory condition of the milk-supplies of the above districts, and can be regarded as the result of efficient work on the part of the various inspectors.

Plunket Society: 308 samples of human and humanized milks were analysed for the Plunket nurses in the Wellington District.

Stores.—As in previous years a considerable number of analyses were made for the Post and Telegraph Stores, Public Works, Stores Control Board, and Railways Departments. This work consisted principally of examinations of stores in order to furnish data as a guide in the purchase of Government supplies. The samples examined included the following: For Stores Control Board—Fencing-wire, greases, "Joy" metal-cleanser, liquid soap, lubricating-oils, metal-polish, motor-oils, mineral turpentine, soap, and washing-powder. For Public Works Department—Concrete, electro-galvanizing iron, crude glycerine, Admiralty fuel oil, asbestos-covered flex, lubricating-oil, roofing-material, tiles and elbows, transformer-oil, and water. For Railways Department—Baking-powder, carbide of calcium, Krystol window-cleaner, coal, cocoa, coffee, soluble essences, jam, linseed-oil, lubricating-oil, mustard, ovoids, oranges, polish, and solder.

Other Departments.—Samples analysed for other Departments included, oil, sand, water, whey-paste, and wine, for the Department of Agriculture; fireworks, oil of citronella, and sulphuric acid, for the Explosives Branch; copra, for the External Affairs Department; cement, clay, feathers, graphite, syrup, and xylonite waste, for the Industries and Commerce Department; brass, preservo, and water, for the Defence Department; waters from Lake Taupo, for Internal Affairs Department (Fisheries); boiler-water, for the Marine Department; and water, wood, and wood-preservatives, for the State Forest Service.

Public Bodies (including Borough Councils, Harbour Boards, Hospital Boards, &c.).—Samples comprised: ashes, boiler-scale, water, effluents, debris and deposit from beach, lacquer.

Research.

The investigation of the incidence of goitre in relation to iodine content of soils and of waters has been completed, and the results are being published as a joint bulletin of the Departments of Health and of Scientific and Industrial Research.

In connection with fishery problems a general chemical survey was made of the waters of Lakes Taupo, Rotongaio and the principal streams entering the lakes. The results obtained are of considerable interest and practical value.

A considerable amount of investigational work was carried out for the Public Works Department in connection with the problem of finding a suitable lining material for the mineral-water baths at Rotorua.

An examination was made of waters and sediment from the Arapuni Dam for the Public Works Department.

In connection with a programme of bud-selection, &c., decided on by the Council of Scientific and Industrial Research, carefully selected samples of Australian, Californian, and New Zealand lemons were examined for comparative quantities of citric acid, peel, and woody matter, in order to determine the relative qualities of the lemons.

As a result of inquiries as to the utilization of mutton-bird feathers, some experimental work was carried out with a view to discovering methods of preventing the development of objectionable odours.

Research on New Zealand clays has been continued throughout the year, and special attention has been given to possible improvements in the manufacture of roofing-tiles.

For the State Forest Service an investigation was made into the efficiency of penetration of certain wood-preservatives.

As in other years, investigations into various cases of corrosion were carried out for Government Departments and local bodies.

The gold and silver content of a number of sinters from the thermal districts was carefully determined for the Geological Survey Department. This work involved extreme care and manipulative skill.

Abstracts of scientific papers and reports on chemical processes were prepared by various members of the staff as required.

Gas-control.

Regular tests of town gas for calorific value, purity, and pressure were carried out in Auckland, Wellington, Christchurch, and Dunedin.

Branch Laboratories.

Auckland.—The number of samples analysed for Government Departments was as follows: Health Department, 2,590; Justice (Police), 14; Post and Telegraph, 8; Collector of Customs, Apia, 3; Naval, 2; Public Works, 1; total, 2,618.

Health Department: Comparatively few food-samples were found not complying with the regulations. A number of samples of soda-water contained traces of lead due to lead piping, and even

where tin piping was used lead was found to come from the solder. Nine samples of the spirits were not true to label, and six contained added water, in one case to the extent of 40 per cent. Refilling was also found in seven samples of beer.

Sea-water: The results of a number of analyses of samples of water from various baths showed that in some cases considerable contamination of the water had taken place, especially in the salt-water tepid baths.

Milks: The number of samples taken was again slightly less than in the previous year. The results show no improvement on previous years, and indicate that a more thorough system of inspection is desirable. The chief deficiency is, as in previous years, the low fat content of milk supplied to Auckland City. Boric acid was found in several samples, and the addition was traced to one farmer.

Christchurch.—The number of samples analysed was—Milk, foodstuffs, drugs, &c., 1,891; water, 29; pathological and other exhibits, 25; miscellaneous, 22: total, 1,967. The miscellaneous samples were from the Customs, Post and Telegraph, Public Works, and Mental Hospitals Departments.

Board of Trade (Gas) Regulations: Under these regulations 144 tests of the Christchurch gas-supply were made. The Inspector of Gas-meters, who was appointed in July, 1928, examined 1,786 meters during 1928.

Dunedin.—The number of samples analysed was—Health Department, 1,369; Scientific and Industrial Research, 14; Agriculture, 7; Post and Telegraph, 23; Public Works, 8; Justice (Police), 7; Marine Fisheries Investigation Station, 71; Plunket Society, 28; University Medical School, 1; miscellaneous, 2: total, 1,530.

Milks: The number of samples taken was much more satisfactory than in the previous year, especially as regards those from Dunedin City, but could with advantage be considerably increased. The general standard of milk supplied shows a very decided improvement compared with that of last year. Three samples taken on two separate occasions from the same vendor in Invercargill contained formalin.

Health Department: Of the 1,006 milks examined, forty were deficient in fat, two were watered, and fifty-nine slightly below standard.

Five samples of brandy and four of whisky were not true to label.

Eleven samples of butter contained more than the maximum permitted amount of water, and four samples contained boric acid.

A certain brand of cod-liver oil tablets contained no cod-liver oil and no vitamin A.

The coffee and coffee and chicory essences examined contained only about one-fifth of the required amount of coffee.

Three samples of cream were deficient in fat, and one contained formalin.

Of the soda-water examined a very large proportion was contaminated with lead.

A number of analyses of whey and whey-products were made in connection with the experimental manufacture of whey-paste for pig-feeding.

Department of Agriculture: A cave deposit from Central Otago proved to be an exceptionally rich guano, containing nearly 25 per cent. of nitrogen and 4·5 per cent. of phosphoric anhydride.

Marine Fisheries Investigations Station: The salinity determinations instituted last year are being continued.

Gas-testing: Regular tests of calorific value, purity from sulphuretted hydrogen, and pressure were made on the gas supplied by the Dunedin City Corporation.

METEOROLOGICAL OFFICE.

REPORT BY THE DIRECTOR.

Forecasting.

Early in the year arrangements were made whereby additional weather reports were received from Australia. Many more reports are now being received also from ships at sea, the improved service provided by the Meteorological Office having made mariners much more willing to co-operate in this manner. Visits to vessels in port have stimulated interest in the work of the Branch, and the personal contact thus gained has been of great value. The additional information received has not only enabled the forecast to be improved on particular days, but permits of a much better understanding of the weather-changes of the region being gained. Forecasts, therefore, are based on a fuller knowledge of the meteorological processes involved.

During the latter part of 1928 the provision of additional funds for telegraphic purposes made it possible to issue much more complete reports and forecasts in the evening than had been possible previously. The evening report now includes a synopsis of the general situation and a forecast of conditions in the eastern Tasman Sea as well as those in New Zealand. A welcome addition, also, is that of reports of actual observations from sixteen well-distributed stations. Included in the latter are Norfolk Island, Chatham Island, Sydney, and Hobart. These reports would enable any one with an elementary knowledge of meteorology to draw weather charts, and an increasing number of ships' officers are doing so. For most people, however, the drawing of satisfactory charts will be a difficult matter until the publication of official ones in the daily press or elsewhere familiarizes them with the normal run of pressure-changes.

The whole of the evening report, which is based on 4 p.m. observations, is issued at about 7 p.m. by the Radio Broadcasting Co. from each of the four main centres, and in Morse by the Wellington Radio Station (ZLW) at 9 p.m. The forecast only is again transmitted from the broadcasting-stations at 9 p.m. There is no doubt that this evening report has been very much appreciated by the public, and especially by mariners and farmers.

During the harvest season in February an experiment was made, in co-operation with the Radio Broadcasting Co. of New Zealand, in the issue at midday of special forecasts for farmers in Canterbury. In these forecasts the general situation was described and the outlook given for as far as possible in advance. Numerous letters received from farmers showed that this service was appreciated.

Requests for special forecasts have been received in increasing numbers, particularly from farmers during shearing-time, who have desired warnings of heavy rain or cold snaps. Aviators, also, are making increasingly frequent applications for forecasts.

In connection with the first crossing of the Tasman Sea, numerous reports were interchanged between the two sides, the Commonwealth meteorological service and ourselves co-operating in the furnishing of information and advice to the aviators. Owing to unvoidable delays from bad weather, this interchange of reports had to be continued over a long interval, and a considerable responsibility was thrown on the meteorologists. The period proved to be the most stormy of the whole year, and the successful completion of the journey in both directions was a very notable triumph of modern airmen and aircraft over adverse weather conditions. Squadron-leader Kingsford Smith and Flight-Lieutenant Ulm made thoughtful expression of their appreciation of the assistance given.

Observing-stations.

New climatological stations have been established during the year at Rudstone (Methven), Cambridge, Alexandra, Manorburn Dam, and Golden Downs (Kohatu). Twelve additional rainfall stations have been established, while five have been discontinued for various reasons. In co-operation with the Cook Islands Department, instruments have been provided for a number of island stations in the Pacific.

The quality of the observations received from reporting stations still gives cause for concern. The proportion of observers, for instance, who send in barometer-readings which are frequently inaccurate is much larger than would be anticipated. There are many, also, who seem unable to maintain grass minimum thermometers in satisfactory order. The alcohol in the stems of these thermometers is liable to distil to the top of the tube or to develop bubbles, but such defects can in nearly every case be easily remedied if instructions be followed. The only way in which radical improvement can be produced is by frequent inspections. Numbers of observers have never seen a meteorological officer or had personal instruction. As much inspection as was possible with the available funds has been done, and somewhat more than half of the country has been covered. Experience has emphasized the need for these visits. Few stations are found where all work is being done under proper conditions. It is surprising how few people realize, for instance, that it is important to have a rain-gauge at the standard height of 1 ft. above ground and distant from surrounding objects.

Aviation Meteorology.

The progress in the direction of the provision of meteorological information for aviators has not been so great as anticipated. To a large extent this has been due to the failure of airships to make as rapid progress as their protagonists had expected. The trials of the large new British vessels will, however, soon have made it possible to decide whether rapid developments of airship services are to be expected or not. There can be little doubt that the inauguration of an overseas air service to New Zealand, whether by airships or aeroplanes, is a matter of a few years only. The amount of local flying in New Zealand also is rapidly increasing. It behoves us, therefore, to anticipate as far as possible the demand for increased meteorological information that will ensue.

The air-movements occurring in the upper layers of the atmosphere play an important part in the determination of extensive weather conditions. To attempt to forecast adequately surface weather the influence of these vast upper-air movements must be ascertained. These upper-air movements also have considerable bearing in the determination of aviation routes.

At the beginning of the year a commencement was made of the determination of winds in the upper air above Wellington by means of pilot balloons. Similar observations are being made also at Auckland by Mr. F. H. Sagar with the assistance of a grant from the Research Department and the co-operation of the Defence Department. Mr. Sagar's plan is to use his results as the basis of a thesis for the M.Sc. degree. The continuation of the upper-air work has been made possible by the attachment to the Meteorological Office for a year of Mr. Andrew Thomson, Director of the Observatory at Apia, Samoa. If the advance is to be maintained, it will be necessary to secure permanently the services of Mr. Thomson or an officer of the same standard of training.

It is hoped that more frequent observations of upper winds will be made shortly at the Christchurch Magnetic Observatory, and that closer co-operation between the two branches will be possible.

Tentative plans for a preliminary meteorological service in connection with civil aviation have been prepared, and developments in this direction are to be expected. As already indicated, the number of requests for special forecasts from pilots undertaking long flights has shown a considerable increase during the year. Some aviators, unfortunately, fail to make full use of the facilities provided by the Meteorological Office, and unnecessary risks are occasionally run.

Rainfall Data.

The withdrawal of temporary assistance early in the year necessitated the abandonment of the work on the preparation of a new rainfall map of New Zealand. The permanent appointment at the beginning of the current calendar year of Mr. R. G. Simmers, however, enabled the work to be taken up again, and it is now well advanced.

A commencement has been made with the tabulation of the records from the automatic rain-gauge at Kelburn.

A good deal of information regarding heavy rainfalls has been supplied to various engineering bodies, including the Public Works Department. The problem of flooding by rivers has become a serious one in a number of districts.

Miscellaneous.

Experiments in frost protection have been continued in Central Otago, and a number of orchardists have procured heating-apparatus. The meteorological station at Alexandra has been of use in connection with the experiments, and as records accumulate its usefulness should increase. A conference with the Orchard Instructor at Alexandra and representative growers was held early in November and various problems were discussed.

At the request of the Secretary, Department of Scientific and Industrial Research, the relation between wheat-yield at Lincoln College and meteorological factors was investigated during the latter portion of the year. The results are given in a paper which is being printed in the *Journal of Science and Technology*.

Teachers have asked repeatedly for typical weather charts and a simple description of forecasting methods in New Zealand. Since no popular or recent pamphlet on forecasting was available, an article, freely illustrated by charts, was prepared to meet the demand. This article was published by the Education Department in the *Education Gazette*, and has consequently been available to all teachers. Numerous reprints have been distributed also to those interested.

From the 6th to the 9th October, 1928, a remarkable quantity of dust from Australia was deposited over the Dominion, especially in Southland and the ranges of the South Island generally. In March, 1929, enormous areas of snow in the Southern Alps were still deeply discoloured by this deposit, which was of a terra-cotta hue. The latest information available would indicate that the total deposit on New Zealand could not weigh less than 200,000 tons. A paper describing the meteorological conditions leading to the transport of this dust has been published in the *Journal of Science and Technology*.

I have pleasure in acknowledging the loyal and cordial assistance of all members of my staff.

Short Summary of the Weather for 1928.

The year was, like its predecessor, remarkable for the comparative absence of westerly winds. The second most important characteristic, which was no doubt associated with the first, was the large number of depressions of cyclonic form which affected the New Zealand area. As a rule, the type of depression most frequently experienced is the southern type in which pressure falls continuously in the southward direction towards higher latitudes than those from which meteorological reports are available. The nature of this common type of depression is determined by the fact that the principal characteristic of the general circulation of the atmosphere in this part of the world is the prevalence of westerly winds and a decrease of pressure from low to high latitudes. These features being very poorly developed this year, the storms were able to form much more symmetrically, and the cyclone was of abnormal frequency. Cyclones cause strong east to north winds during their approach, and south-east to south as they move away eastwards. Owing to the preponderance of easterly winds, eastern districts get heavier rains from cyclones than do western districts, most of the floods in eastern districts arising in this way. The reverse is, of course, the case with the normal westerly depression. The heavy average falls on the west coast of the South Island and about Cape Egmont are due to the prevalence of westerly winds in normal years and the common type of depression.

For the greater part of the Dominion the rainfall for the year was above average. In the North Island there were large areas where the excess was more than 10 in. Deficits were recorded in some districts, of which the principal ones were in Taranaki and the Manawatu, Westland, and the eastern portions of South Canterbury, Otago, and Southland. The deficits were, however, seldom large. The latter part of the year was particularly wet.

There was abundant growth of feed in most districts, and, generally, conditions were favourable for a good yield from the soil. One region where the favourable characteristics of the season were particularly apparent was in the usually rather arid region in Central Otago. The growth of pasture was too rank in some localities to have the most nourishing qualities for stock. In consequence lambs failed to fatten well in those areas. The humid and warm conditions towards the end of the year, also, were favourable to fungus growths, and small crops, such as tomatoes, were affected to some extent in the Nelson and Wellington Districts.

Sunshine was rather below normal for the year in the eastern districts of the North Island and in Canterbury, but in western districts it was above normal. Nelson, with over 2,500 hours, registered the most.

The year was, on the whole, a warm one, the mean temperature being above the average for previous years in all provinces.

The first seven weeks were very dry indeed, and in many parts the driest January on record was experienced. Relief was brought to much of the country in the last week in February, but it was not until Easter-time that the droughty conditions ceased in Taranaki, western Wellington, and Nelson. Good rains followed, and, being accompanied mainly by mild conditions, they soon put the country in good heart generally.

June was a cold month, but July was remarkably mild and sunny. In the latter month there were heavy floods in the Waikato and Waihou Rivers.

Most of the Dominion recorded heavy rain in August. A southerly gale on the 5th August did damage on the east coast of the North Island. At Wellington the gale was assisted by a high tide, and the Petone railway was undermined by breaking seas.

From the 7th September to the 10th October westerly weather prevailed, and gales were of almost daily occurrence. It was owing to them that such long delays were caused in the trans-Tasman flights. These westerly gales, also, were responsible for the transport of dust from Australia. A small tornado passed over the northern portion of Hokitika on the 18th September, and another wrecked a number of buildings at St. Heliers Bay, Auckland, on the 25th. Thunderstorms were of frequent occurrence, and were particularly violent during the dust storms.

Following a wet October, November was dry and mainly cool. A remarkably fine and summery spell occurred, however, between the 16th and the 25th.

Rainfall was very heavy in December, some districts experiencing the wettest month of that name for many years. Temperatures were, on the whole, mild. A very severe hailstorm caused serious damage to fruit crops along a strip of territory extending from Eskdale, through Greenmeadows, to Pakowhai, in the Napier district.

GEOLOGICAL SURVEY OFFICE.

TWENTY-THIRD ANNUAL REPORT (NEW SERIES).

DIRECTOR'S REPORT.

Summary of Field Operations.

For the twelve months ended 31st May, 1929, topographical and geological surveys were carried out in the following areas:—

(1) Te Kuiti Subdivision, Auckland, by H. T. Ferrar, M.A., F.G.S., Senior Geologist, and N. H. Taylor, Assistant Geologist.
(2) Rotorua-Taupo Subdivision, Auckland, by L. I. Grange, M.Sc., A.O.S.M., F.G.S., Geologist and Vulcanologist.
(3) Tongariro Subdivision, Wellington, by L. I. Grange, M.Sc., A.O.S.M., F.G.S., Geologist and Vulcanologist, and J. A. Hurst, M.Sc., Assistant Geologist.
(4) Wairoa Subdivision, Gisborne, by M. Ongley, M.A., B.Sc., Geologist.
(5) Murchison Subdivision, Nelson, by H. E. Fyfe, B.Sc., A.O.S.M., Assistant Geologist.
(6) Maruia Subdivision, Nelson, by H. E. Fyfe, B.Sc., A.O.S.M., Assistant Geologist.

The Director (Dr. J. Henderson) made official visits to Mahakipawa and Paraparaumu; to the Tokaanu district; to the Big River Mine, Reefton; to the State coal-mines near Greymouth; to Rewanui, near Hokitika; and to Arthur's Pass. On several occasions dam-sites in the Hutt basin were inspected. Mr. Grange and Mr. Hurst spent a day or two in collecting samples from the strong fumaroles of White Island. Dr. Marwick, Palæontologist, visited Cheviot and Mount Somers, in Canterbury, and Takaka, the Sherry River, and Brightwater, in Nelson District, and obtained Tertiary fossils from all these localities.

Progress of Areal Survey.

During the 1928–29 field season approximately 1,790 square miles was geologically surveyed in detail. Of this area about 329 square miles are in the Te Kuiti district, 480 square miles in the Rotorua-Taupo and Tongariro subdivisions, 656 square miles in the Wairoa Subdivision, and 325 square miles in the Maruia subdivision.

At the end of May, 1929, 27,303 square miles of New Zealand had been geologically examined in detail.

Dargaville-Rodney Subdivision.

The numerous maps to accompany the Dargaville-Rodney Subdivision have been photo-lithographed and the colour stones prepared. Much of the manuscript is ready, and the bulletin should be issued in the coming year.

Rotorua-Taupo Subdivision.

Field-work in the Rotorua-Taupo Subdivision is finished, except for part of Waitahanui Survey District in the south-west corner of the district. Most of the maps are now drawn; the draft of the report was begun last winter, and will probably be ready or nearly ready, before the next field season.

Tongariro Subdivision.

Mr. Grange's summary report of his work in this subdivision, about half of which has now been examined in detail, is published on another page.

Te Kuiti Subdivision.

Good progress was made in the mapping of the Te Kuiti Subdivision, which consists of fairly easy pastoral country, for the most part occupied. Mr. Ferrar's account of the geology appears on another page of this report.

Wairoa Subdivision.

The area Mr. Ongley examined during the last field season has a geological structure and stratigraphical succession similar to that of the Wairoa Subdivision, and to avoid much repetition the boundaries of this subdivision are extended to include the upper Wairoa basin and the headwaters of some adjacent streams.

Motueka Subdivision.

The map-drawings of the Motueka Subdivision are now ready for the printer, the manuscript is well forward, and the report should be in the press some time in 1930.

Murchison Subdivision.

Field-work was completed in the Murchison Subdivision in the season just ended, and Mr. Fyfe will continue the preparation of the manuscript during the winter.

Maruia Subdivision.

The season was favourable for field-work, and more than half the Maruia Subdivision was examined in detail. The report covering the work done and a preliminary account of the geology of the district is published on a later page.

St. Bathan's Subdivision.

The preparation of the manuscripts of the reports on the soils of Otago Central and on the Dargaville-Rodney Subdivision fully occupied Mr. Ferrar last winter, but he may be able to begin drafting the above bulletin before the next field season.

Kaitangata-Milton Subdivision.

The maps of the Kaitangata-Milton Subdivision require a final revision before they are ready for the printer; Mr. Ongley will probably finish writing his report this year.

The Soils of the Irrigation Areas in Otago Central.

The final proofs of this report were returned to the printer in April; the proofs of the numerous maps have all been received, corrected, and coloured; and the report will probably be issued before 1930.

Palæontological Work.

Till November Dr. Marwick acted as *locum tenens* at Victoria College for Professor Cotton. For the rest of the year he worked chiefly on the Tertiary Mollusca. It had been hoped that the results of this work would have been ready for publication ere this. But some of the material on close examination was found to have unexpectedly rich undescribed faunas; all required much preparation; new collections have been received; and the report, the manuscript of which is now well forward, will be much longer than first anticipated.

Mr. R. A. Keble, of Melbourne, and Professor W. N. Benson, of Dunedin, examined the collections of graptolites the Geological Survey made a few seasons ago in the Mount Arthur district, and have described them in a paper recently published in volume 59 of the "Transactions of the New Zealand Institute."

Some years ago Mr. R. S. Allan, a 1851 Exhibition Scholar, took collections of Palæozoic fossils from the Baton River and Reefton districts to England. Professor O. T. Jones, of Manchester, has consented to describe the Baton River fauna, which, as is well known, is of Silurian age. Mr. Allan himself undertook the description of the Reefton fossils, which he finds belong to the Devonian. His account of the fauna and the plates he has had prepared should shortly be available for publication.

Publications.

The following official publications were issued in the year ending 31st May, 1929.

"Twenty-second Annual Report (New Series) of the Geological Survey" (parliamentary paper H.–34, 1928).

Geological Survey Bulletin No. 30: "The Geology of the Waiapu Subdivision, Raukumara Division," by M. Ongley and E. O. Macpherson.

Papers by J. Henderson (Pupu Springs, Takaka), H. T. Ferrar (Classification of New Zealand Soils), and L. I. Grange (Eruption of Ngauruhoe, March, 1928) appeared in volume 10 of the *New Zealand Journal of Science and Technology*, and by H. T. Ferrar (Pleistocene Glaciation of Central Otago) and J. Marwick (Tertiary Molluscan Fauna of Chatton, Southland) in volume 59 of the "Transactions of the New Zealand Institute." In addition, several members of the staff read papers at the New Zealand Institute Science Congress held at Auckland in January, 1929. These will shortly be published.

Office-work.

A large amount of correspondence has been attended to, many requests for information more or less connected with the work of the Geological Survey have been answered, and samples of rock, minerals, and ores have been examined and identified. A good deal of time was taken up in seeing through the press the publications issued or about to be issued and in editing the reports of the different officers.

During the year Mr. G. E. Harris drew for photo-lithographic reproductions sixteen maps to accompany the Kaitangata-Milton and Rotorua-Taupo Subdivisions. He also prepared nine block drawings, twenty-eight field sheets, and a number of tracings. Other draughtsmen prepared in the office, under Mr. Ferrar's supervision, the sixteen soil maps to be published with the report on the soils of irrigation areas in Otago Central.

Many publications were received in exchange for Geological Survey bulletins, and a number of books, relating chiefly to economic and structural geology and palæontology, were purchased. The library now contains about 7,000 volumes and many pamphlets, and is invaluable to the members of the staff for reference purposes.

SPECIAL REPORTS.

1. TE KUITI SUBDIVISION.

(By H. T. Ferrar and N. H. Taylor.)

Introduction.

Te Kuiti Subdivision lies mainly in Pirongia Division, on the west side of the North Island, and includes also a small unsurveyed part of Taranaki. Its northern boundary coincides with the southern boundary of the already-surveyed Huntly-Kawhia Subdivision (N.Z. Geological Survey Bulletin No. 28), and on the south it connects with the surveyed portions of Taranaki along the northern boundaries of the Mokau Subdivision (Bulletin No. 24) and the Tongaporutu-Ohura Subdivision (Bulletin No. 31): on the east it adjoins the partly surveyed Rotorua Division and extends west to the Tasman Sea. As at present defined, it includes the following survey districts: Marakopa, Kawhia South, Orahiri, Mangaorongo, Whareorino, Maungamangero, Otanake, Pakaumanu, Pahi, Mapara, and the greater part of Totoro.

Work was begun at Te Kuiti on the 1st November, 1928, and, after being carried southward to Mapiu and westward to Aria, was suspended at Waitanguru on the 27th May, 1929. During this period an area of 329 square miles in Otanake, Maungamangero, Mapara, and Totoro survey districts was surveyed in detail.

Structure and Physiography.

The district examined is part of a broad plateau standing between the Rangitoto Range on the east and the Herangi-Pomarangei Range on the west. The plateau is in reality a shallow graben, or downwarped area, between two higher uplifted earth-blocks, with a subsidiary uplifted block, the Mairoa Hills, near the middle. Faults striking a little east of north form the boundaries of these earth-blocks and allow tilting, but usually their throw is not great. Faults striking east and east-north-east also dislocate the rocks.

The plateau is part of a peneplain portions of which survive at heights of about 1,000 ft. above sea-level. Being deeply dissected, the streams that drain it flow in narrow valleys, 400 ft. to 500 ft. deep, around and between flat-topped hills. No high hills interrupt the accordant summit-levels of the plateau, although the deeply eroded valleys, by making the minor topographical features prominent, reduce the area of "easy" farming-land.

The drainage of the district is by way of several tributaries of the Waipa River, flowing northward, and by certain reaches and tributaries of the Mokau River flowing westward and southward.

The Mairoa Hills, 1,000 ft. to 1,500 ft. high, near the middle of the district form a water-parting of low relief that separates the headwaters of the Marakopa River from these two drainage-basins. Where massive limestone covers the countryside the drainage is largely subterranean, and apparently independent of surface topography. Under these conditions caves and grottos are numerous and sinkholes abound.

General Geology.

Early geological exploration in the newly mapped area was done by F. von Hochstetter, who crossed the district in 1859. Recently J. Henderson and M. Ongley worked in the district during the years 1917 and 1918, and their report (Bulletin No. 24), together with that of L. I. Grange on portions of northern Taranaki (Bulletin No. 31), forms the foundation upon which the present survey is being built. The following table of strata is tentative and will be expanded as the work proceeds:—

Local Name.	Content and Local Thickness.	Approximate Age.
Mamaku beds	Alluvium, pumice silts, andesitic ash, rhyolitic ash, dune-sands, river-gravels	Recent and Pliocene.
	Rhyolitic tuffs, massive, subaqueous above, subaerial below; 100 ft. to 300 ft.	Pliocene.
	(Unconformity.)	
Tongaporutu beds ..	Yellow mudstone; 100 ft.	Upper Miocene.
Mohakatino beds ..	Soft grey claystones; 150 ft.	..
Mokau beds	Massive sandstone with shelly conglomerates and coal-seams; 500 ft.	Lower Miocene.
Mahoenui beds ..	Claystones and sandy limestones; 500 ft.	..
Te Kuiti beds	Massive limestones, incoherent sands, conglomerates in places, thin coal-seams; 250 ft.	..
	(Local Unconformity.)	
Whaingaroa beds ..	Argillaceous and glauconitic sandstones, coal; 250 ft. ..	Oligocene.
	(Great Unconformity.)	
Mangaotaki beds ..	Massive sandstone and conglomerate, plant-beds, dark-gray shales, and mudstones; 10,000 ft.	Jurassic.
Mairoa beds	Argillites (fossiliferous) and shattered greywacke; 10,000 ft. or more	Triassic.

The Mairoa greywackes and argillites crop out in the Mangaokewa Stream near Te Kuiti form the Mairoa Hills, and probably underlie the whole district at no great depth. They stand nearly vertical or dip to the west at high angles, and strike generally north by east. The abundant casts of *Pseudomonotis richmondiana* in places show that these beds are a continuation of the Triassic sediments of the Huntly-Kawhia Subdivision.

The Mangaotaki mudstones, shales, and sandstones underlie Tertiary beds to the west of the Mairoa Hills and cover large areas to the west of Mangaotaki Stream. In general, these beds dip west on the east side of the Mangaotaki and to the east westward of that stream. The mudstones and shales contain very numerous casts of *Inoceramus haasti* and other fossils described by C. T. Trechmann, but only a few were found in the overlying massive sandstones. These beds are, therefore, a continuation of the Jurassic deposits exposed on the south side of Kawhia Harbour.

A great unconformity separates the above Mesozoic strata from a series of Tertiary sandstones, limestones, and mudstones. The serpentine boss on the Kohua Road, in Totoro Survey District, probably belongs here, and probably is of Eocene age and coeval with the serpentines of North Auckland. The lowest Tertiary bed, a fissile glauconitic sandstone, correlated with the Whaingaroa clay of the Kawhia district, is absent from the eastern portions of the area, but appears from beneath the overlying Te Kuiti limestone on the flanks of the Mairoa Hills. Conglomerates and thin coal-seams in places form the basal beds of the well-known Te Kuiti limestone, that covers great areas. The Mahoenui claystones and sandy limestones succeed the Te Kuiti limestone, usually in conformable succession, although in places conglomerates indicate unconformity. The southern part of the district is covered by thick beds of massive Mokau sandstone that give rise to characteristic flat-topped hills with cliffs bare of vegetation; Mohakatino and Tongaporutu claystones appear only on the southern edge of the district.

Rhyolitic tuffs, partly subaerial and partly water-sorted, were deposited upon an eroded surface in Pliocene times. These tuffs are contemporaneous with those at Mamaku, in Rotorua district, and once completely covered the whole district. Subsequently they were indurated and eroded, and now form flat caps to many isolated hills. Of Plistocene and Recent sediments that enshroud older rocks, a deposit of brown andesitic ash is of importance, since it forms the soil over many square miles.

Economic Geology.

A geological survey, by taking stock of economic resources of a district, drawns attention to the presence or absence of mineral substances of intrinsic value, and incidently tends to counteract land speculation. Minerals of high market value are almost absent from the district examined, and the greatest natural resource is the soil.

When first opened for settlement the district was renowned for its productivity, but by degrees the price of land reached a figure above its present market value, and many farms, overburdened with debt, have been abandoned. The nature of the soil is said to be responsible for this. Great areas are covered by a brown sandy loam derived from an andesitic ash that almost smothers the underlying rocks. Stock do not thrive on considerable areas, and a deficiency of calcium is said to be the cause of their debility. Since adjacent farms, one of which is reputed to be unhealthy and the others healthy, are covered by the same soil, the lithological survey becomes a preliminary measure that must preceed a more intensive investigation of the affected areas. In this connection the writers of this report wish to acknowledge the kindly co-operation of Mr. C. M. Wright, Country Chemist, New Zealand Department of Agriculture. In places where the andesitic ash has been removed by erosion or turned under by natural slumping, the underlying rocks give rise to somewhat better soils. Such variations as these will not be discussed here.

Vast quantities of hard though high-grade limestone occur in the district. This rock is pulverized at Te Kuiti and, together with phosphatic and other fertilizing mixtures, is transported by motor-lorries into the backblocks, but high costs prevent many farmers using adequate quantities. In places the rock is comparatively soft, but the amount of soft material cannot be gauged until trial quarries are opened.

Coal occurs in small lenses and in seams in many far-separated localities, several of which were examined by J. Henderson in 1917. These outcrops, being at several horizons in the Tertiary beds, indicate that there is small probability of a workable field existing.

Roadmaking-materials of differing quality are fairly well distributed over the district, and most of the roads are macadamized. Mairoa greywacke (both quarried and as natural river-shingle), Mangaotaki claystones and conglomerate, Te Kuiti limestone, Mamaku rhyolitic tuff and pumice silts are used in making up and surfacing roads. Greater lengths of road are surfaced with limestone than with any of the other rocks. The rhyolitic tuff is easily quarried, and, as it hardens on exposure, it also provides an important reserve of good building-stone.

The absence of mineralized veins indicates that reports as to the presence of precious metals have little import when contrasted with the great agricultural resources of the district.

2. WAIROA SUBDIVISION.

(By M. Ongley.)

Each season since November, 1926, a geological survey party has been examining the Wairoa Subdivision—that is, the country to the east of the Huiarau Range between Poverty Bay and Hawke Bay. In the 1926–27 season 200 square miles, in 1927–28 600 square miles, and in 1928–29 season 650 square miles were traversed, examined, and mapped. Two more survey districts—namely, Moanui and Motu—remain to be examined in order to complete the survey of the subdivision.

General Geology.

The formations identified in the 1927–28 season (see last year's annual report) were followed and mapped in the new districts examined during the season that has just passed. An erosion interval was found dividing into upper and lower sets the beds formerly included in the Mapiri Series. The contact between the two sets of beds can be examined at three places in Hangaroa Survey District —on the road below Te Ratetahi peak, in the Hangaroa Valley two miles to the south-east of the peak, and at a spot two and a half miles farther west on the Hangaroa Road. The two sets of beds have the same attitude at these three places. The under-bed is dense fine dark mudstone. Upon it lies fine conglomerate a foot thick, containing well-rounded pebbles of mudstone (most of them about $\frac{1}{4}$ in. through, but a few are 2 in. in diameter), broken shells, pumice-flakes, shark-teeth, and coarse crystal tuff-fragments. Above the conglomerate lies coarse tuff and pebbly shell-rock in beds 5 ft. and 6 ft. thick respectively.

In the north-west and west of the subdivision rocks older than any seen in the two previous seasons are exposed. On lithology they are correlated with the Raukumara and Taitai Series of the Waiapu Subdivision, as described in N.Z. Geological Survey Bulletin No. 30. In the rocks in the south-east of Moanui Survey District that are correlated with the unfossiliferous Taitai Series of Waiapu on strong lithologic evidence (the peculiar igneous conglomerate and massive sandstone at the two places being indistinguishable) fossils were found. Among them Dr. J. Marwick recognized *Aucella spitiensis* Holdhaus, a characteristic Jurassic species. As the Waiapu equivalent of these fossiliferous Jurassic Taitai strata overlie the Tapuwaeroa and Raukumara Series, that both contain upper Cretaceous fossils, is strong evidence that the Taitai conglomerate has been thrust over them, as suggested by C. W. Washburne in 1926. The difference of opinion with regard to this conception is set out at length on pages 28, 54, and 55 in N.Z. Geological Survey Bulletin No. 30. The recognition of the existence of overthrust gives a new outlook with regard to our views on the structure of New Zealand.

In the west of Ngatapa Survey District and over much of Koranga Survey District Upper Cretaceous (Mangatu) mudstones crop out, and, as elsewhere in the East Coast districts, they generally smell faintly petroliferous and yield hydrocarbon gases at points situated along faults. In Koranga Survey District these mudstones are less disturbed than in any other places so far examined, and provide more favourable oil-drilling sites than are known elsewhere in areas covered by Cretaceous beds.

Structure.

Over a large part of the area Tertiary beds have a regional strike to the north-east, and dip to the south-east at low angles, generally less than 30°, but in places where they strike more to the north or more to the east the dip is correspondingly more nearly east or south. The differing attitudes of the beds indicate a large dome-structure in the north-west quadrant of Koranga Survey District, with the Tertiary beds dipping off it round its south-eastern slopes. This regional structural uniformity is interrupted in several places by reversed dips. Every reversal of dip is worth investigation.

In previous annual reports a few main "structures" were mentioned—namely, the Morere anticline, Moumoukai syncline, Mangapahi anticline, Wairoa syncline, and another unnamed anticline west of the last. During the past season the Wairoa syncline was followed northward, and the covering limestones were traced across its narrowing and rising end in Hangaroa Survey District. The anticline west of it—namely, Hangaroa anticline—was followed north through the west of Hangaroa Survey District and eastward across its northern boundary into Patutahi Survey District, where the anticline grades into the fault that runs up the Mangawehi Valley and through Gentle Annie Hill. Another Tertiary anticline crosses the south-east of Koranga Survey District into Ngatapa, the next survey district to the east.

The Upper Cretaceous beds form strong monoclines dipping 20° westward in the north-east of Koranga Survey District, and south-west in Ngatapa Survey District. In the north-west of Koranga Survey District the complex structure of the Taitai overthrust mass has not yet been worked out, but further work will be done there and also in Moanui and Motu Survey Districts next season.

Economic.

The Taranaki Oil Fields Ltd., is drilling a trial borehole in the Morere and also in the Mangapahi anticline.

3. TONGARIRO SUBDIVISION.

(By L. I. Grange and J. A. Hurst.)

Introduction.

The geological and volcanological survey of the active volcanic belt of the North Island of New Zealand as outlined in previous reports was extended from Lake Taupo to the western slopes of Tongariro, Ngauruhoe, and Ruapehu. The field season lasted from the 1st November, 1928, to the 28th May, 1929. During the early part of the season the Ohaki and Reporoa districts, north of Lake Taupo, were mapped, the remainder of the season being devoted to areas south of the lake. A great deal of topographical work was done on the volcanic mountains, the maps in existence displaying little accurate work other than the trig. stations. Altogether an area of 480 square miles was surveyed in detail.

The senior writer hastily examined the Kaingaroa Plains between the Waiotapu–Murapara and Taupo–Napier roads to ascertain whether water could be obtained on them.

The rocks outcropping are almost solely volcanic, though in a few places sandstones of Lower Miocene age are exposed. While in the Rotorua–Taupo Subdivision the most abundant rocks are rhyolites, in the Tongariro Subdivision they are mainly andesitic flows, scoria, and conglomerates. White pumice blown from a vent in Lake Taupo is a widespread surface deposit, usually only a few feet thick.

Topography.

The volcanic mountains, which are the most conspicuous features of the district, rise from a plateau 2,300 ft. to 3,000 ft. above sea-level. The main peaks are Ruapehu, Ngauruhoe, and Tongariro, and they lie on a line trending north-north-east. Ruapehu (9,175 ft.), at the extreme southern end of the volcanic belt, is a shapely cone with an oval unevenly flat summit about one mile and a half in diameter. Tongariro (6,458 ft.), eleven miles to the north and separated from Ruapehu by a saddle 4,200 ft. high, is a truncated cone nine miles long and five miles wide at its base, and about five miles long and two miles wide on top. The summit is very irregular, for there are many peaks on it more than 5,000 ft. above sea-level. Ngauruhoe (7,515 ft.), a symmetrical volcanic cone, rises from the southern portion of the truncated top of Tongariro. Ngauruhoe is still active; a column of steam can usually be seen rising from its crater, and occasionally rock-fragments are blown into the air.

The extinct volcanoes Pihanga (4,352 ft.), Tihia (3,824 ft.), and Kakaramea (4,269 ft.), aligned in a north-east to south-west direction, occupy the north-eastern corner of the subdivision. Their northern slopes end near Tokaanu, on the southern shore of Lake Taupo (1,200 ft.).

The plateau on which all these volcanoes stand declines gently outwards from a height of 3,000 ft. to a height of 2,300 ft. on the western boundary of the area, where it merges into the well-dissected Wanganui peneplain. On the mountains the stream-valleys are shallow, but at a distance of seven miles from them they all flow in narrow precipitous gorges as much as 200 ft. deep.

The largest lake in the subdivision is Roto Aira (maximum depth, 45 ft.). It is nearly four miles long, and occupies a portion of a long depressed area between Tongariro and Pihanga. Small lakes occur in the craters of Ruapehu and Tongariro and in the saddle between.

General Geology.

The table below shows the sequence in downward order and the approximate age of the rocks encountered:—

1. Andesite ash and scoria from Ngauruhoe, &c. (Recent.).
2. White rhyolite pumice from the Taupo vent (Recent).
3. Dark andesite flows, scoria, and ash, from Ruapehu, Tongariro, and Ngauruhoe; olivine basalt from Pukeonake (Pleistocene and Recent).
4. Grey andesite flows, agglomerates from vents beneath Ruapehu and Tongariro, andesite from Kakaramea and Pihanga (Pleistocene).

(Unconformity.)

5. Sandstones of the Mokau Series (Lower Miocene).

The Tertiary sandstones with their thin bands of greywacke conglomerate are the oldest rocks, and only outcrop in the gorges of the deeply entrenched streams that cross the plateau. The beds wherever observed have an extremely low dip, amounting to not more than 2°. Dr. Marwick states that fossils gathered from the Whakapapa Stream belong to the coal-bearing Mokau Series (Lower Miocene) of Bulletin No. 24. A strong fault between National Park and Raurimu Railway-stations with downthrow to the east and strike north and south brings them against the Mohoenui Series.

Following a period of faulting and erosion in Pleistocene times, volcanic eruptions commenced and still continue. Ruapehu and Tongariro, more particularly the latter, have complex histories. "Ancient Ruapehu" was built up of grey andesites probably to a height a little greater than it is to-day. Its top down to about the 7,000 ft. level was removed by collapse or by explosions, but later lava-flows have almost restored the mountain to its former shape and size. Three grey andesite ridges extend up to about the 7,000 ft. level, the most prominent being that on which are situated the needle-like rocks called the Pinnacles. The latest lava-flows from Ruapehu, extending far down the valleys, are dark-coloured and have a rough surface similar to the "*aa*" of Hawaii.

Conical hills of all sizes up to 30 ft. in height are numerous on the north-western slopes of Ruapehu. They occur at a height of 4,000 ft. and form a belt two miles wide that extends down the slope a distance of five miles to the 2,300 ft. level. Two at least are single blocks of agglomerate. They are not underlain immediately by lava-flows, and thus cannot be blisters on a lava-stream as stated by Hill.* Park† considers the hills are of glacial origin, but the writers think they are part of a mud-flow that came from the crater of Ruapehu.

"Ancient Tongariro" was an elongated mountain of grey andesite with several craters, the rims of which were perhaps a few thousand feet above the present highest peaks. The mountain was subsequently broken up by collapse and by explosions on a grand scale, and altogether about nine new craters were formed, the bigger ones being located on its southern half. Shortly afterwards floods of lava issued from North Crater, and ran down into Lake Roto Aira. Near the close of activity from this centre the lava rose in a crater some 55 chains in diameter, bounded on the south and north sides by steep walls up to 180 ft. high. This gentle outwelling of lava was succeeded by explosive eruptions which built scoria cones, much the largest being Ngauruhoe, that rises 2,100 ft. above an old crater near the southern end of Tongariro. Other scoria cones on Tongariro are Red Crater and Te Mari, in

* H. Hill: Trans. N.Z. Inst., vol. 37, p. 457; 1905.
† James Park: Trans. N.Z. Inst., vol. 42, p. 580; 1909.

line with Ngauruhoe. Flows of dark andesite from Ngauruhoe cover the upper portions of collapsed areas on either side of Pukekaikiore Hill, a remnant of ancient Tongariro. The latest of these outpourings (most likely one that took place at the time of the 1869 eruption) descended to the bottom of the steep slopes of the cone. The others are much older, for they are covered by the Taupo shower of pumice. The flows and fragmental ejects of the volcanoes already dealt with are all hypersthene augite andesites, except a flow of hornblende andesite in the wall of Tama Crater. The Tama Lakes, near the saddle between Tongariro and Ruapehu, lie in explosion craters that, in addition to the country rock, erupted angular fragments of dense black basic augite andesite not unlike Tarawera lapilli.

Overlying grey-andesite conglomerate and forming the surface flow on the plateau west of Pukekaikiore Hill is an extensive sheet of vesicular olivine basalt with clear bright-green olivine crystals up to ¼ in. in length. Pukeonake is an olivine basalt scoria cone, 4,018 ft. high, on the eastern margin of the sheet. A viscous flow of dark olivine basalt poured out of a fissure on Pukekaikiore and ran several chains down the side of the hill.

Kakaramea and Tihia are really one complex volcano of hypersthene augite andesite, which, like its neighbours to the south, has suffered collapse. This has taken place along a fault trending east-north-east which crosses the mountain within a few yards of the highest peak of Kakaramea. The Tihia peaks are about 400 ft. lower than those on Kakaramea. Pihanga, a conical-shaped mountain without a crater, is composed of andesite with big augite crystals but no hypersthene.

One isolated mass of flow rhyolite, a pumiceous hornblende-biotite rhyolite similar to that of Haparangi Dome near Rotorua, was found on a low peninsula on the western side of Lake Roto Aira.

The ash and lapilli showers that follow the present contour of the land are well exposed in road-cuttings. A typical cutting on the Tokaanu–Waiouru Road shows, in downward order,—

White rhyolite pumice from Taupo (much dark vegetal refuse in top 6 in.), 4 ft.
Thinly bedded dark-grey andesite ash containing leaves, 1 ft. 6 in.
Fine brown andesite ash, 3 ft. 6 in.
Layer of andesite lapilli, 1 ft. 6 in.

The leaf-bearing ash, probably from a violent eruption of Ngauruhoe, is thinner on the western side of Tongariro than on the eastern. The andesite ash, 3 ft. 6 in., and lapilli, 1 ft. 6 in., at the bottom of the section most likely came from Tama craters.

Fumaroles and Hot Springs.

In the area here described hot springs are far less common than in the Rotorua district; fumaroles are, however, more plentiful. Thermal activity occurs at Ketetahi, Tokaanu, and in the craters of Ngauruhoe, Tongariro, and Ruapehu. Near Tokaanu Township there are a number of hot and boiling alkaline pools, some of which have a salty taste. Taumatapuhipuhi Geyser plays regularly to a height of about 20 ft. at intervals varying between twelve and fifteen minutes. Actually three "shots" take place in quick succession, followed by intervals of twelve minutes to fifteen minutes. The total overflow of water from the three "shots" on the occasion it was measured was 65 gallons. The geyser-pipe is about 2 ft. wide at the top, but at a depth of 4 ft. 6 in. it narrows to a few inches. The springs of Waihi, situated farther to the west along the shore of Lake Taupo from Tokaanu, lie on the fault already mentioned that crosses Kakaramea. The gases from the three main fumaroles issue at a little above atmospheric pressure, and much gas rises from the muddy acid pools in the vicinity.

The active subcrator of Ngauruhoe was filled with molten lava when seen in March, 1928; but in March and May of this year no lava was in sight, and the funnel-shaped crater was dotted with fumaroles depositing sulphur, which in some cases was liquid. White aluminium sulphate and yellow ferrous sulphate are deposited abundantly. A few had their vents coated with white salts, and these probably had a temperature above the melting-point of sulphur. Small weak fumaroles were found high up in Red Crater. Te Mari, last seen in active eruption in 1896, has not yet been visited.

The water in one of the craters on Ruapehu is warm. A white deposit, 1 in. thick, of thermally altered rock coating the higher slopes of Ruapehu was ejected from the volcano shortly before the arrival of European settlers.

At Ketetahi, on the northern slopes of Tongariro, the fumaroles and small hot springs occur together in a depression about 12 chains square. The main fumarole, which is on the eastern edge, issues at atmospheric pressure from a wide vent. Three fumeroles in the middle of the depression emit steam at slightly higher pressure, and about equal to that of Karapiti near Wairakei. Two of these emit a spray of water in addition to steam. Probably they all contain a low percentage of gases other than steam, although such noticeable gases as sulphur dioxide and sulphuretted hydrogen were not detected in the field.

Economic.

Soil.—Except on steep slopes, the soil is derived from the Taupo rhyolite pumice, which is the parent material of the soils over many square miles of country. From Lake Taupo, extending northward to within a few miles of Rotorua and eastward to Te Pohue near Napier, Taupo pumice predominates. On the plateau close to the mountains there is probably a dusting of andesite ash from Ngauruhoe on the pumice. Among the successful farms on the pumice land are the Hautu and Rangipo penal settlements. On the steep slopes—*e.g.*, south-west of Waihi and west of the Wanganui River, north of the Waimarino-Tokaanu Road—the reddish-brown fine-textured soils are derived from andesite ash that antedates the pumice shower.

Sulphur.—The main accumulations of sulphur occur at Ketetahi, where there are two shallow basins containing not more than a few hundred tons.

Diatomaceous Earth.—Although no noteworthy deposits of diatomaceous earth have been found in the Tongariro Subdivision, other outcrops in addition to those already listed* have been found in

* 22nd Annual Report, N.Z. Geological Survey, p. 11; 1928.

the Rotorua–Taupo Subdivision. Five new cuttings for the proposed Rotorua–Taupo Railway (between five and six miles south of Rotorua) expose beds of high-grade material, with a maximum thickness of 10 ft. These should be of economic value in the future.

Tongariro National Park.—The National Park is becoming increasingly popular as a tourist resort. The topographic maps and volcanological data, when published, should prove useful and instructive.

4. MARUIA SUBDIVISION.

(By H. E. Fyfe.)

The Maruia Subdivision lies in the southern part of Nelson Province, and includes the survey districts of Burnett, Matakitaki, Rahu, Una, Lewis, and Travers, comprising in all an area of about 650 square miles. The Murchison Subdivision adjoins it on the north and the Reefton Subdivision (see N.Z. Geological Survey Bulletin No. 18) adjoins it on the west. Field-work was commenced towards the end of November, 1928, and continued to the end of May, 1929; during which time some 325 square miles of the Burnett, Matakitaki, Rahu, and Una districts were surveyed in detail.

Physiography.

Three meridionally-trending mountain-ranges and their intermontane valleys occupy the greater portion of the area so far examined. The easternmost is the Nardoo Range, that commences as bush-clad highlands south of the Matakitaki River, near Hunters' Station. Southwards the range soon rises above the bush-line (about 4,200 ft.), and increases in height to about 6,000 ft. at its junction with the Spenser Mountains. This range forms the western watershed of the upper Matakitaki, and the eastern watershed of both Station Creek and the headwaters of Glenroy River.

The Mount Cann Range occupies a central position in the area, and forms the western watershed of the Glenroy south of the Granity Creek junction, and a part of the eastern watershed of Maruia River. The Mount Baldy highland, separated from the Nardoo Range by a south-westerly extension of the well-known Wairau fault, is the structural continuation northward of the Mount Cann Range.

The westernmost mountains are the Victoria Range, that forms the western watershed of Maruia River. It is an exceedingly rugged range, averaging about 5,000 ft. in height. Two isolated mountain-masses, culminating in Mount Mantell and Mount Rutland, are separated from the Victoria Range to the west by the Maruia Gorge, and form Mount Cann Range by the southern extension of the Murchison depression, that southward forms the graben called the Upper Maruia Plains.

Three main drainage-channels traverse the area, and all lead northward throughout the greater part of their courses. From east to west they are the Matakitaki, the Glenroy (a tributary of the Matakitaki), and the Maruia.

The highlands and the headwaters of the main rivers show the effects of former glaciation, especially in the Upper Matakitaki Valley where hanging and U-shaped valleys, truncated spurs, and terraces of morainic debris are prominent features of the landscape. An interesting feature of the Matakitaki-Tutaki valley-system is the evidence of a change of drainage that has taken place in post-glacial times. This change of drainage was first noted by Cox, who wrote "thus the Upper Matakitaki drained down the Tutaki River, and thence by that branch of the Mangles which now heads towards Lake Rotoroa, and either through the 'grassy patch' to Murchison Creek, or more probably through to Rotoroa Lake." *

The evidence gathered recently shows that ice and a post-glacial river formerly drained from the Upper Matakitaki Valley into the Tutaki Valley, whence they flowed northwards up the southward-flowing Grassy Creek into Murchison Creek.

Principal Faults.

The structure of the area is controlled by faults that strike in directions between the north and north-north-east. The Nardoo Range is separated from the Mount Baldy highland by a continuation of the arcuate Wairau fault, that traverses Station Creek Valley (tributary of the Matakitaki) and the middle reaches of Glenroy River, and crosses the Mount Cann Range near the headwaters of Station Creek (tributary of the Maruia River). Its continuation southwards has not yet been traced. To the south-east of this portion of the Wairau fault are some north-north-easterly-trending fractures of less importance. Another fault traverses the portion of the Glenroy Valley that lies between the junction of that river with the Matakitaki and a point about one mile west of the Granity Creek-Glenroy junction, and extends southward along the western flank of the Mount Cann Range. There are a number of other faults between this one and the Wairau fault, chief of which is the Tutaki fault of the Murchison Subdivision. This fault continues southward from the northern boundary of Maruia Subdivision and crosses the Glenroy River near Shale Creek junction. The courses of the Warbeck and Warwick streams are determined by a fault, or a fault-zone, that continues south-westward skirting the eastern flanks of Mount Rutland and the Victoria Range. Northward this line of weakness skirts the base of Mount Mantell and passes into the Murchison Subdivision. The conspicuous rectilinear or westward reach of the Matakitaki River from Hunters' Station to Horse Terrace is probably fault-determined.

General Geology.

As no internal evidence as to the age of the pre-Tertiary rocks has been discovered, no attempt will be made at present to correlate them with strata of known age outcropping elsewhere in Nelson Province. Cox* considered the ancient sedimentary rocks of this portion of the province to range in age from Upper Silurian to Lower Carboniferous, and included the bulk of them in the Te Anau and Maitai Series.

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* Cox, S. H.: "On the District between the Maruia and Buller Rivers." Rep. Geol. Explor. during 1883–84, No. 16, p. 9; 1884.

The main mass of these sediments occurs east of a line drawn from the Rahu–Maruia junction to the Wheeler Creek-Matakitaki junction. The rocks strike north-north-easterly with minor variations from this direction, and are vertical or dip eastwards at high angles. Greywackes and carbonaceous argillites are the dominant rock-types, and these grade into semi-schists and phyllites or semi-phyllites, according to the amount of dynamic metamorphism they have suffered. Chlorite schists in which magnetite is abundant, outcrop at the head of the "Branch of Glenroy" in the Nardoo Range. Similar rocks crop out in the Cann Range five miles south-westward from Prebbles' hut where they are also garnetifrous. In both localities they are overlain eastward by garnet-mica-schist which grades upwards into semi-schists and greywacke.

A series of greywackes, with interbedded igneous conglomerates which closely resemble the Haupiri conglomerates, outcrops westward from the Station Creek-Matakitaki junction. A considerable thickness of marble is associated with these rocks. The marble again outcrops at Marble Hill and at other localities in the Upper Maruia district. In the Victoria Range, in Mount Mantell, and in Mount Rutland greywackes, metamorphosed in places to hornfels and spotted schists, are common.

Rocks of Tertiary age occupy wide areas in the Upper Maruia district, and extend thence north-eastward into the Glenroy and Matakitaki valleys. A narrow fault-bound strip of these rocks occurs in the "Branch of Glenroy." The rocks, which are of Upper Miocene age, consist of arkositic grits, mudstones, sandstones, and conglomerates with coal-seams or with carbonaceous layers. They strike chiefly north-eastward, and dip at angles varying between 45° and 90°, with the exception of a gently-warped block between the Rappahannock and Glenroy rivers that has dips seldom greater than 20°.

Igneous Rocks.

Granites and diorites and their basic differentiates form much of Mount Mantell, Mount Cann, and Victoria Range. Great blocks of the fine-grained pre-Tertiary marble, several chains in extent have been incorporated in the Mount Cann granite and recrystallized into a coarsely granular marble. Basic and ultrabasic rocks crop out in Station Creek (tributary of the Matakitaki) and on the Mount Baldy highland.

Economic Geology.

Gold.—Gold-bearing gravels in river-beds and on terraces have attracted the attention of prospectors since gold was first discovered in the district, shortly after 1860. Much labour and capital have been expended on alluvial mining, but with the exception of some claims at Horse Terrace the returns have been unsatisfactory. The principal gold-bearing areas are the Matakitaki from Horse Terrace down-stream towards Murchison, the Glenroy from Granity Creek junction to the Matakitaki junction, and the Maruia from the vicinity of Warwick Junction northward. At present some leased areas in the Upper Maruia are being systematically prospected by the Siamese Tin Co. The distribution of payable wash is so closely associated with the distribution of Tertiary conglomerates that it seems the bulk of the alluvial gold has been derived from these conglomerates. This opinion was first expressed by Cox*, and later it received support from McKay†.

As a rule, the pre-Tertiary rocks are barren, but in Branch Creek, a tributary of the Matakitaki, the quartz stringers associated with them have yielded some "specimen stone," though recent careful prospecting in this locality has revealed nothing of value.

Coal.—Bituminous and sub-bituminous coal crops out at several places in the district, but the seams appear to be thin and much crushed. The measures are the equivalent of the coal-measures at present being prospected in the Murchison Subdivision, at Owen Junction and in the vicinity of Murchison.

Oil.—For many years seepages of oil have been known to occur near Warwick Saddle and in some tributaries of Blackwater Creek. The oil seeps out along the fault- and fracture-planes in the steeply-dipping Tertiary rocks.

As interest is being taken in the oil possibilities of the Murchison and Maruia districts, prospective investors should consider carefully the authorship and the value of geologic reports submitted to them. The success of many ventures depends upon a correct interpretation of the geologic structure of the district, and to obtain this much preliminary field-work is essential. The prospects of success may be seriously jeopardized by acting on the advice of an incompetent individual or before the structure has been correctly interpreted.

Copper.—Sulphides of copper, mainly chalcopyrite, occur in a few small reefs associated with the ultrabasic rocks of Mount Baldy highland.

Wolframite.—The tungstate of manganese ($MnWO_4$) was prospected with unsatisfactory results in a branch of Warwick Creek on the east side of Mount Mantell.

Roadmaking-materials.—Granite, greywacke, Tertiary conglomerates, terrace-gravels, and river-shingle yield an inexhaustible supply of roadmaking-material throughout the district. The terrace-gravels and river-shingle, being easily obtained, are used to a greater extent than are other rocks that require quarrying.

5. MURCHISON SUBDIVISION.

(By H. E. Fyfe.)

Certain portions of Maruia and Lyell Survey Districts that are very difficult of access were not completely mapped during the 1927–28 field season. During the past season these were mapped as opportunity permitted. Apart from the completion of the regional mapping, few additional geologic or economic results have been gained. For short accounts of the geology of the subdivision see 20th Annual Report, N.Z. Geological Survey, pp. 11–12, 1926; 21st Annual Report, pp. 4–7, 1927; and 22nd Annual Report, pp. 11–14, 1928.

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* Cox, S. H.: Rep. Geol. Explor. during 1883–84, No. 16, p. 9; 1884.

† McKay, Alexander: "Report on the Geology of the South-west Part of Nelson and the Northern Part of the Westland District." Mines Report, C.–13, p. 3, 1895.

The Active White Creek Fault.

Recent movements observed along the White Creek fault after the earthquake of the 17th June are the chief subject of geologic interest at present attaching to the area. The fault crosses the former main road to the West Coast near White Creek, a tributary of the Buller River, seven and a half miles west of Murchison, or practically midway between Newton Flat Post-office and the Buller-Maruia junction. This fault is slightly concave westward, and determines the eastern boundary of a fault-bound strip of Tertiary sedimentary rocks, averaging one-quarter mile in width. This Tertiary strip has been traced from the mouth of White Creek south-westward for six miles into the Big Deepdale basin, where the two faults that bound it appear to unite and continue as a single fault. Northward from White Creek the traces of the two faults continue across the basin of Newton River and head towards the Mokihinui basin. Since the 17th June the country west of the White Creek fault has subsided about 15 ft. relatively to the country to the east. Reports from various quarters indicate that the movement was spasmodic. No recent movement has been detected along any other fault of the Murchison Subdivision. The widely scattered centres of origin of after-shocks show that release of stress is taking place over a large part of Nelson Province. This sympathetic release of stress is accompanied by minor tremors, and will probably continue for some months.

A structurally similar strip of Tertiary rocks that is so conspicuous near the Glengarry-Maruia junction was recognized in the Big Deepdale about twelve miles south-south-west from the junction of this river with the Buller. The strata of this strip probably wedge out southward, as the two bounding faults approach one another and unite.

Coal.

The coal-measures at Owen Junction are being capably prospected by a small party of miners. A seam from 5 ft. 6 in. to 6 ft. thick at the outcrop was approached by an adit; the coal was about to be mined when the earthquake of the 17th June caused the collapse of the adit. The seam is so disposed as to permit economical mining, and ready access to the main road and projected railway places the prospect in a favourable position.

6. PALÆONTOLOGICAL WORK, 1928–29.

(By. J. Marwick.)

The chief work during the past year has been the preparation of a Palæontological Bulletin on the Tertiary Mollusca of the Gisborne – East Coast district. This is now nearing completion, and should be ready for publication during the present winter. The extensive fossil collections on which this work is based were gathered chiefly by the geologists of Taranaki Oil Fields, Ltd., and as a result of their careful collecting we have a much more extended view of the Tertiary faunas than was hitherto possible.

In December, 1929, following a reported mud-flow in the Cheviot district, the writer visited the locality, which is in the bed of the Gower River, on the farm of Mr. A. Sloss, who kindly provided transport from the railway. A description of the mud-flows, of which several occurred, has appeared in the *Journal of Science and Technology*, Vol. XI, No. 1, 1929. A visit was also paid to Gore Bay, and a small collection of Mollusca was obtained from the clays exposed on the roadside at the last bend before going down to the beach. The shells are almost certainly of mid-Tertiary age.

In company with Professor R. Speight and Mr. S. Sylvester, of Canterbury College, the writer spent ten days collecting in Mount Somers district. Evidence apparently favouring the Ngaparan age of the coal-measures here was obtained, but the collections have not yet been examined in detail. A visit was also made to Charteris Bay, Lyttelton Harbour, and further fossils were gathered from the rusty sandstones. The specimens, though all casts and moulds, confirm the previously expressed opinion that the beds are approximately Awamoan in age.

During February a fortnight was spent in Nelson Province, chiefly in the Takaka and Tadmor districts. As a result of several days collecting in the quarries of the cement-works at Terakohe a large number of specimens were gathered from the limestone and overlying marl. A finely preserved fossil crayfish from the marl-quarry, the first recorded in New Zealand, was presented to the Geological Survey by Mr. Ulrich, chemist at the cement-works.

Collections were also made from the Tertiary rocks outcropping in the Wairoa River, a little below the gorge, and from the Triassic rocks of Garden Gully, above the gorge. A considerable amount of poorly preserved material from the foreshore at Nelson was collected in the hope that careful preparation and study will afford evidence as to the age of these beds. Several points of agreement tend to correlate the Nelson Mollusca with those from the Wairoa Gorge. In the Tadmor district the principal collection was got in Greenhills Stream, a tributary of the Sherry River. The beds outcropping in the Sherry and Tadmor Rivers were also examined, but with little result.

From March until October, 1928, the writer was acting as *locum tenens* for Dr. Cotton at Victoria College.

7. MANGANESE AT PARAPARAUMU.

(By J. Henderson.)

On the 25th March I visited Paraparaumu, and was shown by Mr. Davies, the lessee of the sheep-farm, prospecting-trenches cut many years ago on the outcrops of manganese-ore. These trenches are now in part fallen in and their sides covered with turf, so that little could be ascertained beyond the fact that manganese-ore occurs in places. McKay,* who examined the trenches in 1899, soon after they were cut, had a much better opportunity of seeing the extent and manner of occurrence of the

* A. McKay: "Report on a Deposit of Rhodochrosite at Paraparaumu, Wellington." Mines Report, C.-9, pp. 2 and 3, 1899.

ore. He states that the ore, which consists largely of rhodocrosite, occurs as a lode from 3 ft. to 10 ft. wide, and traceable for a distance of 5 to 7 chains. A sample taken at that time and freed from the black oxides of manganese was found to contain*—

	Per Cent.
Carbonate of manganese (rhodocrosite)	63·03
Silicate of manganese (rhodonite)	18·23
Carbonate of iron (siderite)	4·00
Carbonate of lime (calcite)	14·48

The largest outcrop is on a hillside about a mile and a half south-east of Paraparaumu Railway-station and 660 ft. above sea-level. The cut exposes ore over an area about 10 ft. wide and 5 ft. high, but the relation of the ore to the country rock is not shown. The ore consists chiefly of hard dark oxides of manganese and soft earthy-looking "wad." The black ore contains patches and fine interlacing veinlets of the pinkish-brown rhodochrosite and some crystals of calcite. About 3 chains south-south-west is a turf-covered trench with large blocks of black ore beside it, and on the creek-bank a chain or so farther south manganese-ore is also exposed. In the next gully north from the main outcrop are several old trenches, but no trace of ore was observed.

The outcrops are probably part of a lode which strikes north-north-east parallel with the steep north-west face of the main ridge of hills between Paraparaumu and the valley of the Maungakatukutuku. This steep face is probably a fault-scarp, and the manganese-ore is thought to have been deposited along the fault itself. The greywackes and argillites of the Tararua Range and most of the mountain-ranges of the North Island contain a small proportion of manganese (see analyses, N.Z.G.S. Bull. 18, p. 72). This is leached out of the rock by surface waters containing carbon dioxide, and redeposited usually as nodules and pockets of manganese oxide, but occasionally as lodes and in the form of manganese carbonate. Numerous small pockets of ore have been reported from the Wellington District, and larger deposits have been worked in North Auckland and on Waiheke Island. Lodes of manganese carbonate in part altered to the oxides are known in Germany, Japan, and the United States. These do not extend to great depths, exceptionally to 200 ft., and are interpreted as having been formed by descending surface waters. The Paraparaumu deposit, from the little that can be seen of it, probably resembles those of Thuringia and the Harz of Germany.

The chief uses of manganese are in the steel and chemical industries, and the world's supplies are drawn largely from Russia, India, and Brazil. The deposits, which are a different type from those of New Zealand, are very extensive, and labour is cheap, so that there seems little chance of New Zealand manganese competing in the open market. At the present time ore containing from 47 to 50 per cent. of manganese is worth, c.i.f. London, from 1s. 2d. to 1s. 4d. per unit (about £2 15s. to £3 3s. per ton.) The highest-grade-ores—containing, say, 65 per cent. of manganese—used in making dry cells, are worth considerably more. The sample of which the analysis is given would contain about 37 per cent., and ore of this tenor, if saleable at all, would probably be worth about £1 10s. per ton in London.

8. DAM-SITES IN THE AKATARAWA AND WAKATIKEI VALLEYS.

(By J. Henderson.)

The Wakatikei and Akatarawa, which drain part of the southern end of the Tararua Mountains, join the Hutt respectively twelve and fifteen miles from where that river discharges into Port Nicholson, The Tararua highlands are elongated north-north-east, and consist of greywackes and argillites closely folded in the same general direction. The precise direction of folding cannot be stated, since the strikes of the strata are locally altered by faulting, and by the tilting and warping of the earth-blocks. During the folding, which probably took place in late Mesozoic times, the rocks slipped along bedding-planes and were in parts fractured and faulted. There then ensued a long period of stable conditions when the shattered zones were consolidated and more or less recemented by infiltrating quartz, and erosion reduced the whole region to a surface of low relief. Earth-deformation followed in late Tertiary times; the crust was ruptured along many faults, the earth-blocks between were raised to different heights and tilted and the land, as it now is, was roughly shaped out. Regional up-and-down movements and the forces of denudation have since produced the present topography.

The chief faults formed during this last deformation tend to follow the lines of weakness produced by earlier folding—that is, the bedding-planes of the weak argillites and old fault-lines. A complex zone of faulting strikes north-east along the western side of the Hutt Valley, and a branch from it gently curving north, has determined the main Akatarawa Valley. Another well-marked north-east fault follows the upper valley of the Pahautanui, enters the Wakatikei basin above the Wainui junction, and turns north along the main stream. Between these faults, in the valley of the Little Akatarawa, there are numerous parallel fractures which, as far as can be made out, follow the bedding-planes of the strata. The many abrupt bends of the Little Akatarawa are probably due to the stream in the longer and wider reaches following the bedding of the softer rocks and faults, and in the narrow gorges cutting across the strata.

The dam-site at the bridge by which Snow Hill Road joins the Little Akatarawa Road is topographically favourable, in that the valley is here constricted a short distance below a relatively long open reach. The rocks at the site are well exposed by the benches at stream-level on both sides and by the extensive side-cuttings of the roads, the surfaces of which are 10 ft. or 12 ft. higher. They strike some 10° or 20° west of true north, and dip steeply west. The stream here crosses the strike

* Dom. Lab. Rep. No. 33, p. 14, 1906.

obliquely. A good deal of the rock is hard greywacke, traversed by but few planes of movement, but on the west side, a few yards above the bridge, and on the east side below the bridge, there is a zone made up of rock flaked by movement into innumerable flat fragments which are readily detached and broken, though the rock as a whole stands well in the cuttings and forms steep slopes. A few quartz veinlets were observed in the more intensely crushed part of the zone. In addition, several small flaws and planes of movement, some fairly flat and others dipping steeply in different directions, from $\frac{1}{2}$ in. to 3 in. wide, and filled with crushed rock, traverse the rock at this site.

Down-stream, some 15 chains south from the bridge, the stream cuts nearly directly across the strike of a band of hard greywacke several chains thick. Benches cleared on both sides at stream-level and the road-cutting on the east side, extending from 20 ft. to 40 ft. above the stream, expose the rock. Except for the joints and a few small irregular planes of movement, the greywacke is quite solid. On the west side a bench about 50 ft. above the stream shows for the greater part of its length rather weathered greywacke. About its centre a slip covered, when the site was visited, a few yards of the bench. Two or three small planes of movement were observed here. The actual bed of the stream has not been explored, but since the strata strike directly across the stream, and identical rock is exposed on both sides, no change or break is to be expected. This site is a few feet lower than that at the bridge, and will require a dam of somewhat greater mass; but the rock is much more solid, and is free from any except very small planes of movement. From the geological point of view it is a decidedly better site.

In the Wakatikei Valley the upper dam-site is topographically admirable—a comparatively broad flat-bottomed valley with steep sides which converge abruptly to a narrow gorge. Cuts through slope-deposit, up to 15 ft. thick, expose the rock on the east side of the site. There are six or seven cuts at stream-level and five about 15 ft. higher. Not more than 10 per cent. of the rock at these contours is exposed in these cuts. All show solid greywacke, except that farthest down-stream, where a narrow plane of movement traverses slightly crushed rock outcropping at stream-level. On the west side benches, each about 150 ft. long, have been cleared at and about 20 ft. above stream-level. The rock consists of greywacke with minor bands of argillite (5 per cent. or less). There are eight small planes of movement in the upper bench, and four, entirely distinct from these, in the lower. The topography suggests that the stream has cut its beds along an unexamined and larger plane of movement. The rocks in this locality strike about 35° east of north, and dip north-west at about 75°; the stream flows nearly due south.

The other site in the Wakatikei Valley, about 30 chains downstream and 20 ft. lower, is at a very narrow gorge cut through a wide band of greywacke that strikes across the stream nearly at right angles. A dam at this point would contain decidedly less material than one of the same height at the upper site. Two benches on the west side, respectively 20 ft. and 50 ft. above the stream, expose the rock, which also outcrops at many points on both sides of the precipitous gorge. No planes of movement or bands of argillite were observed. The stream-channel is rather tortuous, and the gorge is probably due to erosion through solid greywacke, and not to cutting along a plane of weakness.

Provided that the strata in the actual streams are sound, the rock at the lower dam-sites in the Akatarawa and Wakatikei Valleys is more impervious and better able to carry the weight of dams, and to withstand the scour of falling water and of water under pressure, than that exposed at the upper sites.

The Hutt Valley, which is of structural and not of erosional origin, is, except for Port Nicholson, filled to grade-level with gravels, sands, and silts. These will occur in irregular layers and in different successions at different points, the finer material tending to be in greater amount at the lower end. Water, making its way to the sea under the influence of gravity, saturates these deposits to the ground water level. The Hutt River itself is the surplus of the run-off that, owing to the frictional resistance, cannot escape through the gravels and sands. In the Hutt Valley there is a large body of subartesian water from which domestic supplies could be drawn to a much greater extent than at present. This supply may become polluted, a possibility that will increase as the valley is more closely occupied and as more water is pumped.

In the Hutt Valley there is clear evidence that the land has been uplifted within, geologically speaking, comparatively recent times. The high terraces at Hayward's and near the junctions of the Wakatikei and Akatarawa Streams are the remnants of the higher flood-plain that formerly existed. The upper Wakatikei is entrenched about 300 ft. in the comparatively wide floor of its ancient valley, which here follows a strong fault. The valley was wide and mature, and the stream meandered at grade. After land-uplift the rejuvenated stream entrenched these meanders; where they chance to cross hard bars of rock gorges occur, but where they are in soft or crushed rock the valley is wide.

9. WAINUIOMATA AND ORONGORONGO VALLEYS.

(By J. Henderson.)

The Wainuiomata and Orongorongo have long narrow subparallel basins nearly equal in size, and the waterworks in each valley are at approximately the same distance from the sea. But the valleys at these points are unexpectedly different. For three miles or more up-stream from the confluence of Moore Creek the Wainuiomata meanders through a flat-floored valley-bottom from 6 to 8 chains wide, and formed of gravel flood-plain and low gravel terraces. Rock is exposed only where the stream approaches the valley-sides. Half a mile above Moore Creek junction a series of pits sunk across the valley showed that the gravel-filling there was up to 44 ft. deep; moreover, the two pits nearest the centre of the valley, where the filling is likely to be deepest, were not bottomed, and here

the solid rock is probably 60 ft. below the gravel-surface. Up-stream the gravel filling will gradually decrease, but as far as the valley retains a similar profile the ratio of the width of gravel filling to the depth of filling will remain approximately the same.

Though the headworks in the Orongorongo are about the same distance from the sea as the reservoirs in the Wainuiomata, the two valleys are decidedly unlike. The latter is mature, with graded valley slopes; the former, which at this part is more than 300 ft. higher, is a youthful steep-sided V-shaped valley.

In the Orongorongo patches of flood-plain are small and discontinuous, and rock outcrops everywhere. But the stream-bed is encumbered with a considerable amount of debris, the bulk of which is subangular and quite unweathered. It has evidently not travelled far, and is, in fact, being brought into the main stream by a tributary entering from the east some 10 or 15 chains above the intake of the pipe-line. Three large screes descending from high bare ridges in the basin of the tributary supply it with large quantities of waste. Above the tributary, the Orongorongo appears to carry the amount of debris normal to a stream draining steep mountainous country wooded to the summits.

10. MANANUI FLAT BOREHOLES.

(By J. Henderson.)

Mananui, a sawmilling township, about five miles south of Hokitika, was visited on the 9th March, and I traversed the sawmill tram-track for a distance of about three miles from the railway-station.

West from Mahinapua Stream to the Tasman Sea, a distance at Mananui of about 60 chains, the land is formed of Recent marine sands, which rise in a series of five distinct uplifted beaches to a height of about 25 ft. at the railway-station. There is a low foredune along the shore. Between the station and Mahinapua Stream the sands have a level surface. From the mill the tram-line rises on to gently undulating country on which the highest points for some miles are about 150 ft. above sea-level. The numerous outcrops along the line show that this higher area consists entirely of ancient glacial deposits.

A few years ago three boreholes were sunk with a Keystone drill at points beside the tram-line. The first bore, about 60 chains from the station, reached a depth of 151 ft.; a colour of gold was noted at 5 ft., otherwise the hole was barren. The second, 117 ft. deep, a mile farther on, passed through ground with a few colours at 19 ft. and 27 ft. There is a small stream at this point, and the colours are probably in the gravels of this stream. The third hole, a mile distant on one of the swampy flats that dot the surface of the old moraine, was drilled to 113 ft., gold colours being reported at 23 ft.

DOMINION OBSERVATORY.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR THE YEAR 1928.

Buildings and Equipment.

The buildings and equipment have been kept in good order and condition. The Observatory grounds are kept in 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, 293; Nauen, 238; Malabar, 166; Bordeaux, 123; Annapolis, 13; Elgin Watch-factory, 4; Rugby, 4; Chelmsford, 1. Scientific time signals were also received at the Observatory as follows: Bordeaux, 54; Nauen, 91; Rugby, 7.

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 sec.	Over 2 sec.
Honolulu (NPM)	5	10s·93 slow 23rd June.
Nauen (POZ)	2	..
Malabar (PKX)	2	..
Bordeaux (LY)	1	..

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 1,684. Of these, 462 were sent by wireless telegraph, 643 were sent by special circuit to the Telegraph-office, 365 by the signal lights at the Observatory, 102 by switching off lights at the Harbour Board building at Auckland, 101 by dropping the time-ball at Lyttelton, and 11 by telephone.

No radio time signals were sent out on the following dates owing to line interruptions between the Observatory and the Wellington Radio Station: 1928—16th, 22nd, 28th August; 28th September; 14th October; 8th December.

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, except on Government holidays and on Sundays:
(2) To ships and to the general public at Wellington, by electric lights at the Observatory, daily:
(3) To the Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays, except Government holidays:
(4) To the South Island telegraph-offices, by telegraph, 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) Radio time signals through the Wellington Radio Station (ZLW), on Tuesday and Friday evenings at 8.30 p.m., except on Government holidays:
(7) Radio time signals through the Wellington Radio Station (ZLW), every day at 10.30 a.m. The Radio call signal for the Observatory is ZLO, and this sign is used in transmitting radio time signals.

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 to some 2,300 telegraph and telephone offices, distributed all over New Zealand, at 9 a.m. daily.
(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.

Wellington General Post Office Clock.—The Post-office clock is checked at 3 p.m. on Mondays, Tuesdays, Thursdays, and Fridays by the broadcast signal through Station 2YA, Wellington. On Wednesdays, when Station 2YA is not broadcasting, the clock is frequently checked by the signal heard through the air. This clock is not under the control of the Observatory. The greatest errors were 9 seconds slow on the 29th May, and 14 seconds fast on the 5th December.

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. The greatest errors of this clock were 53·0 seconds slow on March, 28th, and 27·6 seconds fast on June 2nd.

Sun-spots.

The regular observation of sun-spots has been discontinued.

An enlarging camera for photographing the 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 the 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.

"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."

Occultations.

In response to a request to Professor E. V. 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 9h. G.M.T., and every day at 23h. 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 of the moon is recorded on the chronograph. In this way a number of plates were obtained with the 9 in. telescope. The plates have not yet been measured.

The occultation of stars were observed at Wellington on January 30th, February 28th, June 3rd and 30th, July 1st, 24th, 25th, 29th, August 26th, 29th, September 18th, and November 19th.

Auroras.

During the year 1928, the following auroras were observed :—

May 3—Aurora australis observed from Wellington.
May 5—Aurora australis observed from Christchurch.
May 9—Aurora australis observed from Wellington.
June 16—Aurora australis observed from Temuka.
July 9—Aurora australis observed from Blenheim, Waimate, Christchurch. Also seen in Sydney.
July 10—Aurora australis observed from Christchurch.
October 19.—Aurora australis observed from Auckland.

Meteors.

SUMMARY OF METEORS FOR 1928.

Place.	New Zealand Date.				Notes.
		d.	h.	m.	
Wellington	January	18	00	00	Observed by Miss E. Wilson.
Wellington	January	28	11	18	Observed by A. G. C. Crust.
Wellington	February	19	10	25	Observed by A. G. C. Crust.
Feilding	July	20	21	00	Newspaper report.
Napier	November	15	23	00	Bright meteor. Newspaper report.

Precision Pendulum.

The precision pendulum made by Mr. E. C. Isaac, Wellington, was installed in the Observatory in November, 1926. A number of difficulties have arisen in its construction, and alterations have been undertaken by the workshops staff of the Post and Telegraph Department. The pendulum is installed in the cellar, and will be used to operate an electric-impulse dial placed in the transit-room.

Photographs of Moon and Surrounding Stars.

This research was begun 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.

Comets.

Of the comets reported none was observed, owing to their faintness and difficulty in observation.

Eclipses.

There were two eclipses of the moon visible in New Zealand during the year—on June 3rd and November 27th. These were observed generally in New Zealand. There were no eclipses of the sun visible in New Zealand during 1928.

Summer Time.

The Summer Time Act, 1928, provided for the time in New Zealand being half an hour in advance of New Zealand standard time for the period beginning at 2 a.m., New Zealand standard time, on Sunday, October 14th, 1928, and ending at 2 a.m., New Zealand standard time, on Sunday, March 17th, 1929.

SEISMOLOGY.

The Observatory has three seismographs in use—one Milne and two Milne-Shaws. These are all horizontal component machines, and with them 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 211 ; on the Milne-Shaw (north-south component) 284 ; and on the Milne-Shaw (east-west component) 287

earthquakes were recorded. Particulars of the numbers of the earthquakes registered on the three machines are given in the following table :—

1928.	Machine Milne.	Machine Milne-Shaw (N.–S.).	Machine Milne-Shaw (W.–E.).	Remarks.
January ..	18	23	23	
February ..	29	44	44	
March.. ..	27	34	36	
April	7	18	18	
May	13	15	16	One shock lost on Milne-Shaw (N.–S.).
June	17	20	21	
July	14	20	17	
August ..	13	19	17	One shock lost on Milne-Shaw (E.–W.) owing to lamp burning out.
September ..	15	20	22	
October ..	18	19	20	
November ..	19	25	25	One shock lost on Milne-Shaw (E.–W.) owing to clock stopping.
December ..	21	27	28	

Inequality in the number of shocks recorded on each seismograph is due to the following causes (other than those stated above) :—

(1) The Milne machine is less sensitive than the Milne-Shaw machines ; it therefore does not record many of the smallest shocks.
(2) The Milne-Shaw (N.–S.) component appears to be specially susceptible to disturbance by high winds ; therefore very small shocks are occasionally not traceable on the records.
(3) A few very feeble shocks have been recorded on one Milne-Shaw machine only, possibly on account of directional effect.

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 1928 was 80 ; 60 of these were felt in the North Island and 23 in the South Island. In three cases the same shock was felt in both Islands. The maximum intensity of the shocks felt in 1928 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, 1927, and 1928 was 8 on the same scale.

Fifty-seven reports were received from the officers of the Post and Telegraph Department, eight from the Marine Department, forty-six from other observers, and 136 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 year 1928 earthquake reports have been received from fifty-eight observatories.

Steps are now being taken to obtain 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.

Earthquakes in New Zealand, 1928.

Table I is a general summary of all earthquakes experienced in New Zealand during the year 1928. The table gives the day and hour of each shock, the towns or districts where felt, and the maximum intensity reached.

Statistics for sixteen of the principal towns in New Zealand show that the southern portion of the North Island was by far the most active area in 1928. Wellington recorded the greatest number of shocks (eight) during the year, New Plymouth six, and Napier six. In the South Island there was considerable activity in the west-coast districts, most of which occurred in the months of March and December. Westport and Queenstown each experienced five shocks during the year.

Seismic activity was greatest during the first three months, and showed a decline towards the close of the year. The maximum number of shocks (seventeen) occurred in March, and the minimum (three) in November.

Table II gives the distribution of earthquakes in each month of 1928, and the number occurring in each Island ; also the maximum intensities. The total number of separate shocks felt during the year was eighty, sixty of which were felt in the North Island and twenty-three in the South Island, three being felt in both Islands. The maximum intensity was 8 on the Rossi-Forel scale. This was

reached at New Plymouth on the 7th March, and near the Hermitage, Mount Cook, on the 25th March. The lowest maximum intensities occurred in May and October, when no shocks above force 4 were experienced.

Table III represents an attempt to discover whether earthquakes are more likely to occur at one time of the day than at another. The total figures for the year 1928 show that the earthquakes were almost evenly distributed throughout the day. There was a slight preponderance of morning over evening in the earthquake numbers, but this only amounted to 6 per cent.

Table IV gives the number of earthquakes whose maximum intensity fell in different numbers of the Rossi-Forel scale. The table shows that 90 per cent. of the earthquakes in 1928 were of intensity 5 or under, and 65 per cent. of intensity 4 or under. Only two shocks reached intensity 8, and none exceeded 8.

A map has been prepared to show the approximate epicentres* of the most outstanding earthquakes in 1928. The epicentres were determined by reports from observers in conjunction with data from the seismograms of the Dominion Observatory, Wellington. The small inset map shows the epicentres in the south-west Pacific. Those outside New Zealand have been determined from the seismograms at Wellington and Suva in conjunction with seismological reports from Apia and Melbourne.

TABLE I.—GENERAL SUMMARY, 1928.

New Zealand Mean Time.			Where felt.	Maximum Force, R.-F. Scale.
Day.		Hour.		
Jan.	11	2	Dannevirke	4
	15	12	Opotiki and Gisborne	3
	18	23	Dannevirke	4
	25	17	Hawke's Bay district	4
	27	19	Cheviot	5
	30	00	Wairarapa district	5
Feb.	5	1	Whakatane	5
	5	12	Opotiki	4
	7	13	Waiau	3
	11	12	Wairoa	3
	13	18	New Plymouth	3
	16	2	East Cape district	6
	19	7	New Plymouth	4
	19	14	Opotiki	3
	23	21	Whakatane	5
	27	23	Taihape	5
Mar.	3	2	East Cape and Bay of Plenty districts	6
	5	20	Wairoa	2
	6	11	Balclutha	4
	7	6	Western portion of North Island from Kawhia southwards, and Collingwood in the South Island	..
	8	10	Waitara and New Plymouth	3
	9	11	Wellington	4
	9	13	Southland	4
	10	10	Nelson Province	6
	16	7	Manawatu and Wellington districts	4
	18	23	Queenstown	3
	19	13	Havelock North	3
	23	8	Paradise	3
	23	13	Paradise	3
	25	9	Westland, Otago, and Southland	8
	25	14	Hermitage	3
	25	23	Queenstown	3
	31	4	Wairoa	3
April	6	7	Hawke's Bay	5
	18	15	Tarawera	3
	21	14	Tarawera	3
	28	22	Pahiatua	4
May	2	7	Nightcaps	4
	9	9	Napier	3
	12	4	North Island from Woodville southwards	4
	17	11	Opotiki	3
	27	21	Bay of Plenty district	4
	28	4	Opotiki	3

* The epicentre of an earthquake is the point on the earth's surface directly above the origin.

TABLE I.—GENERAL SUMMARY, 1928—*continued.*

New Zealand Mean Time.		Where felt.	Maximum Force, R.-F. Scale.
Day.	Hour.		
June 12	5	Southern portion of North Island from Horopito to Masterton ..	6
12	9	Taupo	4
14	18	Moko Hinou Lighthouse	4
16	13	Hastings	3
18	10	Napier	3
20	13	Opotiki	4
22	5	Waipawa	4
July 4	5	Bay of Plenty	4
6	7	Dannevirke	4
11	5	Opotiki	5
15	20	Westport	4
17	1	Dannevirke	5
17	18	Taumarunui, New Plymouth, Raetihi	5
23	4	Wellington	2
31	5	Patea, Wellington, Nelson, and Marlborough districts	5
Aug. 1	4	Otira	5
8	7	Dannevirke	2
11	22	Dunedin	4
13	6	Thames, Waihi, Tauranga	5
27	5	Southern Hawke's Bay district	5
Sept. 1	19	Otira	5
2	21	Westland	5
12	12	East Cape district and northern Hawke's Bay	4
24	21	Manawatu, Wairarapa, and Wellington districts	5
Oct. 2	1	Rotorua	3
12	13	Wellington	3
13	20	Hastings	4
22	6	Wanganui	3
30	13	Napier	3
Nov. 9	15	In both Islands, from Auckland in the north to Hokitika and Hanmer in the south	6
Dec. 9	19	Farewell Spit	3
22	18	Queenstown	2
31	19	Westland and Ashburton	6

TABLE II.

1928.	Number of Earthquakes.			Maximum Force, R.-F. Scale.
	North Island.	South Island.	Total for Whole Country.	
January	5	1	6	5
February	10	..	10	6
March	8	10	17	8
April	4	..	4	5
May	5	1	6	4
June	7	..	7	6
July	7	2	8	5
August	3	2	5	5
September	2	2	4	5
October	5	..	5	4
November	3	..	3	5
December	1	5	5	6
Totals ..	60	23	80	Max. 8
Per cent. totals ..	72	28	..	..

TABLE III.

1928.	Number of Earthquakes.		
	Morning: 0h. – 8h.	Daytime: 8h. – 16h.	Evening: 16h. – 24h.
January	2	1	3
February	3	4	4
March	5	9	3
April	1	2	1
May	3	2	1
June	2	4	1
July	6	0	2
August	4	0	1
September	0	1	3
October	2	2	1
November	1	0	2
December	0	2	3
Totals	29	27	25
Per cent. totals ..	36	34	30

TABLE IV.

1928.	Numbers on Rossi-Forel Scale of Intensity.							
	Under 3.	3.	4.	5.	6.	7.	8.	Over 8.
January	..	1	3	2	..	..	..	..
February	..	4	2	3	1	..	..	..
March	1	8	4	..	2	..	2	..
April	..	2	1	1	..	..	..	..
May	..	3	3	..	..	..	..	..
June	..	2	4	..	1	..	..	..
July	1	..	3	4	..	..	..	..
August	1	..	1	3	..	..	..	..
September	..	..	1	3	..	..	..	..
October	..	4	1	..	..	..	..	..
November	..	..	1	2	..	..	..	..
December	1	..	..	2	2	..	..	..
Totals	4	24	24	20	6	..	2	..
Per cent. totals ..	5	30	30	25	8	..	2	..

GENERAL.

Observatory Committee.

Meetings of the Observatory Committee were held on 19th May, and on 13th November, at which the following matters were dealt with:—

Report on astronomical site testing in Canterbury and Otago: The results were so satisfactory that it was resolved to have a report prepared for publication. The report was read at the Auckland meeting of the Science Congress, and was printed in full in the *Journal of the British Astronomical Association*, London.

International Longitude Determination of 1926: This report was printed as an Observatory Bulletin, and was presented to the International Longitude Conference at Leiden, Holland, in July, 1928.

Reception of Radio Time Signals: The equipment has been improved by the addition of a short-wave set and a Marconi magnetic recorder.

Total eclipse of the sun at Sumatra in May, 1929: It was not possible to send an expedition to this important eclipse from New Zealand.

Publications.

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

Bulletin No. 68.—" Interpolation," by C. E. Adams.
Bulletin No. 69.—" International Longitude Determinations, 1926."
Bulletin No. 70.—" Reception of Wireless Time Signals at the Dominion Observatory, Wellington."
Bulletin No. 71.—" Tables of Geodetic Factors for use on the Brunsviga Calculating-machine," by C. E. Adams. (Extract from the " Transactions of the Australian Association for the Advancement of Science.")
Bulletin No. 72.—" The Orbit of the Comet, 1927*k*," by P. W. Glover. (Reprinted from the " Transactions of the New Zealand Institute," vol. 59, part 3, September, 1928.)
Bulletin No. 73.—" Earthquakes in New Zealand."
Bulletin No. 74.—" Solution of Euler's Equation in a Parabolic Orbit," by C. E. Adams. (Reprinted from Astr. Nachr. Nr. 5617, Band 235, Marz, 1929.)
Bulletin No. 75.—" Report of the Department of Scientific and Industrial Research."
Bulletin No. 76.—" New Zealand Time Service Arrangements."
E.–12.—Earthquake reports for 1927, February.
E.–13.—Earthquake reports for 1927, March to May.
E.–14.—Earthquake reports for 1927, June to August.
E.–15.—Earthquake reports for 1927, September to December.

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.

APIA OBSERVATORY.

REPORT BY THE DIRECTOR (MR. A. THOMSON).

IN July, 1928, the control of the Apia Observatory was transferred from the Department of External Affairs to the Department of Scientific and Industrial Research. This change was brought about through the general policy of co-ordination of scientific effort in the Dominion. The general programme of geophysical investigation which has steadily gone on since the founding of the Observatory in 1904 has continued without alteration. The valuable co-operation of the Carnegie Institution of Washington and the British Admiralty has been retained under the new administration.

The activities of the Observatory are concerned with terrestrial magnetism, seismology, and meteorology. In these subjects the Apia Observatory has a fundamental duty of supplying information for the South Pacific Ocean, in which no other well-equipped station exists. The chief results obtained will now be reviewed.

TERRESTRIAL MAGNETISM.

In terrestrial magnetism hourly values have been determined of the horizontal component of the earth's magnetic field. The mean annual value derived therefrom was 35,225 gamma, a slight increase from the previous year. The horizontal magnetic field has decreased consistently from 1904 until 1922, losing in eighteen years 1·2 per cent. of its original value. It would now appear to have started to increase. The declination showed an increase of 2·6 minutes of arc, the mean value for the year being 10° 32·1′. The magnetic needle has turned slowly but consistently towards the east since 1904. The easterly movement for 1927 was slightly more than the average.

The number of magnetically disturbed days during 1928 was higher than any other year since the present scale was adopted in 1921. Prior to 1921 the Observatory was under other auspices, so that the records cannot be directly compared. From its place in the sun-spot cycle, the year 1928 was expected to be a year of maximum sun-spots. In the low latitude of Samoa the variation in horizontal force during a magnetic storm is very pronounced. Measurements of the range and especially careful determination of the time of the sudden commencement of the storms were made.

SEISMOLOGY.

Approximately three hundred earth-movements were recorded at Apia during 1928. The seismological equipment consists of a large Wiechert seismograph with a 1,000 kgm. stationary mass for recording horizontal movements and a small 180 kgm. seismograph for vertical earth-movements. During the year the seismographs were adjusted so that the horizontal earth-movements were magnified about 125 times and the vertical movements about 40 times.

Of the three hundred recorded earth-movements almost two hundred occurred within 50 miles of Apia. Despite the tremendous volcanic activity on Savaii, from 1904–11 no earthquake shocks of even the slightest intensity originated there during the year. A considerable number of shocks had epicentres between Niue Island and Vavau. Several subterranean volcanic eruptions in September and October are believed to have been accompanied by earthquakes of moderate intensity. Enormous quantities of pumice-stone were set adrift at this time. Ships reported great floating patches from near the equator as far as 20° S. latitude, and from 175° W. to 175° E. longitude.

Preliminary analyses of fifteen earthquakes were made within a day of their occurrence and the results sent by radio to the United States Coast and Geodetic Survey. In addition, a quarterly report of all earthquakes recorded was published and distributed to about eighty institutions.

Meteorology.

Continuous records on self-recording instruments were obtained during 1928 of temperature, pressure, humidity, sunshine, rainfall, wind force and direction. Every refinement of measurement was exercised in order that the very slight variations of these elements from the average of previous years would be detected. These variations, which are representative of a great area of the South Pacific Ocean, have been found to be closely connected with subsequent changes in the weather of Central Africa and South America. Although the mechanism by which these vast climate changes are affected remains unknown, one of the most hopeful methods of attacking the problem of long-range seasonal fore-casting consists in the study of the changes at centres of action. Continuous records of the wind were obtained in 1928 after a lapse of about twenty years. These records, obtained on the Dines anemometer installed in 1927, are practically uninterrupted.

The temperature for 1928 was practically the same as 1927, which was higher than any year since 1920. Both rainfall and pressure were also above the normal.

On all unclouded days the Gorcynski pyrheliometer was set up and a continuous record obtained of the total solar radiation. The amount of solar radiation transmitted through the tropical atmosphere to the earth's surface is about 70 per cent. of the incident radiation. The intensity of the radiation in the ultra-violet was measured by Hill's method with ethylene blue, and found to be considerably greater than that occurring in England.

Atmospheric Electricity.

Continuous records have been obtained during the year of the electrical potential of the atmosphere at the station in the Observatory grounds and at a station erected on cement piers in the lagoon about one-third mile off shore. Insulation difficulties at the lagoon station were successfully overcome, so that for the first time records were practically complete at the two stations, allowing a comparison of electrical conditions at the two stations. The daily variation of electrical potential at both places resembles that found at Continental stations rather than the marine type found on the open ocean.

Upper-air Observations.

The investigation of the winds at high altitudes was continued, and fifty-six balloons were sent up and observed for this purpose. This is considerably less than the number used in 1927, when more than eighty ascents were rendered possible by better weather conditions. The data for all the balloon flights made to date were published in a recent report. The more important results were—(1) The south-east trade-winds have their greatest velocity about 2,000 ft. altitude; above this their velocity decreases rapidly. (2) Above the easterly winds, which reach to 10,000 ft., are westerly winds which, at an altitude of six miles, are strong and very constant. (3) The mass of air moved northward toward the equator was five times greater than the air-mass moved southward.

Pilot-balloon observations were taken on the Island of Atafu, 450 miles N.N.W. of Samoa, during the months of June and July.

Meteorological Stations outside Samoa.

Regular weather records are now being obtained from Atafu and from Nassau Islands. Atafu records of atmospheric pressure are especially desired, as it is in this vicinity that cyclones which later pass over Samoa and the Cook Group are known to develop. Wireless communication from Atafu is expected to be instituted shortly, with special provision for transmission of weather reports.

Wireless weather reports were received twice daily from November to April (inclusive) from Papeete, Rarotonga, Nukualofa, Vavau, Fiji, Niue, and Norfolk Island. During the remaining months of the year, when the trade-winds blow fairly continuously and cyclones are almost unknown, a single afternoon report is broadcast. Weather reports from ships have increased considerably in number during the year.

Recent Investigations.

The tide produced in the atmosphere at Apia by the moon has been determined from the barometer readings from 1904–27. This work has been done in collaboration with Professor S. Chapman of London University. The moon produces a daily variation in the barometric pressure at Apia of about $\frac{8}{1000}$ in. The hourly variation when the moon is in perigee differs considerably from days when in apogee. A paper giving the results of the investigation will be published in a forthcoming number of the *Quarterly Journal of the Royal Meteorological Society*.

The blue of the sky was measured twice a day for the past eighteen months on a standard scale of blue tints varying from bluish white to deep ultramarine. The sky at Apia was found to be relatively whiter than might be expected from the frequent expressions of the intense blue skies of the tropics. The sky was found to be deepest blue after heavy rains had presumably washed out the deliquescent aggregates of common salt.

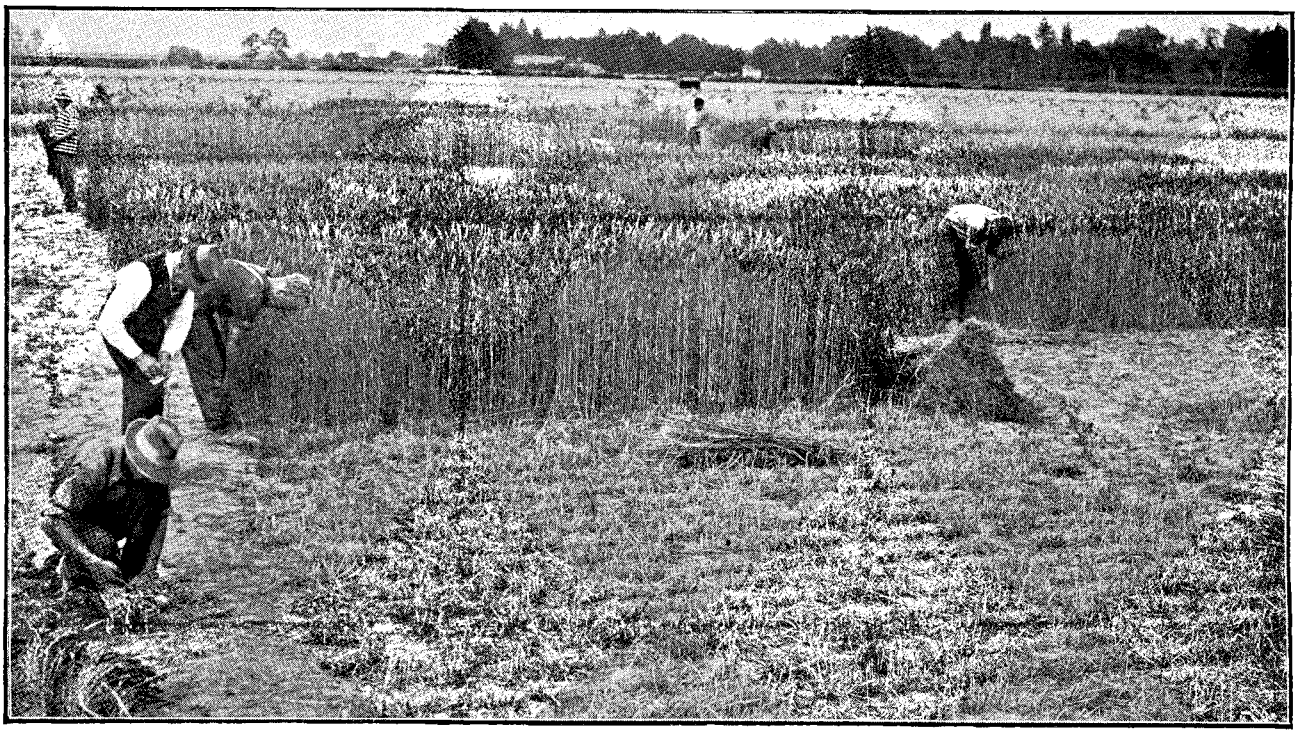
A careful series of weather observations from the New Hebrides from 1914 to 1924 was recently sent to the Observatory. Very little has been known about the meteorology of this large and important island group, the most recent published data being based on observations taken about 1870. A paper has been prepared on the 1914–24 observations and will be published in the near future.

Approximate Cost of Paper.—Preparation, not given; printing (1,000 copies, including illustrations), £85

By Authority: W. A. G. Skinner, Government Printer, Wellington.—1929.

Price 1s. 6d.]

PLATE 1.



WHEAT-TRIALS BEING HARVESTED AT LINCOLN COLLEGE (page 9).

PLATE 2.—XANTHIN CALCULUS FORMATION IN SHEEP'S KIDNEYS (PAGE 29).

The result of pasturing on mineral-deficient areas, Nelson Province.

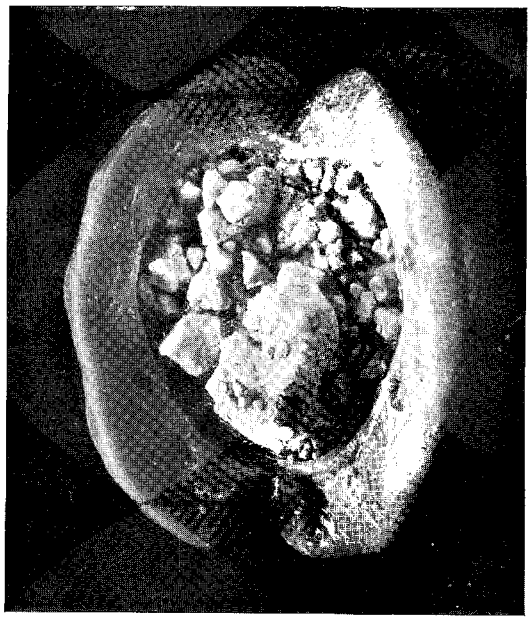


FIG. 1.—ENLARGED KIDNEY OF SHEEP.
The calculi weighed 41 grammes.

FIG. 2.—SMALL KIDNEY, THE COMPANION OF THAT SHOWN OPPOSITE.
Note early stage in calculi-formation.

PLATE 3.—PHORMIUM BREEDING AND SELECTION (PAGE 32).

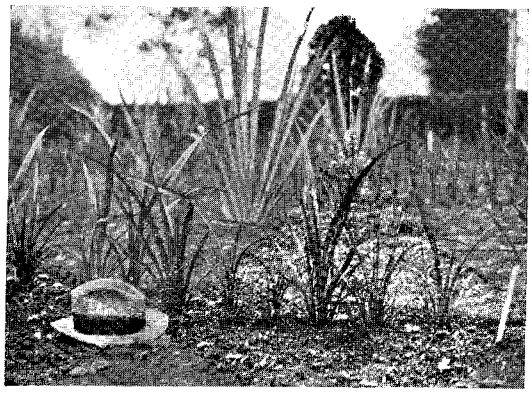


FIG. 1.—YEARLING PLANTS OF VARIETY 13K.

FIG. 2.—YEARLING PLANTS OF CROSS SS × 13K.
Note the great stooling.