1931.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(REPORT OF THE).

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

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The Right Hon. G. W. Forbes, Minister of Scientific and Industrial Research,—

I have the honour to submit herewith the annual report of the Department for the year 1930–31.

E. Marsden.

SECRETARY'S REPORT.

The Research Council has held five regular meetings during the year, at which there have been full attendances, and, in addition, there have been numerous committee meetings.

The personnel of the Council is as follows :—

Mr. George Shirtcliffe, O.B.E. (Chairman).
Professor Henry George Denham, D.Sc., M.A., Ph.D., Professor of Chemistry, Canterbury College, Christchurch.
Mr. Quentin Donald, Featherston.
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 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. Ernest Marsden, M.C., D.Sc., F.N.Z.Inst. (Secretary).

The expenditure of the Department during the year was as follows :—

	£	Recoverable. £
Permanent services—		
Dominion Laboratory (with branches)	15,270	2,280
Geological Survey	7,894	186
Meteorological Office	9,065	298
Petrological Laboratory	668	452
Apia Observatory	2,728	400
Dominion Observatory	2,619	..
Lincoln College	3,700	..
Research investigations (including contributions)	42,028	25,285
Head Office, Publications, Research Scholarships, and miscellaneous, including £2,500 grant to Mawson Expedition	8,385	70

The Secretary of the Department left for England on the 19th July, 1930, to attend the Imperial Wool Research Conference at Leeds and Edinburgh, and the Imperial Conference on Standardization, returning to New Zealand on the 9th February, 1931. He also acted as one of the advisers to the New Zealand delegates to the Imperial Conference. This visit, coinciding with that of the principal research administrative officers of other Dominions and colonies, afforded an opportunity for numerous conferences on major research activities, visits to research stations in England, and conferences regarding the Empire Marketing Board activities and Imperial Agricultural Research Bureaux. The interchange of experiences in research activities, and arrangements for future co-operative effort, should be of considerable benefit. It is obvious that real co-operation in research investigations throughout the Empire, although an invisible link, may be one of the most effective means in binding together the Empire for mutual benefit of its constituent parts. It is unfortunate, perhaps, that the economic depression has been the cause of curtailment of co-operative work in several directions, since, undoubtedly, an excellent atmosphere for such work has been created, and the most cordial and helpful relations established between research organizations in the various parts of the Empire.

Taking a long-range view, the research activities of a country constitute one of the largest factors in economic prosperity; yet it would be calamitous if nationalism and national secretiveness were to be developed in research interrelations.

The activities under the control of the Department have made steady progress during the year, the effect of necessarily decreased finance being largely offset by the maturity of the various units, so that the groundwork of initial preparation has been covered; and experience and training are beginning to produce results more commensurate with the expenditure involved.

A brief *résumé* of the progress of various investigations is given here; the detailed results of investigations are published in bulletins or in the *Journal of Science and Technology* and the *Journal of Agriculture*. As in previous years, the reports of the Dominion Laboratory and the Apia Observatory are separately published.

DOMINION LABORATORY.

The Dominion Laboratory, with its highly trained staff and chemical facilities, is capable of dealing with a wide diversification of problems, and provides the scientific services necessary for the successful conduct of the various State Departments whose activities are concerned with problems of chemistry. Principal among these is the Health Department, for which a considerable amount of work is carried out in connection with the administration of the Pure Foods Act. Eleven other Departments also are served by the Dominion Laboratory, and, in addition, the Laboratory is associated with several specific research activities, among which may be mentioned fuel research, leather research, and investigations into the relation of iodine to human health.

The growing extent to which chemical problems are entering into the successful control of activities of Government and industry has increased the demands made upon the Laboratory.

Though the Laboratory is not concerned with the rendering of chemical services to a private enterprise, need often arises for Departments to explore the possibilities of industrial developments in new directions. On such occasions the facilities provided by the Dominion Laboratory render valuable guidance and indicate whether the proposals in question will assist the industry or will guide the introduction of new processes.

Among special investigations carried out may be mentioned the relation of iodine deficiency to incidence of goitre, ripening of bananas, solubility of various limestones, preservation of passion-fruit juice, examination of certain pastures for cyanogenetic glucosides, investigations of failures of structural and other materials.

Dr. J. S. Maclaurin retired from the position of Director of the Dominion Laboratory on the 31st March of last year. He joined the Public Service as Analyst to the Mines Department in 1900, and the scope of his work was gradually extended until all chemical work required by Police, Health, Customs, and all other Government Departments, except that of Agriculture, was carried out under his direction, and branch laboratories were established in Auckland, Christchurch, and Dunedin. In 1909 he reorganized the inspection of explosives and dangerous goods, and placed it on a sound working basis. In more recent years he was entrusted with the preparation and administration of the Gas Regulations. He leaves behind him a well-organized laboratory, with a keen and efficient staff; also a record of public service of which he may be justly proud. He was succeeded as Dominion Analyst and Chief Gas-examiner by Mr. W. Donovan.

Since his retirement Dr. Maclaurin has brought to completion an investigation on the bleaching of *Phormium tenax*.

GEOLOGICAL SURVEY.

During the year the field survey work of a further 869 square miles was completed, the survey being conducted in the Te Kuiti, Eketahuna, and Amuri districts. This brings the total area surveyed to date up to some 29,497 square miles, or a little over one-quarter of the total area of the whole Dominion (viz., 104,000 square miles).

In addition, two members of the Survey were engaged upon soil reconnaissance work, and have dealt with an area lying between Atiamuri and Te Awamutu, bounded on the north by the Rotorua Railway line. This work is designed to throw light upon the various volcanic showers that have covered the central plateau of the North Island, and whose characteristics place serious limitations upon the agricultural utilization of this area. The most important results that have emerged from this work are methods of differentiating between those soils likely to be bush sick, and, particularly, the rôle the available iron in the soil plays in the incidence of bush sickness.

While the work of the Geological Survey is fundamental in that it is concerned with the detailed examination of earth-structure, this information is of considerable practical value to those seeking to exploit the mineral and agricultural resources of the Dominion. The fact that the mineral-bearing areas, for the most part, already have been geologically surveyed has resulted in constant reference being made to the reports dealing with these districts, and frequently it appears that the dearth of information with respect to districts that have not been surveyed has imposed handicaps upon industrial developments.

Considerable work was carried out in conjunction with the Dominion Laboratory on tests of material from Arapuni, as regards the changes of dimensions and elastic constants with varying amounts of contained water. These measurements were used by Professor Hornell as a basis of his conclusions as to the cause of the breakdown.

METEOROLOGICAL OFFICE.

During the year the work of the Meteorological Office has been greatly facilitated by the location of the staff in the well-equipped new office building at Kelburn, adjacent to the Observing Station and to the Dominion Observatory. The new building has been designed to provide such facilities as render it a first-class observing station, while its proximity to the observing instruments and its being able to command such have been a means of facilitating observations and their interpretation.

The meteorological services are being called upon to an increasing extent to supply information of interest and value to Government and industrial inquirers. This information is improving owing to the greater degree of accuracy in the records made throughout the Dominion, and to the fact that opportunity has been taken to interpret records compiled in the past. In both of these directions, however, a great deal of progress still remains to be made.

Increasing use is being made in the prediction services provided, particularly the special radio broadcasting services to farmers, and although, owing to the financial stringency, it was necessary to curtail the broadcasting of weather reports to shipping during the year, which resulted in a falling-off in data from ships in New Zealand coastal waters, a fairly high degree of accuracy in forecasting was attained.

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, and the policy has been to take only those researches which the position of the Observatory, having regard to both latitude and longitude, warrants. Many other astronomical observations, such as the study of variable stars, sun-spots, meteors, occultations, and planets, are carried out by members of the New Zealand Astronomical Society, and the results are forwarded to the Observatory.

The special astronomical event of the year was the total eclipse of the sun in 1930, October 21–22, visible from the Island of Niuafo'ou, in the Tongan Group. An expedition from New Zealand was

the only British party to observe the eclipse. On the same island an American expedition also took observations. The weather was good, and both expeditions were successful. The New Zealand results comprised direct photographs of the corona, and photographs of the flash and corona spectra. The expedition is to be congratulated on the success obtained in the interests of eclipse astronomy.

In seismology, the standard equipment has consisted of two Milne-Shaw and one Milne horizontal component seismographs. As a result of the increased activity in the number of earthquakes recorded in New Zealand, considerable extra work has been involved in the working-up of seismological records. With the object of providing for more efficient instrumental recording of local earthquakes, additional equipment has been obtained, and is now in course of erection. This equipment includes a Galitzin vertical-component instrument, three Wood-Anderson horizontal components, an Imamura strong-motion horizontal and vertical components instrument, and an Ishimoto clinograph. At Suva, Fiji, there is a twin-boom Milne seismograph, the records of which are sent to the Dominion Observatory. Dr. T. A. Jaggar has presented one of his earthquake-recorders to the Observatory.

Seismographs now are in operation in the following towns: Wellington, Arapuni, Hastings, Napier, Wairoa, Gisborne, Stratford, New Plymouth, Takaka, and Christchurch.

A detailed account of the geological and seismic aspects of the recent earthquakes is in course of preparation.

PETROLOGICAL LABORATORY.

As in previous years, the rock-tests that have been made under standard conditions have shown that many of the rock-materials that occur most widely in New Zealand give good results, and are perfectly suitable for road construction. In particular, the hard feldspathic sandstone—greywacke—which is most widely distributed in New Zealand, has given very uniform and satisfactory tests on samples from all parts of the country. New Zealand granites give about average tests when compared with standards elsewhere, but they are not generally available for use. The basalts generally are good, but the andesites are often poor. In comparing the tests of New Zealand rocks with those from the United States it often is found that the abrasion tests in New Zealand are relatively low. It is thought that fragments of a more angular form have been used in the local tests. This matter shortly will be investigated.

Further samples have been collected in the Waikato for investigation in regard to the utilization of some of the huge formations of vitric tuff as building-material. It is satisfactory to note that the good qualities of this stone for building purposes are now recognized. One type of it is now being used in the construction of the Campanile tower at Wellington. It is confidently hoped that this will lead to a wide use of this type of stone throughout New Zealand.

The great number of samples dredged off Otago Heads were first dried and then graded. They were then treated with acid to remove the shell fragments and were again graded. The latter result must be considered the more important since the shells and shell fragments generally have been formed in place, and their presence is not related to the drift.

MINERAL CONTENT OF PASTURES.

The general object of the work is to investigate the mineral content of pastures with a view to determining the grassland areas in which deficiencies exist, and the most economical methods of alleviating the effects of these deficiencies.

The importance of the mineral composition of pastures is now recognized the world over, and the thriftiness of stock is largely dependent upon the presence of suitable minerals in adequate amounts in the grass and clover upon which they are grazing. There are, in all countries, districts where stock do poorly, and New Zealand is no exception to this rule. Fortunately, such areas where mineral deficiencies occur in the Dominion are restricted, and, while the trouble is serious to farmers located thereon, the fact that adjoining districts are perfectly stock-healthy often enables the whole to be successfully farmed. In the aggregate, mineral deficiencies do not constitute so serious a restricting feature of the Dominion's pastoral production as, possibly, might be assumed from the attention that has been given to them by investigators. Nevertheless, as they occur on land with great potentialities for production, the solution of the trouble well merits careful research.

The programme of investigations during the year has been continued at Ngaroma, Mamaku, and Mairoa, all of which places are located in the region affected by volcanic-ash showers. In the Poverty Bay, Wairarapa, Taranaki, and certain other districts the pastures have been examined with a view to ascertaining their seasonal variation in mineral composition. Evidence has accumulated testifying to the curative effect of the ingestion of iron compounds in all cases of bush sickness. Iron carbonate, found in quantity at Huntly, and hydrated iron oxide, supplies of which are available from Whangarei, fed to stock as licks or incorporated in ensilage, have proved effective in combating bush sickness of both cattle and sheep.

Dopiness disease of sheep in the Mairoa district has been overcome by the top-dressing of pastures with lime at 5 cwt. per acre and superphosphate at 2 cwt. per acre. The trials with this manurial application, which were originated some three seasons ago, have given continued good results, and thus enabled sheep to be retained on this class of country throughout the year, giving increased yields of both wool and mutton, with high lambing percentages. The control of bush sickness and dopiness by means that are economical and readily applicable by farmers should greatly help in the utilization of large areas of land of which the value has been at a very low level on account of the incidence of these two diseases.

Several pasture-analyses of the Wairarapa pastures have demonstrated that during the light rainfall period of late summer the phosphoric-acid content of the herbage fell to a very low level. This was associated with a rise in the lime content and a depression in the protein content, a state of affairs resulting in a deficiency disease (Waihi disease) caused by the bad balance of minerals in the diet of the stock.

The work of the Cawthron Institute dealing with Nelson soils and pastures has now enabled a complete picture to be made of the changes in pasture composition throughout the year, and the influence exerted on the composition by rainfall, manurial applications, and soil types. One of the most marked seasonal influences is that produced by periods of drought, which depress the soluble ash contents of the herbage. In March and April such depressions occur, and these are associated also with low percentages of nitrogen, potash, and phosphoric acid. Pastures, normally, are particularly rich in their content of these minerals in the spring months, subsequent to their being top-dressed. In all cases where sulphate of ammonia top-dressing was used the lime content of the herbage was reduced. The changes in the mineral composition of these pastures are now being associated with variations in stock health and thriftiness throughout the year.

PHORMIUM TENAX.

The botanical and cultural work on *Phormium tenax*, carried out mainly at the Massey Agricultural College, has suffered from the fall in the research levy on exports; nevertheless, thanks mainly to the capacity and energy of the Director, Dr. J. S. Yeates, very satisfactory progress has been made, and much more definite information now is available regarding improved varieties and the conditions under which *Phormium* may be profitably grown. It is unfortunate that this information was not available for the many flax-planting companies that have been inaugurated during the past few years, for in many cases the absence of such knowledge may have seriously jeopardized the chances of success of such ventures.

It is now probable that good varieties of leaf can be grown at an over-all cost of £2 10s. per ton, fibre content, uncut; and it is obvious that increased attention to the cutting, carting, stripping, &c., is necessary, so that the final baled-fibre costs may be sufficiently attractive to stimulate utilization and production. In this regard the following extract from a lecture by Mr. A. Wigglesworth, Chairman of the Vegetable Fibres Committee of the Imperial Institute (Jour. Royal Soc. of Arts, March, 1931) is significant: "Little or no attempt has, until recently, been made in the way of improving the plant [*i.e.*, *Phormium*] by breeding pedigree types, and no improvement has been effected in the process of scutching, with the result that the high wages now payable have raised the cost out of proportion to that of other fibres produced under more favourable conditions. But the Government is now alive to the necessity of research, so as to secure better-grade plants with a higher yield of fibre, and an improved method of preparing them, without which it is unlikely that the industry will be able to hold its own in competition with sisal."

While in England, the Secretary attended a meeting of the Vegetable Fibres Committee of the Imperial Institute, and, in addition, witnessed tests of strength of ropes made from *Phormium*, which tests were being carried out there; also trials of several decorticators under development. Arrangements have been made for field trials of one of these machines in New Zealand.

In addition to the work at Massey Agricultural College, and elsewhere, on improved strains of *Phormium*, there have been completed during the year an investigation of methods of bleaching the fibre, by Dr. J. S. Maclaurin, and tests of papermaking qualities of flax, the latter being carried out and published by the Bureau of Standards in the United States. For co-operation in the last-named investigation my Council wishes to express its gratitude.

Taking a general view of the situation, it would appear that with a continuance of effort on the part of all concerned and an intelligent application of the results there are good reasons for hope of a revival of the flax industry and for extended uses of the fibre for new manufacturing purposes.

FUEL RESEARCH.

The Fuel Research Station attached to the Dominion Laboratory has continued its work on the physical and chemical characteristics of New Zealand coals and the products of distillation at temperatures usual in low-temperature carbonization. Considerable work also has been carried out on briquetting, with a view to determining the amounts of pitch or other binder required to make good briquettes with various coals and chars of various degrees of fineness.

While in England, opportunity was taken by the Secretary to discuss the question of production of fuel oils by hydrogenation of coal, with representatives of the Fuel Research Station (Department of Scientific and Industrial Research), Dr. Bergius, representatives of I.C.I., and Standard Oil Co. He reached the definite conclusion that, given free, unfettered competition, oil from coal can compete with flow oil. Hydrogenation of certain black and brown coals for the production of petrol certainly is, technically, proved possible in both England and Germany; but the Secretary did not consider it worth while spending any money on such trials, for the next five years, at any rate, even if the industry had a tariff protection equivalent to the present duty on petrol.

Hydrogenation of crude oil to produce petrol, however, is a more practical proposition, although a plant to produce New Zealand's requirements would cost about one million pounds in New Zealand. If a plant with such an output would still involve heavy distribution costs, a better proposition would be a plant of about one-quarter the output required for the whole of New Zealand, situated at one of the main ports. A unit plant of such a size, it is understood, is not yet available; but one might well be developed; and it then might be a question of comparison with the costs—capital, running,

and obsolescence—of a distillation and cracking plant, taking into account the saleability of the by-products in the latter case, and the associated chemical industries using hydrogen (*e.g.*, ammonia, as fertilizer) and carbon dioxide in the former.

Such a plant would have political advantages, and also might be adapted to the oils from low-temperature carbonization plants, should a number of such be successfully developed.

Comment on production of oil from coal by low-temperature carbonization will be included in a general report on the technical aspects of fuel utilization in New Zealand, which at present is in course of preparation by a competent local committee and will be published shortly.

WHEAT RESEARCH INSTITUTE.

The Wheat Research Institute's year was one of steady progress in the breeding and selection, milling, baking, chemical, and economic investigations upon which its staff is engaged. One cross-bred variety of wheat, the progeny of Tuscan, New Zealand's best-yielding crop, and White Fife, one of the highest-quality Canadian varieties, gives promise of being able to surpass in climatic adaptation, yield, milling extraction, and baking-quality the best varieties now grown in the Dominion. Based upon the breeding and selection work is a thorough system of seed-certification, which has gone far towards assisting the production of better yields, and done much to simplify the problems of the miller and the baker. Each year an increasing area is being sown in certified seed of known variety, free from fungous pests and weeds, and is exerting a profound influence on the whole industry.

Very large numbers of milling tests were completed during the year, and, from these, millers were advised of the best procedure to adopt to provide flour of as even and high a grade as possible. Baking and chemical tests of all samples milled were also conducted, so that a great deal of valuable information has been secured regarding the effects of soil, climatic, harvesting, and storage factors on wheat-quality; and this, being made available to growers, millers, and bakers, has enabled measures to be taken by each with some degree of certainty as to the results to be expected, as against the random trials which previously were necessary.

Many problems of special interest to bakers have been investigated, particularly satisfactory results being secured relative to the use of milk in bread-manufacture. The work carried out has indicated that small alterations in the manufacture of dried milk have yielded a product of much greater use for improving the nutritive value of the loaf. As a result of investigations by the chemist, it has become possible to provide a wholemeal bread free from the drawbacks which previously were associated with this class of loaf, and in consequence its use has greatly extended.

In order that the savings in cost arising from the adoption of the header harvester might not be nullified through loss in quality, the Institute has provided an advisory service at harvest-time so that the grain dealt with by these machines was treated and seasoned in a manner best suited to maintain the highest quality, and in consequence it has been noted that harvesting wheat by this method has not resulted in any sacrifice in regard to quality.

It is worthy of attention that the scientific guidance which the Wheat Research Institute is rendering to these important industries is gradually producing results which are inspiring confidence in all three, and leading them each to secure their own future welfare by the adoption of improved methods established on a scientific basis.

PROBLEMS OF MEAT FREEZING, STORAGE, AND TRANSPORT.

During the year the extended survey of meat freezing, transport, and storage, carried out in conjunction with the Department of Scientific and Industrial Research in Great Britain and the New Zealand Meat-producers Board, was completed, and the results circulated to all concerned. An account of the work is in process of publication, and reveals avenues along which savings can be effected and by which an improved product can be placed in Smithfield. A quickened realization that improvements can be made is desirable; also application of the results obtained. In my opinion, freezing-works would do well to encourage their engineers to take an active part in this work and to display initiative, and give responsibility to progressive engineers and managers. The technical care taken in treatment of carcasses on the cooling-floor, and during freezing, storage, and transport, in certain foreign meat-works, is in marked contrast to practices in some works in New Zealand.

Mr. C. R. Barnicoat, who took part in the observations of the shipments of lamb in connection with the main survey, was retained at the Low Temperature Research Station to work for a year on the changes that take place in the fat of pork, mutton, &c., due to storage. An article has been prepared by him on "The Influence of Atmospheric Oxidation on the Palatability of Fats." In the case of mutton, the exposure of carcasses to ordinary temperatures for short periods during storage (*i.e.*, sweating) has a deleterious effect on the fat. In the case of pork, particularly for ultimate use as bacon, the effects are much more serious. It is realized that if we are to increase our exports of pig-products an increasing proportion ultimately will need to be used as bacon. Two possible methods of accomplishing this have been suggested. First, the frozen carcasses can be transported to Great Britain and made into bacon in factories there. Laboratory experiments have shown that very good bacon can be made from suitable frozen carcasses, and that inferiority usually can be traced to the frozen pork having been stored under bad conditions or for too long a time. Bacon equal in quality to Danish, or even better, can be made in Great Britain from frozen carcasses exported from New Zealand. Carcasses, of course, must be of the right conformation and properly finished, and the fat must be hard: soft, oily fats tend to become rancid during storage. It is far more important that the fat should be hard if the carcasses have to be frozen and used for the subsequent manufacture of bacon, than if they are to be consumed at once as pork or made into bacon for local consumption. Unless the fat is hard, rancidity tends to develop during storage and transport of the frozen carcass, although it may not

appear until the final product—bacon—is in the retailer's hands. This danger can be guarded against only by careful attention to the pig's diet. It is now generally accepted that fish-oils, certain fish-meals and meat-meals of large fat content, and maize, are especially liable to cause soft fat if used in too large quantities. The use of such foodstuffs, therefore, while often desirable, should be carefully controlled. It cannot be too strongly urged that pig-producers should exercise the greatest care in the feeding of their animals, so that the soundest reputation, based on quality, should be established for the Dominion's output of pork and bacon.

In co-operation with Lincoln College, the Waikato Pig-recording Association, and the Low Temperature Research Station at Cambridge, several shipments of carcasses of known life-history and feeding have been examined, and the results have proved valuable and have been published.

The second method of utilizing our pork for export—*i.e.*, the transportation of frozen bacon—so far has not proved promising. Opportunity must be taken here to acknowledge the valuable work for the Dominion carried out by the Low Temperature Research Station of the British Department of Scientific and Industrial Research. This is published in the Report of the Food Investigation Board for 1930, which merits full attention by all concerned in New Zealand.

QUICK FREEZING.

The Secretary returned from England via America to report, *inter alia*, on the developments in regard to quick freezing. It is realized that should this method of freezing—generally associated with the selling of frozen products in packets—quickly develop, it would have a profound significance so far as our export trade is concerned, particularly in regard to the possibilities of export of beef and fish. An abstract from this report is appended.

PLANT RESEARCH STATION.

Marked advances in a number of directions have characterized the activities of the Plant Research Station during the year. Measures have been devised whereby effective control of the serious club-root disease of turnips is now possible. This can be achieved by the use of resistant strains and the application of lime and non-acid phosphates to the soil. The simplicity of the necessary precautions is such as will make very easy their adoption by the farming community, and will make it possible again to grow swedes and turnips in many areas where on account of the ravages of this disease they have been abandoned as farm crops.

Steady development in connection with strains of pasture grasses and clovers has proceeded, and, through certification, the time is fast approaching when it will be possible, by the proper utilization of approved strains of pasture plants, to increase the per-acre stock-carrying capacity of the Dominion's grassed lands. It is a matter for much satisfaction to know that the local strains of rye-grass, cocksfoot, white clover, and other grasses, under trials conducted at the Plant Research Station, have shown themselves to be unsurpassed by the best imported lines in their suitability as permanent pasture grasses.

Control of dry-rot of swedes has been shown to be dependent upon the use of disease-free seed, supplies of which it is possible to grow locally; wheat-rust has been controlled by the use of sulphur dusts, but, while this is not practical except on small plots, useful light has been thrown on a baffling problem; great improvement in the growth of lucerne has been secured through the use of special cultures; investigations of strains of rape and lucerne have been commenced, and show promise; in top-dressing, experiments have shown the best times for application of fertilizers and the advantages accruing to frequent small applications of phosphates.

The foregoing indicates only some of the advances made by the Plant Research Station along its two main lines of endeavour—(1) the control of limiting factors, such as disease, upon crop-yield; and (2) the adoption of such measures (strain selection, top-dressing) as will give positive yield-increases. Similar progress has been made with almost every farm crop. Such progress comes most opportunely at a time when low prices have adversely affected farmers' returns; and its application will have some influence, not only in mitigating these losses, but in giving hope and encouragement for the future through higher yields per acre.

By means of a system of certification, based on research, it will be possible, rapidly and surely, to put into practice the new advances made, so that the standard returns from farming will show a steady increase. It is probable that no other branch of the Department's activities has such possibilities in this direction, since the foundation of the Dominion's wealth rests upon the use to which it puts its soil, pasture, and crop resources. The advances being made at the Plant Research Station warrant every assurance that the Dominion will be well situated to take early advantage of any improvement in the economic outlook as soon as such occurs.

DAIRY RESEARCH.

During the past year the Dairy Research Institute at Palmerston North has continued its investigations of cheese problems. It has been shown—(*a*) That the pasteurization of milk for cheesemaking as commonly practised in New Zealand is not responsible for any type of openness of texture; (*b*) that the pasteurization of average quality milk results in a cheese of a cleaner flavour, but the use of finest-quality milk results in cheese of a fuller Cheddar flavour at an earlier age than does the pasteurized milk; (*c*) that where it is impracticable to manufacture raw-milk cheese the temperature of pasteurization should not exceed 160° F., because above this limit the cheese develops a somewhat bitter or slightly acid flavour rather than a full Cheddar flavour—at temperatures between 150°–160° this difficulty is not observed; (*d*) raw-milk cheese matures rather more rapidly than does pasteurized-milk cheese; (*e*) when milk is pasteurized at a temperature above 165° the body of the resulting cheese is soft and most unattractive; (*f*) pasteurization of milk distributes the fat evenly throughout

the cheese without increasing the fat-loss, whereas raw-milk cheese made from high-testing milk often contains visible pockets of fat: these are largely avoided in the same milk when it is pasteurized; (*g*) the pasteurization of milk slightly increases cheese-yield to the extent, on the average of 0·02 lb. of cheese per pound of butterfat. Further studies of effect of salt on cheese-quality have shown that the addition to curd ot large quantities of salt results in cheese with a distinctly gritty body, which is not wanted by the cheese trade. Analyses of a number of export cheeses have been made for salt content, and it has been shown that high salting is one of the factors responsible for grittiness in our export cheeses. It also has been shown that other factors—for example, high acidity and excessive sweetness—are responsible for gritty body.

In regard to openness in cheese-texture, it has been shown that the common types of openness are not due to only one cause. Whilst much remains to be understood regarding openness, it has been demonstrated that, firstly, the manufacture of cheese containing an excessive amount of moisture results in accentuated openness. Secondly, the lack of development of sufficient acidity in curd at the time of salting is another cause. In some cases this is practised in order that the process of manufacture may be hastened: the results are injurious to quality. Thirdly, when care is taken to add curd to cheese-hoops in small quantities, and thoroughly pack the curd into position, a much closer cheese results than when the curd is simply thrown in without proper packing. Fourthly, slit openness tends to disappear, or, at least, become much less accentuated, as the cheese matures. Thus one method of effecting an improvement in the texture of export cheese is to mature it more thoroughly before exporting it for sale. Fifthly, a mature cheese does not crack so badly on the exposure of the cut surfaces as does an immature cheese. Sixthly, the use of active, pure starters is essential in the production of good-quality cheese. Seventhly, efficient control of the purity of milk-supply is essential to the reduction of difficulties in the manufacture of good-quality cheese in the Dominion. Extensive studies have been made of (*a*) the effect of milk of high fat content on the quality of cheese; (*b*) different methods of keeping starter mother cultures; and (*c*) factors affecting the maturity of cheese. Results are not yet available, as some of the cheese in these studies remain to be examined.

With a view to developing rather more flavour in export butter, experiments on the use of starter have been tried out. It has been shown that the discriminate addition of starter to cream for butter-making results in butter with an attractive flavour if finest-quality fresh cream is used. The addition of starter, however, to cream of lesser quality than finest does not materially improve the flavour and endangers the keeping-quality of the butter.

Important developments have taken place in chemical analysis of cheese to indicate the break-down of the casein or protein as an indication of the extent of development of the maturation process. The aim is to develop a chemical method to indicate the degree of ripeness, so that the optimum conditions may be worked out for storage and transport of cheese with a view to delivering a mature product on the London market. These chemical methods have been developed at the University of British Columbia, and as a result of the Secretary's visit to this Institution close liaison with this work has been established. At the same time, the laboratory at the Dairy Research Institute is concentrating on the influence of the various types of starter organisms on cheese-maturation and the more exact effect of renneting.

WOOL RESEARCH AND WOOL CONFERENCE.

These are dealt with fully in Bulletin No. 30, just issued, and entitled "Wool Research," by D. J. Sidey; and a full treatise on the influence of various contributory factors on wool quality, and the technique of their measurement, is under issue by the Empire Marketing Board. It would appear that we are at last getting down to the fundamental factors in fibres in wool which are of importance in manufacturing, and their significance to the breeder.

GEOPHYSICAL SURVEYING.

One of the subjects investigated by the Research Subcommittee of the Imperial Conference was the application of geophysical methods of surveying for minerals, geological structures indicating oil, &c. The results of the recent Imperial geophysical survey were discussed, and the Committee were fortunate in having witnesses with practical experience of the various methods. As a result of the deliberations the Committee passed the following resolution: "That geophysical methods of prospecting have been developed to a point of definite usefulness, and that their employment in the search for minerals and oil deposits is justified, provided that the work is carried out under proper scientific supervision and in close association with the geological survey of the area concerned." It is unnecessary to discuss here in detail the various methods and their application, as the results of the survey now have been published in detail—"The Principles and Practice of Geophysical Prospecting," reviewed in the *New Zealand Journal of Science and Technology*, October, 1931.

STANDARDS AND STANDARDIZATION.

One of the most important conferences attended was that on standardization. Representatives of all of the Dominions were present, as well as of the colonies, the Board of Trade, British Department of Scientific and Industrial Research, British Standards Association, and Federation of British Industries. The resolutions passed are contained in your report to Parliament (A.–6, 1931, p. 31).

The questions were discussed under two main divisions—(1) Fundamental standards of length, weight, light, electricity, &c.; (2) industrial standardization. With regard to the first question, satisfactory agreement was obtained and steps taken for the removal of the significant differences between fundamental measurement units in different parts of the Empire with a view to the adoption of uniform standards, and periodic reverification of local standards. Advantage was taken of the presence in London of the Law Draftsman, and conferences were held with officers of the Board of Trade with a view to bringing legislation on standards in New Zealand into conformity with that in Great Britain. The second, wider question of industrial standardization, with a view to reasonable uniformity within the Empire, led to a valuable exchange of opinion, and highly satisfactory progress was made towards intra-Imperial unity.

It is generally agreed that the adoption of standard specifications of dimensions, material, and method can be usefully applied in many branches of industry, with resulting national economies, and with advantage to industry. The move in this direction in Britain and the other Dominions has been accelerated in recent years. As a result of the conference, arrangements were initiated by which the Dominions' standardizing agencies are to be consulted before final publication of British Standard Specifications. The Dominion representatives generally advocated the basing of their local specifications on those of Britain, with local variation where necessary. Recommendations also were made regarding the marking or branding of materials and equipment, which thereby are guaranteed by the makers to comply with National Standard Specifications.

It was decided that, in addition to consideration of standardization in regard to dimensions and materials, and simplified practice, it was desirable that reasonable agreement should be aimed at regarding regulations and codes, and that these questions should be considered by the local standardization agency, since they have a direct bearing on manufacture. It was recommended that the local standardizing authority should be established as an independent body, comprising representatives of manufacturers, technical men, and users, but assisted by Governments, with close liaison through appropriate Departments. The British Standardization Authority, which started as an Engineering Standards Association, is in process of reorganization as a National Standards Association with four coequal and largely autonomous main divisions for engineering, chemistry, building, and textiles.

The incidence of standardization in agricultural products, &c., was not discussed at the Standards Conference, but the Research Sub-conference discussed certain aspects of the subject, particularly with regard to certain standards under consideration by the British Ministry of Agriculture, and arising from work financed by a grant of £40,000 per year from the Empire Marketing Board, and the following resolution was passed :—

> "*Agricultural Standards.*—The Research Committee of the Imperial Conference desire to draw attention to the assistance which might be rendered to intra-Imperial trade in certain agricultural commodities by reasonable uniformity of standards or grades, and urge that those responsible for formulating regulations of this character in each part of the British Commonwealth of Nations should bear this aspect in mind."

Discussions took place with manufacturers and the Cotton Research Association regarding the setting-up of standards for cheese-cloths and mutton-wraps as a basis of tender. This would involve careful trials of the most suitable types, but would avoid the aspect of the alleged claims of unfair competition from certain foreign countries.

FRUIT RESEARCH.

During the year, thanks to the co-operation of the Fruitgrowers' Federation and the Empire Marketing Board, an experimental orchard has been secured at Appleby, Nelson. Located on typical Moutere Hills soil, and containing some 29 acres of mixed export varieties of apples and pears in full bearing, together with a large vacant area to be used for further planting, this orchard will serve admirably for dealing with the major problems confronting the fruit industry. With a view to commencing manurial and spray trials at an early date, yield records of all of the trees have been kept. The work at this orchard will be associated with the investigations carried out at Cawthron Institute and at the Plant Research Station, and the field work of the Department of Agriculture, so that fruit research work will be proceeding in all of the main orchard areas of the Dominion. The general programme already decided upon, and in part commenced, will deal with rootstocks, manurial and cultural methods, the control of insect and fungoid pests, and cold-storage trials. The cold-storage investigations at Cawthron Institute are steadily revealing the best range of temperature and humidity for each variety of apple in order to reduce to a minimum the amount of wastage during storage. A limited amount of overseas-transport investigation was conducted during the year, initial trials indicating that the adoption of all-round wraps, using corrugated cardboard linings in ordinary fruit-cases, reduced the amount of damage due to bruising.

MISCELLANEOUS.

As a result of visits to European linoleum and other factories, a valuable report has been prepared by Dr. Hosking on the types of gum required and their uses. The report indicates the value of further study of our kauri resources with a view to providing a product more in accordance with the requirements of manufacturers. In view of the inroads made by the use of synthetic gums in this industry, the need for protecting our national product by scientific methods has become all the more pronounced.

In co-operation with the Department of External Affairs, work is being carried out in Samoa on the distillation of essential oils and bases for perfumes from some of the more promising plants indigenous to these islands. Samples have been forwarded to prominent manufacturing works on the Continent for estimation of value. There are distinct possibilities in this direction.

Work has been carried out on the ripening of bananas received from Niue and Samoa. Laboratory experiments would indicate that the best humidity to ensure ripening without mould-growth is about 80 per cent., and the best temperature 64–72° F., but these have yet to be confirmed upon a larger scale. An addition of about 1 part in 2,000 of coal-gas or acetylene to the air in the ripening-room ensured a better colour to the product and better ripening. The experiments carried out by us at the Dominion Laboratory are being continued.

Apart from specially organized activities, the Department during the course of the year has received hundreds of requests for scientific information on matters concerned with the primary and secondary industries of the Dominion. There can be no doubt that in this field, in so far as its resources will permit, the Department has met a definite want.

QUICK FREEZING.

In accordance with your directions, I returned from England via America to report, *inter alia*, on the developments in regard to "quick freezing." The following brief report outlines some aspects of the position:—

The present practice in New Zealand is to export frozen lamb almost entirely as carcasses, and it is unusual, even in the case of cattle and sheep, to cut the carcass and export it in the form of joints. The freezing process invariably consists of allowing these to remain at a temperature of about 0° F. for a day or so until frozen. Prior to freezing, the carcasses are usually held on a cooling-floor from twelve to twenty-four hours, and recently numerous works have attempted to eliminate part of the 2 to 3 per cent. of moisture loss (shrinkage) occurring in this stage, by placing the carcasses almost immediately after dressing into the freezing-chamber. This modification of making the treatment a more rapid one should not be confused with that of "quick freezing," in which process the choicest cuts (steaks, fillets, chops, &c.) and edible small-goods (kidneys, livers, sweetbreads, oxtails, &c.), as well as fruit, and especially fish, are moulded, frozen, and wrapped in such a manner that the purchaser may receive them in a condition which is claimed to be almost indistinguishable from the fresh material. The temperatures employed in this "quick-freezing" process are usually of the order of —50° F., and special machinery is necessary. For reasons which will now be explained, the so-called "drip" (on thawing), which is the greatest difficulty and problem found in ordinarily-frozen meat, is largely obviated.

So-called "quick freezing," as applied to fish, meat, and small fruits, has very rapidly developed in America during the last two years; and probably the greatest impetus to its application to meat has been the development of the chain food and grocery store, and the move towards the marketing of foodstuffs in packages or cartons.

The ordinary methods of freezing by placing the product in a "freezer," as in New Zealand, are fairly satisfactory in the cases of lamb and mutton; but beef, when placed in the same freezer, because of its thickness, naturally cools internally much more slowly than does mutton, and the resulting product is neither so palatable nor of as good texture as is the fresh meat. It has been generally understood that this slower freezing of the meat-juices results in the formation of large ice-particles, which fracture the cells, alter the texture, and cause a drip of juices after thawing. For the same reason, fish fillets, because of their higher percentage of water (80 per cent.), suffer the same action on being frozen, although they are smaller and the penetration of cold takes place more rapidly than in the case of beef.

The developments in America were based largely on this theory of formation of ice-particles during freezing; but it is now obvious that there are many more fundamental factors involved in the preservation of the meat proteins in their pristine condition as regards flavour, &c., and that the true explanation of what happens is to be found largely in the province of colloid chemistry rather than in that of mechanics.

The proteins in meat, and the characters giving rise to flavours which one associates therewith, are of extremely complex chemical constitution, and are unstable in that they are liable to undergo changes during storage. Moreover, in the juices there are mineral salts, and the concentration of these mineral salts in the freezing process, due to the removal of water as it freezes out as ice, reacts on the nature of the proteins and their holding-power for "bound" water.

In some respects the problem is analogous to that of the homely custard, which, properly prepared and stored, keeps its moisture and its jelly-like constitution; but under certain conditions the custard is a failure because it parts with its liquids and breaks, or fails to set, and in consequence is less suited for the table. In other words, the holding-power for fluid of the custard is in some way lost.

Considering first the juices in the meat, which we can compare to saline solutions: On freezing, the ice-particles produced are at first of almost pure water, and the slower this freezing process, the more can this water be transmitted through the muscle substance and *accumulate* in large crystals, causing a rupture of the cells.

In quick freezing the juices are more or less frozen *in situ*, and the ice-particles which separate out from the juices are microscopically small, and do not rupture the cells. It must be remembered that the freezing-point of a solution is lower than that of pure water, and consequently the juices are never wholly frozen, because, as ice crystallizes out, the strength of the salt solutions in the remaining juice is concentrated, and the freezing-point successively lowered, and at any given temperature there is a definite ratio between water in the solid state and the water in solution. If during storage, even, of quick-frozen products, any fluctuations of temperature occur, the tendency is to reproduce the big crystals characteristic of the slow-frozen product, because with each slight increase of temperature more ice must go into solution—that is, as temperature rises, the ratio of solution to ice increases. Much of the ice that goes into solution in this condition is that of the smallest of the crystals, which thereby disappear, and when, later, the temperature may fall again, there is a tendency, when this water goes back to the solid state, for it to deposit on the crystals already formed rather than to form new ones. For this reason alone, problems of storage and transportation of quick-frozen meat-products are of paramount importance to New Zealand. Apart from fluctuations of temperature, which are unavoidable, but which can be minimized, there is a far more important factor in the storage of quick-frozen products. As stated above, there is always some of the juice in the liquid state, whatever the temperature. The juice is more concentrated in salts, and the action of this solution on the protein may gradually accelerate changes in the latter, and the subtle alterations of the protein affect mainly their property of acting as gels and holding moisture, and, apparently, the particular chemical constituents of these proteins which give rise to flavour are the things that alter.

This change of the protein is known as an "irreversible" change, because when the meat goes back to normal conditions the protein does not reabsorb its moisture or resume its original chemical composition. When the rate of change is estimated at different temperatures in the

laboratory, it is found that there is a maximum rate of change or deterioration at about 16° F., this, unfortunately, being the temperature at which we normally store and transport meat. The rate of irreversible change falls off both as the temperature is increased above 16° F., and as the temperature decreases below that figure. It is small at about 30° F.—*i.e.*, the temperature at which Argentine exports her chilled meat. It also progressively decreases towards 0° F., and for many years practice in America with ordinary frozen meat has been to keep the meat at much lower temperatures than are customary in New Zealand because of the preservation of flavour, apart altogether from the question of ice-crystal formation.

It will thus be realized how important it is that, if quick-frozen packaged goods are to be manufactured in New Zealand for transport to the Old Country, the paramount question is *proper storage and transportation*. In fact, this is an all-important but, so far, relatively neglected question, independent altogether of introduction of quick-freezing processes, and has far-reaching consequences in the store in New Zealand, in transport to the wharf, the speed of loading, and proper conditions during both transportation and unloading in England. I regret to state, however, that the case is similar to that of the changes of proteins in cheese, in that the fundamental chemistry is little known, and there are few people who have the necessary training to tackle the problem. As illustrating this point, I found that several chemists attached to the companies preparing quick-frozen packaged meats are still groping on this problem, and the only people from whom I could obtain an at all reliable viewpoint were biochemists—one in the University of Chicago, one in the Leland Stanford University, California, and the other the President of a large packaged-fish factory. In the former case I tracked down the expert working on the question because some other researches had indicated that the holding-power for proteins without change was fundamental to the question of whether certain varieties of wheat could withstand frost, because prolonged exposure to low temperatures caused the water in the wheat-germ to become free instead of bound to the protein; also the question of whether certain pests of wheat could winter over appeared to depend on the holding-power for water at low temperatures of the protoplasm in the insect.

The changes in our frozen products during transportation and storage should have been studied from this point of view for many years; and it cannot be too strongly pointed out that similar work should be carried out in New Zealand, even from the point of view of our present exports. Any development of the quick-frozen packaged meats or fish for transport to England will be fatal unless the right type of men are watching the experiments.

These preliminary semi-scientific considerations are necessary for the proper understanding of the developments of the packaged-meat trade.

That further expansion in the packaging of chilled, as well as quick-frozen meats seems assured, is undoubted, and the recent very expensive case conducted on behalf of the large national meat-packers in America for modification of the so-called "Packers' Consent Decree" is eloquent testimony to the way in which this development is viewed abroad. At present some of the big meat-packers in America cannot enter the retail business. The evidence in this Court case is included in two volumes, which make very interesting reading. The packers, through the Supreme Court, asked for modification of the Packers' Consent Decree in two main directions: Firstly, they desired to enter the retail business as a bargaining force against the chain-store companies who were threatening to enter the packing business so as to supply their own retail stores; secondly, the big meat companies asked the Court's permission to use their branch houses and stores to capacity by handling other food lines. Their anxiety can well be understood when it is remembered that even to August, 1929, 260 of the biggest grocery chains in America had added meat departments to some of their stores. The evidence of Swift's in this case may be briefly synopsized as follows:—

> "Mr. G. F. Swift, Vice-President, Swift and Company, Chicago, testified that his company is experimenting with their own process of quick freezing of foods, which has not been patented. They are selling a small quantity of these products. Although not an expensive process, the lower temperatures require more power in machinery. One of these units costs from 5,000 dollars to 25,000 dollars, depending on the size of the branch or plant, the volume of products handled, &c. About 25 per cent. of his company's branch houses have freezers which carry a temperature of between zero and 16 degrees. (Pp. 2080–95.)"

The evidence of another big packing concern, which is a part of General Foods Corporation, and controlling the "Birdseye" process, is also to the point:—

> "Mr. Frederick S. Snyder, president and general manager, Batchelder and Snyder, Dorr and Doe, Boston, Mass., testified that the quick-freezing process cannot be promoted rapidly for the benefit of either the public, the packers, or the stock-raisers unless all packers have the same freedom of action enjoyed by intermediate packers and chain stores. The leading chain stores purchase in car-load lots, ship to their own warehouses, and spread overhead of delivery, avoiding use of packers' branch houses for that purpose. Some chain-store organizations have undertaken the processing of meat products. The Kroger Grocery and Baking Company has put two packing-houses into operation since 1920, while the First National Stores of Boston have a plant for curing and processing meats with the most modern equipment. The quick-freezing process will entirely change packing-house operations from mere slaughtering to the packaging and shipping of identifiable meats, leaving the inedible parts behind. The only salvation for the big packer is to use his branch houses to capacity by handling other lines, and having freedom to do the same as the next hundred packers do. (Pp. 777–860.)"

There are other considerations regarding storage of fats in the meat, and the effects on enzyme action of rapid freezing, and the development of suppressed rancidity. Certain fats must be stored below 5° F.; and this applies also to the unsalted butter.

I have stated in the foregoing that the development of quick freezing and packaged meats owes its impetus to newer methods of marketing in America. The two major changes that have occurred

in the food industry since 1920 are the consolidation of retail outlets in the hands of regular and voluntary chain-store organizations and the concentration of control in the sale of manufactured meat-products. For instance, in 1929 the number of such stores had increased to 60,000, with sales to 3,500,000,000 dollars. These 60,000 chain stores were operated by 900 separate corporations, and the seventy largest of these corporations owned 48,700 stores. The largest chain-store organization is the great Atlantic and Pacific Tea Company, and its sales in 1929 were nearly 1,000,000,000 dollars. I stayed for an hour in one of the stores of this company in Chicago, and watched customers enter the shop and choose quick-frozen packages from a low-temperature case, such purchases varying from roasts to chops, livers, &c. The meat was prepared by Swift's, and wrapped in moisture-proof "cellophane," indicating the brand, weight, and Government stamp, and was sold over the counter by a girl, probably earning £1 10s. a week, instead of by a butcher at £7 a week. The result is that the housewife need visit only one meat and grocery store and purchase the whole of her supplies there in attractive packaged form. Moreover, she need park her car only once.

It is claimed that this method of freezing and packaging of meat avoids some 4 per cent. shrinkage of stored meat, and some 6½ per cent. loss due to butchers' cutting wastes. Moreover, in certain circumstances, economies are possible in distribution costs. As an offset, it must be remembered that freezing costs at such low temperatures are higher, while the retail store must carry a freezing-cabinet. It is estimated that the cost of quick freezing, packaging, and storing, amounts to about 1½d. per pound of meat. For transport, however, twenty-seven lambs of 40 lb. weight each, when cut up, complete with package, occupy a space of 1 cubic yard; under present conditions, as carcasses, this amount of lamb would occupy about two and a half times the volume.

In America it is claimed that customers' prejudice against frozen meats is being overcome in this way. This prejudice, as stated above, is correctly based on inferior texture and flavour of the *slow-frozen* article; but I could obtain no evidence against the claim that quick-frozen meats, properly wrapped and stored, were in flavour inferior to fresh meats.

The main problem which at present is engaging considerable attention is the production of a properly insulated display cabinet and equipment to maintain the low temperatures desired. If such a method of marketing could be arranged in England, the advantage would be that our product would be placed on the market under its own brand and name. There may be strenuous opposition from Smithfield merchants and from retail butchers. Such opposition already is in evidence in America against package meats, but it will be accentuated manifold in Britain. It is probable that the retail butcher often succeeds in selling New Zealand lamb as English lamb in spite of the national "mark" scheme. It should be noted that in January of this year English second-quality lamb was sold at a premium of 2½d. per pound over New Zealand first-quality lamb, though this may refer to a demand to a certain extent specialized. Consequently, New Zealand is vitally interested, in that the first of such products sold should be of the very highest quality and in the very best condition. In the "Birdseye" system the smaller meat-cuts are wrapped in cellophane, placed in packages, and frozen by the machine. Roasts of beef are wrapped in cellophane, covered with an open muslin wrap, and quick frozen between the plates of the machine. From a study of the practice in America, and from the reports already furnished by the Health Inspectors in England, I do not foresee any difficulty regarding meat inspection of packaged meats, unless some subtle outlet is found for the propaganda which may temporarily arise from retailers.

Other firms are quick freezing their meats, in many cases doing the cutting after the freezing, in special very low temperature stores. I do not think that any firm has as yet fully developed its process to secure the full advantages of the method. They have been preparing packaged meats and relying on the novelty of the idea to sell the product, and using newer methods of distribution. Some samples of meats quick frozen by this method and examined by me undoubtedly showed signs of surface deterioration. Such frozen cuts of beef probably were inferior to those of "Birdseye," in that the wrapping had been carried out after freezing, and was loose, and considerable moisture had distilled from the meat and crystallized in big ice-crystals on the top of the meat, while, in addition, the surface colour had changed.

There are several methods of quick freezing on the market, apart from the above, and I am convinced that we in New Zealand can develop an effective method.

A more technical discussion of these various methods is hardly suitable for this report.

Regarding Fish.—In my opinion, there are ample possibilities in New Zealand in this connection, and the same quick-freezing machinery would be applicable. The industry would need to be developed on a moderately large scale and by-products worked up. In America there have been greater developments in regard to fish than has been the case with meat. The production of frozen package fish-products increased 71 per cent. from 1928 to 1929. Moreover, one firm—the Atlantic Coast Fisheries—which sold 2,000,000 dollars' worth of quick-frozen fish last year, has developed an additional safeguard to keep the fish in proper condition during storage. They introduced into the fish certain salts, which, although not infringing the Pure Foods Act, have the effect of rendering the fish-cells the better able to hold moisture after thawing, and obviating the drip and flabby appearance characteristic of fish that has been thawed after freezing. This development, unfortunately, is not applicable to meat; but even in samples of filleted fish, after long storage, it was possible to detect the chalky appearance of certain of the surface fish-cells, and this would detract from the value of the product.

Either quick-freezing and package methods, or export of chilled meat, which is now possible owing to the uniformity of temperature now obtainable in the ships of newer design, is not without significance from the point of view of export of beef, a very desirable development, which would assist in the better utilization of much of the land in New Zealand. Should a development of beef export appear likely it would be necessary to consider the question of importation of improved stock. Under the present changing conditions it is worth while to closely watch all the technical developments in regard to freezing and transportation. Fortunately, we now have in the country men competent for this if their services could be utilized in this direction.

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

DAIRY RESEARCH.

Advisory Committee: Hon. 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.

Investigations, which were referred to in the report for the year 1929–30, affecting the manufacture of cheese, were continued in the dairying season 1930–31, and trials on the use of starter in the manufacture of export butter were carried out. At the outset of the experimental work in 1929 special attention was devoted to the causes of "openness in texture," but as investigations have progressed it has become increasingly evident that consideration of this is inseparable from the study of cheese quality in general. Special attention, however, has been devoted to factors affecting texture, body, and flavour.

The removal of the laboratories in March, 1931, from temporary accommodation to better-appointed and more commodious quarters in the new Science Building of the Massey Agricultural College, has been a great improvement, and will greatly assist in the carrying-out of more intricate and extended laboratory investigations.

Types of Openness.

The appearances of mechanical, slit, and fermentation openness were described in detail in last year's report. During the present year it has been conclusively shown that slit openness does not necessarily coincide with the line of junction of milled curd particles; it just as frequently arises within the particles of curd packed in the cheese-hoops before pressing, and has no connection with the pieces of curd cut by the curd-knife. It generally starts to develop when the cheese has been three or four days on the curing-room shelves, and thereafter takes a fairly definite course of development, running at one end more or less parallel to the end and thereafter forming indefinite sectors of a circle with a centre in the direction of the line of application of pressure in the cheese-hoop. The defect is more accentuated in "sweet" or "overmoist" cheese than in "acid" or "normally made" cheese, but it is apparent that its development is a physical reaction of the chemical condition of the curd at the time of hooping. This in turn undoubtedly is dependent on the many biochemical changes occurring in the making process, and, in particular, on the individual and combined influences of the state of the cheese solids in the raw milk, the starter, and any extraneous organisms that may be present in the milk. These questions are being closely studied.

Practical Cheesemaking Experiments.

Whilst fundamental work is absolutely essential to the placing of cheesemaking on a scientific basis, it takes considerable time to obtain results which have direct application to practice. Thus straight-forward cheesemaking experiments which have a direct bearing on cheese quality have been carried out since the inception of experimental work. A detailed account of some of these was given in the annual report for the year 1929–30. The results of others completed since that time are reported hereunder.

Experiments on the Effect of Pasteurization of Milk on Cheese Quality.

A detailed statement of the methods adopted in carrying out this investigation was given in the last annual report. One hundred and nine pairs of cheeses were made from raw and pasteurized milk respectively. Most of these were exported to London, where they were examined by the London officers of the Dairy Division, at an approximate age of three to four months. The remainder were held in cold store at 50° F. in New Zealand from fifteen days old till they were four months old. When finally examined at three to four months none of the lots was really mature; but it was considered advisable to use grading at this age as a measure of quality, so that the treatment and results would be directly comparable with normal export produce. To secure information on the effect of holding for a longer period than the normal time taken to market export cheese, a certain number was held in store in New Zealand for a further period of two months. The following conclusions respecting cheese quality have been drawn from the experiment:—

(1) *Texture.*—The pasteurization of milk was not responsible for any type of openness. When openness appeared in the experimental makes the raw- and pasteurized-milk cheeses were affected alike. Pasteurizing temperatures of 165° F. and above resulted in very brittle curd, which lacked cohesion so much that difficulty was experienced in properly matting the curd. Yet the resulting cheeses were not open in texture; the grain of the cheeses, however, was coarse, and both body and flavour were badly affected.

(2) *Flavour.*—(*a*) With pasteurization of the milk by the regenerative flash method at temperatures between 150° F. and 160° F. the pasteurized-milk cheese graded better in flavour on the average at three to four months than the corresponding raw-milk cheeses, the average difference in sixty-eight cases being 0·7 points in a maximum of 50. The flavour of the pasteurized-milk cheeses was preferred in forty-one cases, and the raw in seven cases; in twenty cases equal scores for flavour were given.

Of those held in New Zealand till they were mature, the raw-milk cheeses made from finest-quality milk developed the fuller Cheddar flavour. This is a very significant point, since the more real Cheddar flavour that can be developed in reasonable time, the more acceptable to the consumer is the Dominion product. It is important to observe, however, that cheeses made from milk of lower grade than finest had less desirable flavours than those made from the corresponding pasteurized milk.

(*b*) When the milk was heated to temperatures which brought about slightly or distinctly cooked flavours in either the milk or freshly made cheese, the mature product usually had an undesirable flavour, generally bitter and acid, and altogether lacking in true Cheddar character.

(3) *Body.*—Whilst pasteurizing temperatures of 160° F. or less made no apparent difference in the body of the pasteurized-milk cheeses, temperatures above 165° F. brought about distinct pastiness and grittiness. Thus, of fifteen pairs of cheeses, one of each made from milk pasteurized at 175° F., the raw-milk cheeses were preferred in eleven cases, they were equal in three cases, and in only one case was the pasteurized-milk cheese preferred in total grading-points.

(4) *Fat-distribution in the Cheese.*—Raw-milk cheese made from high-testing milk frequently exhibited visible pockets of butterfat, while cheese made from the same milk after pasteurization showed this defect to a much lesser extent. No definite relationship was found to exist between the percentage of fat in the milk and the occurrence of these pockets of butterfat. As the season progressed, the tendency for free butterfat to appear visible decreased with milk of any definite fat content. Thus a cheese made from 4·2-per-cent.-fat milk may show free butterfat in the spring months, while a cheese made from milk of the same fat content in the autumn would exhibit no butterfat sacs. This is no doubt due to the decrease in the size of butterfat globules with advance in lactation period of the milk cows.

(5) *Cheese-yields.*—At temperatures of 150°–165° F., pasteurization of milk increased the cheese-yield on the average by 0·02 lb. cheese per pound butterfat when yields were based on weight of the cheese at fourteen days old. At a pasteurizing temperature of 175° F. the pasteurized-milk exceeded the raw-milk cheese yield by 0·1 lb. cheese per pound butterfat. This benefit was entirely offset by marked deterioration in body and flavour.

No benefits were derived from pasteurizing milk in a cheese-vat by the holding method at temperatures of 140°–150° F. for thirty minutes, as is practised with market milk. When the milk was treated in this way the cheeses more readily developed cooked and bitter flavours.

Control of Pasteurizing Temperatures.

It is most important in the pasteurization of milk for cheesemaking that temperatures be carefully regulated to avoid defects arising from the over-pasteurization of fractions of the milk. Experimental work has shown that many ordinary dairy thermometers with thick glass walls, while accurate, are not sufficiently sensitive to quickly register fluctuations in temperature that occur with variations in the flow of milk and steam through the pasteurizer. Care has to be taken to use good-quality, sensitive thermometers. Splendid results have been obtained with time- and temperature-recording instruments fitted with mercury in steel bulbs which are readily fitted to the pasteurizer at the point of maximum temperature of the milk.

The Waxing of Cheese-surfaces.

The experiments referred to in last year's report showed that the protection of cheese-surfaces with wax to avoid evaporation of moisture has no effect on preventing slit openness, although it decidedly reduces loss in weight of the cheese. Thus more is involved in the development of slits than the mere control of moisture-evaporation. Observations made in the present dairying season show that when cheeses carrying a high percentage of moisture are waxed, although apparently dry at the time of treatment, there develops between the wax and the rind a distinct sliminess, which has an objectionable smell and appearance. Cheeses of normal moisture content when waxed at fourteen days old do not develop this defect.

Care in packing Curd in Cheese-hoops.

Trials made of packing curd carefully and carelessly, respectively, in cheese-hoops in commercial factories have verified previous observations that the addition of curd to a cheese-hoop in small quantities at a time, followed by careful manual ramming of the curd, results in much closer texture than is the case when less careful methods are adopted.

The Salting of Curd.

Previous experiments have shown that the addition of large quantities of salt, as is occasionally practised, results in cheese with a harsh, brittle body. Later trials have shown that even an additional 2 per cent. above the normal makes an appreciable difference in body, the higher-salted cheese being distinctly less smooth in body. An increase in the proportion of salt effects an improvement in closeness of texture, but this benefit is more than offset by the reduction in character of body. On the other hand, too low rates of salting of curd (less than 2 per cent. based on the weight of well-cooked curd at salting) bring about a soft body, and frequently a bitter flavour.

It has been demonstrated that the salting of curd before it is ready for this treatment, as indicated by proper tests and the experience of the maker, induces distinctly more openness. Besides, the body of the cheese is made more pasty by this treatment, and the flavour is less attractive. It is, therefore, most inadvisable to hasten the completion of cheese-manufacture before the curd is ready for salting.

Trials on the effect of thoroughly incorporating salt with curd, compared with lack of mixing it properly, demonstrated that the best results are obtained by thorough mixing of the salt and curd at the time of salting, allowing the curd to absorb the salt for a little time (twenty minutes), and again thoroughly stirring the curd before putting it into the cheese-hoop.

A new method of estimation of salt in cheese has been developed and has been applied to the determination of the salt content of cheeses of firm, normal, and tender bodies, as delivered to the grading-stores at various ports in the Dominion. The results show that a harsh body in New Zealand export cheese is, in most cases, due to oversalting.

Figures also are available showing the variations in salt concentration at different places in a cheese, and in different cheeses from one vat; and experiments are in progress which will provide information as to the rate of diffusion of salt in cheese.

Starters.

A considerable amount of experimental work was carried out to determine the effect of keeping starters under different cultural conditions. The main object was to discover, if possible, the reason for the loss in vitality which starters often exhibit in practice. So far, the only treatment which seems to cause a rapid loss in vitality is incubation of the culture for several days at a temperature of 85° F. instead of at the normal temperature of 68° F. Even under normal conditions, however, and with extreme care in treatment, the two starters which were under experiment during the season both ultimately failed to produce acid at a normal rate in the cheese-vat. Furthermore, strains of these same starters which were maintained in daily culture, in milk prepared from a single batch of milk-powder, similarly lost their vitality. This suggests that under the conditions of the experiment the daily chemical variations in the milk used for the propagation of starter are not the cause of loss in vitality of the culture, but that there is some other reason of which at present there is no knowledge. This series of experiments will be continued in the coming year.

During the course of the above experiments a laboratory test was devised which makes it possible to determine in a few hours whether the starter will produce acid at a normal rate when used in the cheese-vat. The test rarely fails to give a true indication, and ultimately it will be possible for a cheesemaker to determine by this means which of several mother cultures to use in his vats. When the test has been sufficiently standardized, details will be published.

Purity of the Milk-supply.

A considerable amount of work has been carried out in the laboratory on the differentiation of organisms present in starters. Methods have been devised for the determination of the proteolyte activity of lactic streptococci. These methods will be applied in an investigation of the part played by the various bacteria in the process of cheese-ripening, with the ultimate object of improving control of ripening by the use of selected starters or modification of the manufacturing process. In future years the work will proceed with the assistance of a grant from the Empire Marketing Board.

Work was carried out on the effect of certain common contaminant organisms in milk on the production of acid by starter organisms, and a paper on the subject was published in the *Journal of Dairy Research*. Further work on the same lines is proceeding.

A paper was published in the *Biochemical Journal* on the effect of sunlight on the reduction of methylene blue in milk. Further information on the mechanism of the reaction was obtained, and will be published in due course.

Throughout the season the milk used in the experimental factory was examined daily by several methods which can be used for the grading of milk. A long series of figures is thus in process of collection, which will prove useful in determining the significance of the different tests. The daily microscopical examination of the milk has also proved an efficient method of keeping mammitis in the dairy herd under control. Early cases of the disease can be immediately detected, and the animals isolated and treated.

It has been observed that certain weeds—viz., land-cress, lupin, and pennyroyal—are responsible for distinctly undesirable flavours in cheese.

Methods of Improving the Maturity of Export Cheese.

Experiments have been carried out to determine immediate practical measures for improving the state of maturity of export cheese at the time of arrival in the United Kingdom. Observations made on various lots of experimental cheeses show that under existing export conditions cheese is not considered sufficiently mature for average trade requirements till it is six months old. The present trial aims at securing definite data on the effects of (*a*) maintaining factory curing-rooms at a temperature of 60° F. (many are not heated and register 45°–50° F in the spring); (*b*) holding cheeses on factory curing-room shelves for periods longer than the present standard of fourteen days; (*c*) holding cheeses in the grading-stores for periods of up to four months before export (many spring makes particularly are held only for fourteen days); (*d*) the use of rennet at the rate of 5 oz. per 1,000 lb. milk instead of 3 oz.; and (*e*) restricting salt added to curd to reasonable quantities. The final results of this trial are not yet available, but the progress report indicates that good-quality cheese of a desirable mature flavour, made from milk to which 4 oz. rennet per 1,000 lb. milk is added and containing normal amounts of salt, results from holding well-made cheese on factory curing-room shelves for one month at 60° F., followed by a holding-period of six weeks in the grading-stores at 50° F. before export. Such cheese is much closer in texture than is corresponding cheese in the immature state, and cracks less on exposure of the cut surfaces to the air. On the other hand,

cheese carrying excessive moisture, too lightly salted, too heavily salted, or held at low temperatures after making, does not mature normally.

Chemical tests have been carried out on the state of maturity of cheese used in this experiment. From the chemical point of view the results are very definite. They will be reported at the conclusion of the experiment in conjunction with the detailed results.

Butter Experiments.

During the 1929–30 season experiments were carried out with the manufacture of butter from cream to which starter was added. The highest degree of acidity in the cream was 0·17 per cent. Both fresh cream and neutralized cream were used. The results showed that when the butter was graded in London at three months old the starter butter made from fresh cream scored highest in fifteen churnings, the fresh-cream butter in eight churnings, and the scores were equal in fourteen churnings. At this age there was a little in favour of the starter butters when fresh cream was used. When these butters were held in New Zealand for six months, the starter butter scored highest in four churnings, the non-starter in five churnings, and equal in twenty-eight churnings. Thus after six months' storage period there was no material improvement from the use of starter. The butter made from neutralized cream scored differently. At three months old in London the starter butter scored highest in seven churnings, that without starter in six, and they were equal in twenty-four cases. After six months' storage in New Zealand, the starter butter was highest in three cases, the non-starter in three cases, and equal in thirty-one cases. Thus no advantage was derived from the addition of starter to neutralized cream.

In the season 1930–31 lots of butter were made from cream in which much higher degrees of acidity were developed. These ranged from 0·20 to 0·46 per cent. The detailed results have not yet been received from England, but cabled advice indicates that some of the starter butters developed "off" flavours and graded much lower than the fresh-cream butter. The results will be made public when available.

Experiments in Progress.

In the present season the following additional trials have been carried out, but all of the mature cheeses have not yet been examined: (*a*) Comparison of cheeses made from milk of high- and lower-fat content respectively; (*b*) comparison of cheeses made from standardized milk and low-fat-content milk respectively; (*c*) the pressing of cheese in different types of presses; and (*d*) determination of the pressure exerted on the cheese while in the cheese-press.

Publications issued.

(1) "The Influence of other Bacteria on the Production of Acid by Lactic Streptococci in Milk." By G. A. Cox and H. R. Whitehead.
(2) "The Reduction of Methylene Blue in Milk: The Influence of Light." By H. R. Whitehead.
(3) "The Methylene Blue Reductase Test." By H. R. Whitehead.
(4) "The Grading of Milk for Cheese-manufacture." By H. R. Whitehead.
(5) "The Influence of Bacilli of the Colon Group on Cheddar Cheese." By H. R. Whitehead.
(6) "A Note on the Direct Microscopic Count of Bacteria in Milk." By H. R. Whitehead.
(7) "The Estimation of Salt in Cheese." By F. H. McDowall and L. A. Whelan. (From the *Journal of Dairy Research*, June, 1931.)
(8) "Treatment and Disposal of Dairy Wastes." By F. H. McDowall. (Bulletin No. 27 of the Department of Scientific and Industrial Research.)
(9) "Temperature-change in Cheese and Butter." By F. H. McDowall. (From *New Zealand Journal of Science and Technology*, Vol. 12, No. 4, pp. 215–27, 1931.)

Co-operation with other Organizations.

The Institute has closely collaborated with the Dairy Division of the Department of Agriculture, the laboratory of the Taranaki Federation of Co-operative Dairy Factories, the laboratory of the New Zealand Co-operative Dairy Co., the Massey Agricultural College, the New Zealand Dairy-produce Board, and the other Branches of the Department of Scientific and Industrial Research. To all of these bodies thanks are expressed for their ready co-operation and valued assistance.

Finally, especial thanks are personally due to all members of the staff for their painstaking care in assiduously carrying out their work, and especially to Dr. McDowall and Messrs. Whitehead and Valentine for their valuable co-operation and advice at all times.

PLANT RESEARCH STATION.

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

Herewith I submit a synopsis of the main features of the work of the Station during the year. I particularly wish to place on record appreciation of the excellent work performed by all members of the staff, resulting in a large volume of valuable data being secured, which must be of great value in developing agricultural progress.

MYCOLOGY.

(1) *Club-root of Turnips and Swedes.*—Results of outstanding importance have been secured from this work, which has now been carried out for two seasons.

The following are the main features that give promise of great practical value :—

(*a*) No type of lime, even in excessive quantities, exercises any appreciable control when the seed is sown immediately subsequent to liming.

(*b*) Any type of lime, even in comparatively small amounts of 1 or more tons per acre, appreciably controls the disease if the seed is sown not sooner than three months after liming.

(*c*) The controlling effect of lime is nullified if the seed is sown with an acid phosphate.

(*d*) The controlling effect of lime is intensified if the seed is sown with a non-acid phosphate.

(*e*) Certain strains of the Bangholm type of swede are highly resistant against club-root even when sown on infested unlimed ground. These strains are being selected out and seeded for further trial.

(*f*) Promising resistant strains of Superlative swede have been isolated. When Superlative was first introduced it was highly resistant to club-root, but subsequently this resistance became largely lost through the development of non-resistant types.

(*g*) A selection of rape practically immune to club-root has been isolated.

(*h*) Much valuable information on host, range, soil, persistence, and means whereby soil becomes contaminated has been secured.

(2) *Dry-rot of Swedes.*—A continuance of the work on seed-treatment has shown that, so far, complete control can be secured only by methods that cannot be practically adopted by the farmer, but which can be used with success for the purpose of producing nucleus lines of disease-free seed. It has been shown that the complete control of dry-rot can be secured if clean seed alone is used. In order to effectively carry this out the best method would be for New Zealand to grow her own supplies of disease-free seed. In consequence, studies in methods of seed-production have been carried out, and these show that local turnip and swede seed production is practically sound.

(3) *Loose Smut of Wheat.*—Numerous pedigree lines of wheat have been treated by the hot-water method with a view to distribution of smut-free nucleus lines for future certification.

(4) *Wheat-rusts.*—Work has been commenced on the biology of the wheat-rusts, knowledge of which is a necessary prerequisite in the production of rust-resistant strains. It has been shown on the experimental area at Tiritea that by controlling rust by sulphur dusts high payable yields could be secured. Such treatment, however, is practical only on small trial plots, but this work has indicated how cheapening of wheat for stock-feed could be brought about in the North Island if wheats resistant to the rust types prevalent were available.

(5) *Potato-diseases.*—Much valuable work has been carried out on the control of corticium disease and the value of treatment of seed potatoes with acidulated mercuric chloride has been demonstrated. The fungi occasioning wilt diseases have been studied, and out of twenty-one different fungi that have been isolated only one species of *Verticillium* is responsible.

The virus diseases of potatoes are being intensively studied, and the production of nucleus lines of virus-free tubers is well in hand.

(6) *Lucerne Nodule Organism.*—During the year 29,000 lb. of lucerne-seed has been treated with culture provided by the Station, and the success of treated over untreated seed has been outstanding. Cultures for the inoculation of clovers, lupins, and other members of the pea family also will be available at an early date.

(7) *Sclerotinia Diseases.*—The blue lupin so valuable for green manuring is frequently affected with sclerotinia, and, when such is the case, subsequent crops grown on the same ground are likely to be affected. The production of nucleus lines of sclerotinia-free lupin-seed, therefore, has been undertaken, and shortly will be available for limited distribution for seed-growing purposes.

(8) *Fruit-tree Diseases.*—An important development of mycological research has been developed in connection with orchard diseases and their control. A three-years' programme dealing with the relative efficiency of all sprays in use by orchardists has been decided on, and experimental work in this connection has been started in numerous points in both the North and South Islands. Already very valuable results are being secured which have a direct practical bearing on fruit-tree-disease control.

AGRONOMY.

(1) *Pure-seed Production.*—The work on the improvement of standard varieties of cereals, legumes, potatoes, linseed, and other crops has been continued from the viewpoint of both strains and disease-freedom. The position has now been reached that much of the material is available for increase on a commercial scale, and will provide the nucleus material leading to certification. Of outstanding significance is the improvement that has been affected in many of our standard varieties of potatoes by the elimination of seed-borne diseases. It has been shown that there is a direct correlation between yield and the presence of such diseases, and in consequence their elimination by enormously increasing yield automatically reduces the cost of production.

Work of outstanding importance during the year has been that concerning strain in rape. The wide range in growth, palatability, and fattening-quality in different varieties of rape is a matter of great significance, particularly to the fat-lamb producer; and it is essential that the types should be carefully studied and standardized. This is work that will require several years before any definite conclusions can be drawn, but that already carried out indicates that questions of leafiness, recovery after grazing, and general type are as important in such forage crops as rape as they have been shown to be in grasses and clovers.

An intensive study of strain variation in lucerne also has been commenced, and selection work in this crop offers very great opportunities for practical successful exploitation.

(2) *Seed-certification.*—The seed-certification work of the Station, and its application by the Fields Division of the Department of Agriculture has developed greatly during the year. The value of such work is fully recognized by both growers and buyers, and it would appear as if within a very few years it will become general with all farm crops. The success that has attended potato certification and perennial rye-grass certification, based on the intensive research work carried on by the Station, has been particularly gratifying, and, with regard to the last-named, there seems little doubt that certified seed alone will be produced within a very few years.

Grassland Research.

(1) *Strain in Grasses and Clovers.*—This year marks the third year during which intensive work on strain research in grasses and clovers has been carried out. It has now been definitely shown that grass and clover seed crops can, by the technique that has been developed, be easily divided into their respective strain-types, and that certain types are far more valuable than others for pasture purposes. The fact that a system of testing can be applied to the ordinary grass and clover seed crops of the country, defining those that are superior to others, is of great significance. It has enabled a system of certification to be adopted which is of immediate value, and must have far-reaching value. In addition to this, the actual single-plant selection work and study that is being carried out will in the future provide the nucleus material for further certification.

Certification of grasses and clovers as it exists to-day represents discrimination between good and bad type crops. In the future it will represent the certification of those crops derived from the best type within the present certified ones. Work in this direction is progressing well, and within the next two or three years a continuous stream of specially-selected nucleus material for future certification will flow from the Station, particularly as regards rye-grass, white clover, cocksfoot, and brown-top.

Perhaps the most significant result that has attended strain research in grasses and clovers at the Station is the fact that, so far as suitability for permanent pastures is concerned, the strains of rye-grass, cocksfoot, white clover, and other grasses and clovers existent in New Zealand have been shown by comparative trials carried out to be as good as, if not superior to, any that have been isolated elsewhere.

(2) *Pasture-top-dressing Research.*—The top-dressing researches being carried out at Marton Experimental Area have been continued, and a great mass of statistical information on response under varying conditions of application and treatment is being amassed. Work of this description naturally must be of long-time duration before conclusions can be drawn, and the perfecting of methods of measurement in themselves entail concentrated research along certain lines. One trial with phosphates applied at different periods of the year is now in its third year, and clearly shows the increased bulk produced, and the better spread of production by late summer and early autumn applications against those of any other period. Again, in another trial where large quantities are used at infrequent intervals against small quantities at frequent intervals, the economy of frequent application is well shown. In connection with these fertilizer top-dressing experiments, careful chemical work on the mineral change in pasture due to treatment, botanical alteration in composition, and seasonal effect is being carried out. In general, it can be said that response as measured by bulk is represented by increase in phosphorus, lime, and nitrogen in the herbage—so much so, indeed, that chemical analysis might well be an aid towards determining fertilizer response in grazed areas where eye determinations fail.

The sheep-grazing trials at Marton to a remarkable degree show the great increase in stock that can be carried under reasonable rotational grazing, but, at the same time, emphasize the great variation that takes place at different seasons of the year, clearly indicating the part that ensilage or other forms of pasture-conservation can play in increasing stocking density.

General Field-crop Experiments.

The cereal-fertilizing experiment, which is now in its seventh year, has been continued, and trials in connection with varieties, rates of seeding, and hot-water treatment have been carried out. The manurial trials with potatoes, both with regard to the early crop in the North and the main crop in the South, and also in connection with certified as against uncertificated seed, have been conducted. In the case of the trials with certified seed increases up to 150 per cent. were recorded, indicating the economic significance of certified material.

The work of the past few years in Canterbury on the effect of lime in counteracting germination injury in turnip crops is bearing good results from the practical standpoint, as is indicated by the fact that the use of lime in Canterbury has trebled in the past two years. In this connection the fact that many areas of Canterbury are highly lime-responsive, as indicated by the complete series of observational top-dressing trials that have now been completed, will further stimulate the use of lime throughout Canterbury.

Agricultural Systematic Botany.

The close connection with Kew and the British Museum that has been established by the Station through the visit of Dr. Allan to Great Britain during the year will prove of the utmost value in the carrying-out of systematic botanical work that is essential in the carrying-out of crop research generally.

An intensive study of the genera *Danthonia* and *Agrostis* so far as they relate to New Zealand agricultural conditions has been undertaken and is nearing completion, and a full revision of the alien plants of New Zealand has been prepared; while material for a revision of the indigenous grasses of New Zealand, from both the systematic and ecological standpoints, to replace that of Buchanan, is under way.

WHEAT RESEARCH INSTITUTE.

Advisory Committee: Professor H. G. Denham (Chairman), Mr. G. H. Hewlett, Mr. James Carr, Mr. W. W. Mulholland, Mr. C. J. Talbot, Mr. R. K. Ireland, Mr. W. S. Pratt, Mr. R. J. Lyon, Mr. C. E. Boon, Mr. F. H. Hawker, Mr. Burton, Mr. A. G. Cannons, Mr. A. Jones. Director of Research Dr. F. W. Hilgendorf.

The Institute, having now been just over two years at work, has reached the full development contemplated under its present organization. Its staff is complete, and all of its members are fully employed in those activities decided upon by the committee.

A comprehensive annual report of its work was published during the year, and gives detailed results of the varied schemes of experimentation embarked upon. Five thousand copies of a summary of the report were printed for general issue to farmers and others interested.

(1) *Wheat-breeding.*—This work is progressing satisfactorily at Lincoln College. The college supplies the land, horse-work, implements, and machinery, much of the labour, and most of the buildings, and undertakes many of the larger trials. The more exact work of crossing and making preliminary trials in hand-sown plots is undertaken by the Institute.

Last year there were some five thousand plots, including about twelve hundred varieties of wheat. Included among these was one which gives some promise of success for New Zealand conditions. It is from a cross Solid-straw Tuscan, the most widely used New Zealand variety, by White Fife, one of the highest-quality Canadian wheats. The cross was made in 1923, and the resultant lines have been reduced to fifteen, of which there is now enough seed for preliminary yield trials. All of these lines are of great evenness: they have short straw, solid straw, tight chaff, and rapid growth, and in all of these respects are equal, or perhaps superior, to Tuscan. In the yield trial only four replicates were possible; so exact results are not obtainable, but the indications are that several of the lines are equal in yield to Tuscan. In milling extraction nearly all of the lines give considerably more flour than Tuscan grown in the same field, and in baking trials nearly all again give a considerably better loaf than Tuscan grown, milled, and baked under the same conditions. There is a fair prospect that one out of the fifteen selections may prove to be equal to Tuscan in both yield and growth qualities, and superior in milling and baking qualities. To find such a wheat was one of the main objectives of the Institute.

Preparations are now under way for the sowing of about ten thousand plots this year.

(2) *Milling.*—During the year 418 samples of wheat were milled on the experimental mill. These were samples of different varieties grown in special localities, of the same variety grown in different localities, or with different manures, &c., while many were millers' blends sent in for test. All of the flours from these millings were baked, and the loaves compared, so as to find out what are the best wheats, or the best conditions of growing them, in the endeavour to improve wheats to such an extent as to make New Zealand independent of foreign supplies.

(3) *Baking Tests.*—All the wheats mentioned in the preceding paragraph were baked, and, in addition to this, practically every flour-mill in New Zealand sends in to the Institute a monthly sample of its average flour. These samples are baked against a standard; and the different millers are given the results, so that they may know if they are keeping up a uniform product. Some mills go beyond this, and send daily samples for baking; and many mills send samples at odd times when there is any doubt as to the quality of their product.

Bakers also send special flours with which difficulties are being experienced; and the bakers' organizations ask for the solution of special problems in procedure.

The use in bread of preserved milks has been extensively investigated, and loaves were baked with all kinds of milk. The result has been to define the conditions of preserving milk that give the best results for bakers' use; and New Zealand is now preparing a dried skim-milk for bakers' use that is equal if not superior to the best milks prepared in other parts of the world.

The suitability of special wheats for the baking of brown bread and wholemeal bread also was investigated, and conclusions reached as to means of judging the value of different wheats for this purpose.

Altogether 3,460 loaves were baked under test conditions, and were judged and reported upon.

Chemical work: A total of 1,024 wheats were tested for moisture and protein: forty stock-feeds were completely analysed, and the mineral constitutents of twenty-five wheats were determined.

(4) *Economic problems.*—The use of the header harvester in Canterbury is being closely watched by a committee of the Institute, costs ascertained, and the best methods of storing wheat after harvesting being investigated. Samples representing 200,000 bushels of wheat were tested by the Institute during the past harvest, and much advice given as to the proper state of the wheat for harvesting or forwarding to purchasers.

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.

From March to October, 1930, Dr. Miller was absent abroad, when he gave detailed attention to noxious-weeds-control research matters. A special report on this subject was prepared and presented on his return.

Investigations.

Blackberry.—Researches on the influence of *Coraebus rubi* upon blackberry were continued throughout the year, but little progress was made with the insect; however, by a modification of the methods of handling the insect and weed more satisfactory results are expected. With *Coraebus* an

important feature is that the adults will attack the foliage of economic Rosaceae, such as raspberry, strawberry, and apple, although the larvae seem to confine their attention to blackberry and rose. In addition to *Coraebus*, attempts are now being made to utilize certain species of insects selected in North America.

Gorse.—During the year *Apion ulicis* was successfully reared in New Zealand and a considerable number of progeny secured. It is to be noted that this insect reproduces more freely under New Zealand conditions than under British. Since the researches showed that *A. ulicis* is not a menace to important Leguminoseae, a permit for its release was secured. In February, 1931, the available New-Zealand-reared material, consisting of 560 weevils, was liberated on gorse in the Cawthron Institute grounds at Nelson, and at Alexandra in Central Otago. Close observations are being kept upon these areas to ascertain the behaviour of the insect under natural conditions. In order to avoid delay in rearing in New Zealand weevils for liberation, and to ensure that only *A. ulicis* is liberated, future supplies of the insect from Farnham Royal will be secured from infested gorse-pods, and not collected free in the field.

Ragwort.—During the past season a total of 1,670,600 eggs of *Tyria jacobaeae* were liberated in the field throughout the Dominion. These eggs were secured from moths developing from large consignments of pupae sent from Farnham Royal. Field surveys show that *T. jacobaeae* is gradually becoming established, and where it already has become so its influence upon ragwort is noticeable. In order to more completely check the weed, other species of the ragwort-insect complex have been selected and are being sent from Farnham Royal. There is every indication that these insects will become an important factor in checking the weed, especially in places beyond the influence of farm-management and from whence infestations spread.

Piripiri.—During April of 1930 a small consignment of *Antholcus varinervis* pre-pupae was received from Brother Claude Joseph of Temuco, Chile, but these insects failed to develop. However, Dr. Miller visited Chile and studied the insect there, bringing with him to New Zealand a large consignment of the pre-pupae. The latter, which arrived in Nelson without damage of any kind, were carried under different conditions, in order to ascertain the best means of transport. By the end of March pupation of the *Antholcus* pre-pupae had set in, and it is expected that this insect will prove a great success.

PHORMIUM RESEARCH.

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

Report by Dr. J. S. Yeates.

During the past year the work has suffered considerably as a result of the depression in the fibre industry. Nevertheless, the work had reached a stage at which it was able to progress for a time at no great expense.

The total area planted in phormium is now about 8 acres. This is made up as follows: 1 acre of Ngaro; 1½ acres of fans of various strains; 3 acres of pedigree three-year-old seedlings; ½ acre of two-year-old seedlings; giving a total of 6 acres in main area.

In the smaller area at the Batchelar Homestead are a further 2 acres planted in fans of varieties, hybrid and pedigree seedlings.

Growth on all of these areas has been good, except in the two-year-old pedigree seedlings. These had to be set out in most unsuitable soil and were sadly neglected owing to labour-costs. An abundance of labour during the past month or two has made it possible to thoroughly clean these plants. They are as good as average commercially-grown plants of the same age.

During the year under review the main development has consisted in the planting-out in some 3 acres the seedling plants obtained from pod-by-pod plantings of seed from strains in the nursery. The age of the seedlings when planted was two years. No selection was exercised, every plant being set out in order to see exactly how much need existed for culling. The spacing was 10 ft. by 4 ft., and planting was done in April. Through an excess of grass, which was not grazed down by sheep, this area suffered rather badly during the spring and summer. At one stage the plants were hidden by the grass. When the motor-cultivator was purchased this area was in too bad a state to be handled by the implement. During February, however, the area was cleared by mowing the grass and hoeing around each plant. In spite of the ill-treatment and absence of culling, the death-rate has been less than ½ per cent., and growth has been excellent, many plants being as high as 6 ft.

The whole 6 acres of the main area was mole-drained in the winter of 1930. The drains were spaced 5 ft. apart. Two tons of lime per acre has been applied to the 3 acres of three-year-old seedlings.

The area at the Batchelar Homestead has grown well. The first plants set out there were single small fans and were planted in June, 1928. Many of these are now large bushes of millable flax.

The hybrid seedlings have grown very well. These are all from crosses in which S.S. was one parent, and are now three years old from the sowing of the seed. Several of the plants are large bushes as high as 7 ft. to 9 ft. The object of the crosses was to combine the excellent fibre and the disease-resistance of S.S. with greater tallness and other desirable qualities. Some of the plants appear likely to fulfil these requirements. A number of yearling plants, hybrids between S.S. and Ngaro, are growing well.

In September of last year a Rototiller 5 horse-power motor-cultivator was purchased. This has proved a most satisfactory implement, and enabled the rank growth of weeds during the spring to be kept under control. It is an implement which might well find a place in commercial phormium nurseries, and should be worth trying even for cross-cultivating in plantations.

Yellow-leaf Investigation.—On account of the financial position, Mr. Meadows is bringing his work to a close. The time that had been devoted to the work was too short for any final result to be expected as to the cause of yellow-leaf. Some of the plants inoculated with extracts or fungus from diseased plants may yet provide information as to the cause. Mr. Meadows' final report is not yet finished.

In an attempt to breed a pure line of yellow-leaf-resistant seedlings from S.S., a number of our seedlings of that variety have been planted in a badly infested area, usually in gaps from which diseased and dying plants were removed. As controls, a number of seedlings of a susceptible strain were planted in the same area.

Manurial Trials.—In May of last year an area of 4 acres was laid down in trial plots of manures, on the property of the Australian and New Zealand Investments, Ltd., Gordonton, Waikato. This land is deep peat. The total area of such trials is now 9 acres, in four localities. Up to the present time no significant results have been shown by any of the manured plots.

The Pollination of Phormium.—It has been very generally accepted that phormium flowers must be cross-pollinated. This view was taken by Dr. B. D. Cross (1911), whose work on phormium was considered to lead to this conclusion. Actually the view depended on negative evidence of an unsatisfactory nature. To enclose a flower in a paper or cloth bag is very likely to prevent it from setting seed, because of the abnormal conditions. Yet the fact that such flowers did not set seed has been commonly accepted as proof of the need for cross-pollination.

The lines of pedigree seedlings grown at the college were grown largely to study this matter of pollination, which is a most important one in any breeding programme.

The pedigree seedlings comprise, roughly, 120 different strains, and, as a rule, five pods from each strain have been sown pod by pod. From a preliminary study of these thousands of seedlings it at once can be said that, in phormium, self-pollination is the rule and cross-pollination the exception.

To further test the view that self-pollination is usual in phormium, during the past summer some experiments were carried out on two inflorescences of Ngaro. These were growing in the main area, and no other phormium was allowed to flower there.

For a period of two or three weeks no pollen was allowed to remain in any flowers on these plants. Before the flowers opened, the stamens were cut out with fine scissors. Of twenty-eight flowers allowed to open without pollen, none set seed. They all fell within three or four days of opening. Having found in this way that no foreign pollen was being carried to the Ngaro plants, forty-six more flowers were treated in the same way except that pollen of S.S. was placed in them every day. Twenty-seven of the forty-six set seed, proving that injury of removing stamens had not been the cause of failure to set seed on the part of the twenty-eight which were not pollinated. The twenty-seven pods should produce nearly two thousand hydrids between S.S. and Ngaro.

Using the same Ngaro plants, a further test was made to see whether each flower could set seed when only the pollen from the same flower was available for pollination. This has been considered improbable by Dr. Cross and others, because the pollen is considered to ripen and be shed before the flower is ready for pollination. In the experiment only one flower on the Ngaro was allowed to be open at the one time. All others were cut off before opening. Each day pollen was dabbed from the stamens to the stigma of the solitary flower; when that flower withered another was allowed to open, and treated in the same way. Each flower required a period of approximately one week before another could be safely allowed to open. The low total of four flowers treated in this way will be easily understood. Each of these flowers set normal seed. As a result of this work we may safely conclude that—(1) No foreign pollen was reaching either of these Ngaro plants; (2) over 60 per cent. of successes can be obtained in crossing Ngaro by S.S.; (3) that Ngaro flowers are quite capable of setting seed when self-pollinated by pollen from the same flower.

Other results of work on Ngaro concern the seedlings grown from ten different Ngaro bushes, some of which were growing sixty or more miles apart. Many thousands of seedlings were grown from these bushes; and there appears to be no difference in the mixtures of coloured and green seedlings obtained from the different sources. Other bushes which at a casual glance appear to be similar to Ngaro produce seedlings either with a slightly different colour, or the coloured ones and the green ones are not in the same ratio as in Ngaro. This is taken as indicating that all of the ten bushes collected as Ngaro have been reproduced by fans from one original Ngaro bush.

A number of well-grown two-year-old Ngaro seedlings are being grown as quickly as is possible in order to quickly develop inbred, pure-breeding strains of this variety. The same thing is being done with seedlings of S.S. and 13K and two or three other promising strains.

Experimental work on crossing different varieties has been extended somewhat, and yearling hybrids include Ngaro × S.S., S.S. × Ngaro, Paritaniwha × S.S., Paritaniwha × Ngaro, and several others.

Most of these crosses were made by kind permission of Mr. A. Seifert and Mr. B. B. Wood on bushes of these varieties growing in their private nurseries.

A number of genetical facts have emerged from study of the hybrids and pedigree seedlings. The main conclusions are:—

(1) Brown or black edge of leaf is dominant to orange edge. From this it follows that black-edged plants may (and in fact nearly always do) throw a certain number of orange-edged seedlings. Orange-edged plants, however, appear never to throw any black-edged seedlings, unless crossed by a black-edged variety.

(2) Orange-coloured butt is partially dominant to white butt. The result is that a hybrid between a white-butted and an orange-butted variety will be intermediate in butt colour. This hybrid if self-pollinated will give amongst its seedlings some with white butts, some with the full orange colour, and others with intermediate colour.

(3) Bronze or purplish colour of the leaf is dominant to green colour. Therefore most bronze plants give rise to some green seedlings which breed true for green colour.

Knowledge of the dominance of these characters is of great use in breeding-work, for it is thus possible to judge whether by inbreeding any particular type we may expect to obtain some plants of another and desirable type. In addition, in many cases, such knowledge allows us to judge if supposed hybrid seedlings are or are not really hybrids. This enables culling at a very early age. The cross between Ngaro and S.S. is a good example. If S.S. is used as the seed parent, any pods of seed that have been crossed by Ngaro will show bronze seedlings. All others can be thrown away at once. The bronze character is shown at a very early age after germination, and therefore is most useful in permitting early culling.

Thanks are again due to the various millers and growers who have helped the work during the past year. The presence of our Chairman in Palmerston North has proved a great boon in these rather difficult times.

MINERAL CONTENT OF PASTURES INVESTIGATIONS.

Bush Sickness.

The value of the work on the chemistry of bush sickness commenced in New Zealand by the writer in the year 1900, and extended and supported by means of the Empire Marketing Board's grant for research on mineral content of pastures in 1926, cannot be estimated by the actual results in this country. Similar conditions attending any given deficiency disease doubtless occur in other parts of the world, possibly over greater areas than those in New Zealand, and any fundamental work in field or laboratory cannot fail to be of value in combating these conditions and applying the correct curative and preventive treatment found efficacious here. All results as soon as they were obtained were published each year in either the annual report to the Government, to which at the time the writer was attached, or in the *Journal* of the Department of Agriculture. As a result of this publicity it was discovered that similar diseases occurred in other parts of the Empire, notably in Scotland, Kenya, Tasmania, and possibly in South Australia. In each country the disease had received recognition and a local name—"pining" in sheep in Scotland, "Nakuruitus" in cattle in Kenya, and "coast disease" in cattle in Tasmania. There is little doubt that all these three diseases are identical with bush sickness. In the case of Kenya the trouble has been effectually and cheaply cured by the same remedy that has been found efficacious in New Zealand, iron compounds given to the animal as a drench or lick. At first the treatment tried in New Zealand was by means of drenching. This method was quite successful, but laborious, expensive, and not regarded as a feeding, but as a medicinal treatment, and therefore used as a curative rather than a preventive.

For years the writer has been endeavouring to introduce some way of automatically giving ruminants additional iron *as a food*, and therefore as a preventive against bush sickness. The author's theory that this was iron starvation, caused by a direct deficiency of iron in the food, may still be considered the best yet advanced. The double citrate of ammonium and iron introduced by him in 1918 as a drench had at once supplanted the cumbersome and expensive syrup of phosphate of iron. Both of these remedies, however, were expensive, compared with crude iron-ores now being used. The citrate is now being imported by the ton (last year 2½ tons were imported), to be used in small quantities sold to the farmer at cost price. A duty of £50 per ton recently imposed, unfortunately, has increased the amount charged to 3s. per pound. Used as a 6-per-cent. solution and given in 2 oz. doses twice daily to cattle, this compound can be relied upon to effect a cure on a sick animal, provided it can be kept alive for a fortnight after the treatment commences. The cost of this treatment as a preventive would be 3s. per year using 1 lb. of the material per cattle beast.

Varying success attended the attempts to make a compound lick which could be automatically given to cattle. Bricks weighing about 8 lb., made in a hand-press brick-machine, supplied various mixtures containing iron and salt or iron and sugar in which the citrate of ammonium was used as the iron salt, which for many months were experimented with on young and mature cattle. Sheep were not experimented with at this stage.

In 1926 the Empire Marketing Board provided a yearly grant of £2,000 for two years to the New Zealand Government for work in connection with the mineral content of pastures (history of the vote and the conditions were given in the 1929 annual report of the Department of Scientific and Industrial Research, p. 20). In 1927 the currency of the grant was increased from two to five years.

The visit of Dr. Orr, the Director of the Rowett Research Institute of Animal Nutrition, Aberdeen, and member of the Mineral Content of Pastures Committee of the Privy Council, to the bush-sick districts in June, 1927, put new life into the investigation by his personal interest and valuable suggestions. One of these was based on the fact that, following the results of the New Zealand work in bush sickness and preliminary report from Kenya Colony that there was a similar disease on similar volcanic soil there, he had tried a ground Scotch bog-iron on some cattle, and the experiment had been extraordinarily successful. (A report recently to hand contains the result of confirmatory work in that colony by Dr. J. B. Orr and Mr. A. Holm, Director of Agriculture in Kenya. (See Sixth Report on the Mineral Contents of National Pastures, published by the Economic Advisory Council, London, 1931.) This information encouraged the writer in his use of ground-up iron-ore, begun in 1925, instead of the costly pharmaceutical iron preparation already found efficacious. A local iron-ore that was to be found in many parts of New Zealand was mixed with salt as a lick, tried, and found successful

in treating both cattle and sheep. The difficulties in obtaining iron-ores in a finely ground condition are described in the *New Zealand Journal of Agriculture* for June, 1931. After considerable experimenting, extending over some years, the finely pulverized native iron carbonate known as spathic iron-ore has proved to be successful as a preventive lick for all classes of ruminants.

It has been known for some time that bush-sick land such as the coarse-textured soils of Mamaku, when utilized in cattle-farming, gradually become less bush-sick—that is to say, the reverse process takes place to that of the "deterioration" which affects some pasture lands derived from volcanic aerial deposits of very fine texture—for instance, Mairoa soils. This gradual improvement, coincident with much dairy-farming carried on, has been experienced in the home paddocks at the Mamaku Demonstration Farm, which, from the original surface-sown pastures among stumps, has been converted into ploughable land, cropped with turnips, laid down in new pasture, and thereafter top-dressed for several years with basic slag and superphosphate mixture. It has now been demonstrated that this new pasture on which stock require little or no iron treatment to keep healthy has considerably increased in iron content. (See *New Zealand Journal of Agriculture* for December, 1930, p. 419.) The question whether the administration of iron to cattle on such improved farms will show increased milk-yield is yet to be determined.

The result of the work undertaken during the last three years shows that bush sickness, when unaccompanied by other complications, such as ragwort poisoning, need no longer be feared in any scheme for settling new country or in treating old-settled country. The prevention of and cure for bush sickness is definitely proved to be the administration of iron in a suitable form to the animals themselves. Improvements may be effected by giving the daily dosage of iron, but the remedy undoubtedly has been found, and all that remains for the practical farmer to do is to automatically apply it mixed with the necessary salt lick. The cost of the iron is so small that at the outside it will amount to only a few pence a year per cattle beast.

DETAILED RESULTS.

Rotorua Pumice or Near-by Volcanic Lands.—Attention has been devoted to the carrying-out of—

(1) Large-scale lick and pellet-feeding experiments with the object of discovering the most economic method of supplying assimilable iron to ruminants, especially sheep; and
(2) To the growth and collection, for analysis, of representative samples of pasture plants and mixed pasture free from contamination.

Both the feeding of pellets containing meals, citrate of iron, and ammonium, and the administration of a lick composed of common salt and finely ground native carbonate of iron (a local product), have succeeded in the case of sheep which previously it was impossible to keep or rear on bush-sick land. Probably some of the good effect of the pellets is due to the concentrated food, in the form of meals, which they contain. As this is an expensive and unessential ingredient, it is hoped that suitable licks may be found sufficiently palatable to enable it to be dispensed with.

Native carbonate of iron added to ensilage during the building of the stack was found to be an effective and economical method of administering iron to cows and calves, and also widely applicable in the bush-sick areas. Analysis shows that the iron is thus rendered more soluble. A prominent settler on bad bush-sick country (Mamaku) has introduced sheep, and intends breeding them on this type of country. He is confident of keeping all stock healthy with the aid of iron-carbonate treatment, which he has succeeded in automatically giving to the whole flock. He carries 1,000 sheep, and has now 350 ewes in lamb at Mamaku since February. Doubtless, therefore, with little additional expense or trouble, the whole of the lands affected with bush sickness *in any degree* can be farmed without fear. This opinion has been arrived at before with regard to cattle-farming, and now can be asserted with regard to sheep-farming; and this certainty of being able to keep both kinds of stock on the same country will make it much easier to farm than if the worst land had to be restricted to cattle. To name only a few reasons, sheep will keep the ragwort down without ill effects, will assist in effecting a better utilization of pasture, and the diverse quality of the products gives a better chance of making bush-sick country pay than if only one class of stock were carried. In making ensilage it is recommended to dissolve 1 lb. of the ammonium iron citrate in water, mix with molasses, and spray on to the layers of ensilage from time to time as the stack is building, 1 lb. of the citrate to 1 ton of ensilage. The option secured over a deposit of spathic iron-ore at Huntly has been continued, and small quantities of the powdered mineral distributed free, or at cost price, to farmers in bush-sick areas for experimental purposes. Results have been very encouraging, and many requests for a supply of the material have been received. The fine grinding of this hard iron-ore has been generously undertaken practically free of charge by the Challenge Phosphate Co., at Otahuhu, a service much appreciated. Analysis of the herbage produced in pot experiments with limonite (hydrated iron oxide) from Whangarei showed that its incorporation with pumice soil did not increase the amount of iron taken up by the plant. Probably, however, the limonite will find a use as an ingredient in stock-licks for providing iron directly to the animals. Stock-feeding experiments with limonite from Whangarei and from Onekaka, Nelson, are now in progress in the Rotorua district.

Green-manuring experiments for the improvement of the pumice soil have been proceeded with in two localities. Good crops of (*a*) red clover, (*b*) lupins, have been ploughed in and the areas resown in pasture.

The drainage-water from the lysimeter has been regularly collected and analysed. Applications of superphosphate to the surface soil have not led to loss of phosphate through the drainage-water.

Ngaroma Experiments.—Ngaroma is an isolated district some 32 miles from Te Awamutu, where there are several types of soil. During May, 1930, an inspection was made of experiments which have been in progress for several years at Ngaroma, where there is evidence of more than one deficiency

disease. On the whole, the results were distinctly encouraging. In one case a farmer's milk-yield had shown a substantial increase on manuring with superphosphate, while a further increase had followed the addition of sulphate of iron to the superphosphate. Carbonate of iron as a lick also was favourably reported on.

The occurrence of bush sickness in cattle recently reported at Kopaki confirms the opinion previously expressed that the trouble affecting sheep in this area is similar to that experienced on the pumice soils of the Rotorua district.

Poverty Bay Back Country.—Experiments have now given indications of the nature of the deficiency disease experienced in sheep in parts of this area. Animals depastured on affected paddocks well top-dressed with superphosphate and basic slag became sick equally with those on untreated areas, thus indicating that deficiency of phosphate could not be responsible, and adding proof that lack of iron is the principal factor. The pastures have an iron content abnormally low.

Two other instances of iron-deficiency disease in sheep on stations between Napier and Gisborne have been investigated. In both cases the trouble has occurred on easy country with a surface-covering of pumice, and soil and pasture analyses and the symptoms point to it being "bush sickness." The soils are "sandy silts" similar to those near Rotorua; steep country from which the surface-covering of pumice had been denuded was not affected.

Wairarapa Pastures, and Waihi Disease.

The completion of the analyses of the series of pastures, taken over a term of years from soils typical of different areas in this large inland district, has produced results of considerable interest. The demonstration of the important effect on the pasture of seasonal drought in summer and autumn has been made more striking by comparing the effect of varying rainfall in the summers of three consecutive years. The areas sampled comprised sheep and cattle pastures, and the altitude aspect, class of pasture, and history were as diverse in the areas chosen as circumstances would permit. The same officer sampled the same paddocks over a term of three and sometimes four years. The results of soils and pastures analysis have been published from time to time; but the culminating paper was printed in the *Journal of Science and Technology* (April, 1931, Vol. 12, No. 5, pp. 304–20), an abstract being given in the *New Zealand Journal of Agriculture* (No. 4, Vol. 42, p. 226).

It may be briefly reported that the outstanding deficiency in this district is phosphoric acid, "Waihi disease," a malnutrition of the bones in cattle having been recorded from several farms. Broadly speaking, however, the district is a very fertile one, and the troubles in stock due to deficiency in the pastures, from a study of the local meteorology, would seem to be due to the unevenly distributed rainfall resulting in droughty summers and autumns rather than to any inherent defect in the soil or the pasture. The following is an extract from the *New Zealand Journal of Agriculture* for April, 1931, p. 229:—

> "It was found in each case of four different localities, sampled regularly in three different consecutive summers, that the summer (1927–28) with the lowest rainfall (between 6 in. and 9 in.) produced pasture in which the phosphoric acid was lowest (average, 0·33 per cent.), and that the summer (1929–30) in which the rainfall was highest (18 in. to 31 in.) produced pasture in which the phosphoric acid was highest (average, 0·63 per cent.), while the intervening summer (1928–29) with an intermediate rainfall (10 in. to 17 in.) produced pasture in which the phosphoric acid was also intermediate (average, 0·49 per cent.) between those figures afforded by the two exceptional seasons. This generalizeration was found to be true in every one of the four localities—Atea, Hamua (two localities), and Mauriceville."

The nitrogen content of the pastures was found to vary with the phosphoric-acid content. During a wet summer in the Wairarapa the percentage of phosphorus in the pasture is not only itself higher, but the amount of protein, the most expensive food constituent of the animal, is also increased in the same direction. The effect of rainfall on the lime content of the pasture was found usually to vary in the opposite direction to that of the phosphoric acid and the nitrogen, the percentage of lime decreasing with the increase of rainfall.

> "*Effect of Season.*—The general trend of the phosphoric-acid and nitrogen content of the Wairarapa pastures is to rapidly increase to the maximum in the spring, falling with the summer, and reaching the lowest figure in the autumn. Calcium (lime), on the other hand, is the lowest in the winter and increases with the progress of the seasons, giving the maximum figures in the autumn.
>
> "The most exceptional result of the maximum nutritive value of the pasture occurring in the winter quarter in the case of the South Wairarapa (Martinborough) sheep-pastures is no doubt due to the rainfall being heaviest in that quarter and causing a quick response in a warm droughty soil.
>
> "*Farm Treatment recommended as a Result of the Investigation.*—Generally speaking, phosphate (especially superphosphate) applications may be expected to give remunerative returns on all Wairarapa lands, rich or poor. The necessity for lime would not appear to be nearly so widespread. Some districts, however, are notably deficient in both of these important aids to fertility and health.
>
> "If top-dressing pastures with phosphates cannot be immediately resorted to as a cure for deficiency diseases in stock—and sometimes it cannot be availed of as a remedy, for rain is essential to the success of phosphates with pasture—and will not effect improvement until rain comes, the use for ruminants of salt licks containing a large proportion of bonedust or finely ground Nauru phosphate all through the year will prove an efficient remedy for the sudden drop in the phosphate content in the summer and autumn pastures." (*New Zealand Journal of Agriculture*, April, 1931, pp. 229–30.).

It is satisfactory to learn that the results obtained from the Wairarapa investigation are borne out by other workers.

LIME DEFICIENCY IN THE KING-COUNTRY.

The following is a brief account of the Mairoa research, giving some account of the practical work undertaken in the field by Mr. Sutherland and others who are charged with the duty of demonstrating in a practical manner, and to the farmers' satisfaction, the need of lime in this once fertile district :—

It should be premised that in the Mairoa district the prevailing type is that characteristic of deep volcanic mud or dust showers, and which may be called the Mairoa type.

(1) The natural plant covering of Mairoa consists largely of rimu, tawhero, and hinau. In addition to this, there occur in the Mairoa district, to such a small extent as to be almost negligible, the following types, which, however, are well developed in other areas outside the Mairoa district.

(2) Mangapohoe, which naturally grows tawhero, rewa, and tree manuka : This type is more unhealthy for sheep than is the first. In addition to the above unhealthy types of country there are three healthy types, namely—

(3) Kihikihi, which grows rata, rimu, matai, tawa, and mangaeo.

(4) Waitangururu, which grows rata, pukatea, matai, totara, rimu, konini, and mahoe.

(5) Mangaotaki, which grows forests similar to No. 4.

Both healthy and unhealthy types may have very dense undergrowth. The first two—(1) and (2)—consist of volcanic dust or mud showers, and the last three—(3), (4), and (5)—of soil are derived from sedimentary deposits. Types one and two were very productive for a number of years. The pastures on them are from eighteen to twenty-seven years old, and are now reverting to danthonia, brown-top, fog, weeds, moss, and fern, and it is to be noted that, in addition, on the No. 2 Mangapohoe type, manuka is coming in. In both, clovers are absent.

The following changes are in evidence on the healthy types :—

(3) On Kihikihi the pastures are reverting to danthonia and brown-top. They still contain a fair amount of cocksfoot and a little rye-grass and clover, but moss, fog, fern, and weeds also take up a good deal of these pastures.

(4) Waitangururu pastures have deteriorated, but still contain a good portion of the original grasses shown. Clovers are holding better than any other types, and fern does not come in nearly so quickly. The above gives a bird's-eye view of the types of subsoil in the large area to the west of Te Kuiti, but it should be said that in the Mangapohoe there is evidence of a deficiency of phosphate as well as calcium in the soil.

Before the present experiments were instituted top-dressing of pastures was spasmodic and confined to small areas, the dressings being largely phosphatic, and composed chiefly of basic super, basic slag, and superphosphate. This treatment produced better pastures, but did not cure dopiness in sheep. Before the war the Mairoa district was producing heavily and was considered one of the good districts of the King-country. It is important to remember this, as it affords a distinguishing difference between bush-sick country and dopiness country. The Mairoa is a good example of deteriorated land, but, on the contrary, bush-sick land always gets better with age and stocking. This matter was discussed in an article " Lime Deficiency in the King-country Soils, and the Effect on Plants and Animals " (Transactions of the New Zealand Institute, Vol. 59, 1928, p. 406). There the history of the country is given. The publication of this and the *Journal* article drew attention to the need for lime, and preliminary experiments with lime carbonate alone and with gypsum alone, and with lime and superphosphate mixed was successful in keeping sheep free from dopiness. (See 1929 report, H.–34, Scientific and Industrial Research Department, pp. 24, 25, and *New Zealand Journal of Agriculture*, July, 1930, Vol. 41, p. 14.) Since then the experiments have been mainly in the direction of practical tests on farmers' lands in which no controls were used, but the test being whether the previous well-authenticated mortality, which always occurred, could be stopped.

As a result of this work showing lime deficiency affecting malnutrition, an arrangement was come to whereby the settlers of the district were given facilities enabling them to obtain ground limestone, a boon which has been much appreciated. The result of this application of lime and superphosphate (5 cwt. lime, 2 cwt. super) to several farms where previously it was impossible to profitably farm sheep has been to enable this to be done much to the farmers' satisfaction. It is hoped that details shortly will be published in full.

The conclusion arrived at with regard to the year's experience with lime and super top-dressing treatment is that, to obtain the best results, these two ingredients must be mixed rather than separately applied to the pasture. In several instances where the lime and super had been separately sown the results were not so good as anticipated. It is thought that after four applications of the 5–2 mixture, with proper management, the carrying-capacity of the Mairoa country should be improved to about two and a half sheep per acre. The Government supply of lime to the farmer has been a great assistance, but the maximum improvement cannot be obtained without the use of superphosphate. The mixture of 5 cwt of lime and 2 cwt. of super per acre applied to land has proved that it is possible to successfully breed and fatten lambs on country where formerly it was impossible to do so.

Some reorganization of the work in the Mairoa and Kopaki areas has been effected as a result of the experience already gained. Carefully controlled sheep experiments have been initiated at Mairoa to compare the effect of various top-dressings on the health of sheep. A large series of replicated enclosed plots with various top-dressings have been established at Kopaki and Mairoa. A series of samples of uncontaminated pasture from these plots is being obtained, whereby it is hoped to secure exact data concerning the variation in mineral content and composition of the pasture with soil-type and manurial treatment.

Iodine Deficiency.

Miss B. W. Simpson, on exchange from the Rowett Research Institute, Aberdeen, during the year investigated the distribution of iodine in New Zealand pastures and the animals grazing thereon. In the districts, Fendalton and Tai Tapu (Canterbury) and Karori (Wellington), the maximum iodine content of the pasture occurs in late autumn and winter and the minimum about midsummer. Analyses of a large number of thyroid glands, some abnormal, taken throughout the season 1929–30 have been published. It is concluded that "the iodine content of the thyroids of lambs born and bred on definite areas seems to give a fair indication of the amount of iodine available on those areas."

It has also been shown that—

(1) (*a*) Garden plants assimilate an increased amount of iodine which has been applied to the soil.

(*b*) The addition of iodine to food grown in the Wellington area and fed to young rabbits improved their rate of growth.

(2) (*a*) Additional lime added to the ration of rabbits on a basal ration low in iodine did not promote the formation of enlarged (goitrous) thyroid glands.

(*b*) A lick containing Kerol, salt, lime, sulphur, bone-meal, and rock phosphate added to the basal ration promoted increased growth in the rabbits as well as reducing the size of their thyroid glands.

(*c*) The addition of lime alone to the basal ration had little effect upon either the rate of growth or the size of the glands of rabbits.

(*d*) Large glands with a very low iodine content were produced by feeding animals with food grown on a goitrous area.

The effect of feeding iodine to laying hens has been studied. In districts where iodine is deficient the method is a convenient one of increasing the amount available for human consumption on account of the concentration of iodine that then occurs in the eggs.

Valuable information may result from the attempt to correlate the iodine content of the thyroid glands of grazing animals with the soils upon which they have been depastured. A circular has been sent out to Stock Inspectors by the Director of Live-stock, requesting them to forward glands for analysis wherever it is possible to obtain a satisfactory history. It is hoped in time to obtain a picture of the normal iodine uptake for the various districts. This may then be used to indicate the probable need of stock for supplementary iodine in the form of licks.

In some pumice districts analysis of the herbage showed a lower iron content than normal, but only in one isolated district on the East Coast side has any symptom in animals indicative of iodine deficiency been reported. Here a few calves have been born in a hairless condition. Recently good results have been reported on a farm free from bush sickness near Rotorua where by feeding iodine, molasses, and lime-water to cows extraordinarily good results were obtained where previously the results were not satisfactory. The situation of this farm was on a lake-terrace near but on a lower level to that farm where good results were obtained by feeding iron and iodine pellets. (See *New Zealand Journal of Agriculture*, January, 1929, p. 11.) It is there explained that the good results of iodine feed may be due to its indirect stimulating action on the animal.

Coromandel.

In a case where it was thought abortion in ewes might be due to mineral deficiency some bones of affected animals were analysed but no evidence of abnormality was obtained.

Taranaki.

A comprehensive report on the second autumn series of pasture-samples from the Taranaki District was incorporated in the tenth quarterly report to the Empire Marketing Board. The fall in phosphoric acid and nitrogen content in the autumn, which has been found to be of widespread occurrence, was strongly marked. Lime was somewhat more variable, though usually showing a considerable increase from spring to autumn. The analyses of the soil-samples taken in conjunction with the pastures also have been completed, and will be of use in recording the soil-types of the province.

Marlborough.

During the late autumn of 1930 an investigation was commenced into the nature and causes of endemic "bentleg" in sheep on certain poor danthonia hill country in the Wairau Valley. A poor all-round composition of the pastures was disclosed on analysis; but analyses are required at other seasons before coming to definite conclusions.

As lime and phosphate were both low in the pastures, feeding experiments were instituted to discover which deficiency, if either, was primarily responsible for the disease. Arrangements were made to feed bone-meal and salt to the flock on one of the affected paddocks, and citrate of calcium (lime) and salt on another. The latter had to be abandoned owing to the sheep refusing to take it. In the former case a report just to hand states: "It has been ascertained that the percentage of lambs found to be affected by the 'Bowie' conditions was only about one-fourth as great as that of the preceding season. It may be said throughout the district, however, that the disease was this season not so prevalent."

Hunterville District.

It was recently brought under notice that certain areas near Rangiwahia gave disappointing results with breeding-stock, abortion in both ewes and cows being common, and apparently endemic. On visiting the locality it was found that the pastures were poor, having been down for forty years, with very little top-dressing. Analyses of soils and pastures are expected to throw light on the trouble, which appears to be due to phosphate deficiency. Top-dressing with phosphates and the feeding of a bonedust lick is recommended.

Southland.

Investigation has proceeded of a deficiency disease among sheep in the Morton Mains district, near Invercargill. The general symptoms are allied to bush sickness. Analyses of soils, pastures, and animal-tissues so far indicate possible deficiencies of phosphate, iron, and iodine. A difficulty in the way of an iron-deficiency hypothesis is that the soils are loams, a texture much finer than anything so far found associated with the recognized bush-sick areas. Further investigation is planned for the coming year.

Pulpy-kidney Disease in Sheep.

At Ranfurly an experiment in feeding to ewes a lick containing sulphur in the form of gypsum was carried out to ascertain what effect it might have in preventing the development of pulpy kidney. Other work on pulpy kidney included the analysis of a large number of samples of milk from ewes in the North Island whose lambs were affected.

B. C. Aston, Director.

THIRD ANNUAL REPORT OF THE MINERAL CONTENT OF PASTURES INVESTIGATION AT THE CAWTHRON INSTITUTE.

During the period under review work has proceeded actively both in the field and in the chemical laboratory.

I. Titanium in New Zealand Soils and Pastures.

Considerable time has been devoted to an examination of the titanium content of a number of New Zealand soils and pastures. At the time when this investigation was commenced it was thought possible that titanium compounds, present in pasture grass or in dust on the pasture, might interfere with phosphate assimilation in the animal-body. The small amounts of titanium found in pasture have given little support to the possibility of titanium ingested by the animal interfering in any way with phosphate assimilation, and actual feeding experiments have definitely shown that sheep are little affected by comparatively large quantities of titanium in their feed. One of the interesting features of the titanium determinations in both soil and pasture was the close correlation between percentages of iron and titanium found in both soil and pasture samples. No correlation of a similar nature was found between titanium and manganese. It seems possible that a low percentage of titanium in either pasture or soil may prove of help in identifying areas where bush sickness is likely to occur.

II. Bush Sickness at Glenhope.

In the spring an investigation was commenced on certain pastures at Glenhope where bush sickness has been reported for a number of years. An attempt has been made to determine the seasonal variation in the composition of pastures causing bush sickness, and to compare the composition of these pastures with that of healthy pastures in the vicinity. A number of sheep also was placed on a typical area of bush-sick pasture in order to study the incidence of this ailment. The sheep did well until the end of November, but then began to go off rapidly. During January two sheep were badly affected, another two were slightly affected, and the fifth remained in fairly good condition. By the middle of February one sheep had died, another was so badly affected that it was killed, another two sheep showed definite symptoms of bush sickness, and the fifth still remained comparatively healthy.

Iron ammonium citrate was used as a drench two or three times a week on two sheep affected with the ailment. Since the commencement of drenching with iron ammonium citrate great improvement has taken place in the condition of the sheep. They are more active and can now be worked with dogs without difficulty. The skin and gums, formerly showing little tone and scarcity of blood, have markedly improved in appearance. The wool, formerly lustreless and of a dead appearance, has begun to show more life and lustre. A definite break in the wool has occurred corresponding to the commencement of drenching with iron ammonium citrate, and the new growth of wool shows lustre and elasticity. The wool of the sheep which has not received iron ammonium citrate continues to show a dead appearance, and little growth of wool is taking place.

The following symptoms appear to be typical of bush sickness at Glenhope: Brightening of the eyes at an early stage in the incidence of the ailment, followed by weeping of the eyes and loss in weight. The sheep begin to be weak on their legs, and cannot be driven. The skin and gums are pale in colour and the heart-beat is accelerated. The wool is of a dead appearance and without lustre, and retardation of growth takes place. When badly affected, watering of the eye stops, but the sheep are very soft and flabby about the mouth. According to farmers in the Glenhope locality, sheep frequently begin to go off in three or four weeks after being placed on bush-sick pastures. The worst period for incidence of bush sickness is the late spring and midsummer period, when growth of pasture is soft and rapid. From April to October, when feed is relatively hard and dry, little trouble from bush sickness is experienced.

III. Correlation of Soil-fertility with Pasture-response to Manurial Treatment.

In previous reports detailed accounts have been given of the experiments which have been conducted concerning influence of fertilizer and season on the yield and composition of a typical dairying-pasture at Richmond, Nelson. The data recorded in Bulletin 26 of the Department of Scientific and Industrial Research show that on this pasture superphosphate and lime treatment have given little increase in pasture-yield. On the other hand, comparatively large increases in yield have resulted from the use of ammonium sulphate either alone or in combination with superphosphate or superphosphate and potash. The best yield, however, was obtained with a complete manure consisting of 1 cwt. of ammonium sulphate, 2 cwt. of superphosphate, and 1 cwt. of sulphate of potash per acre. In order to ascertain whether there was any correlation of soil-fertility with pasture-production, a number of soil-samples was taken from the different plots in the winter of 1928.

The examinations have shown that the soil is well supplied with available phosphate, but is somewhat low in available potash. The amount of replaceable lime, particularly in the top 0–3 in. of soil, is comparatively high, although the soil has a marked acid reaction and a fairly high lime-requirement figure. The amount of replaceable lime in the topsoil no doubt accounts for the failure of lime treatment to effect any very marked improvement in either flora or pasture yield. It must be remarked, however, that the composition of pasture from the limed plots was better than that from the unlimed plots with similar manurial treatment. The soil determinations are in agreement with the yield data published in Bulletin 26, and explain why superphosphate has had so little effect in promoting pasture-yield, and why the use of sulphate of potash has been attended with such good results. One interesting feature of the soil data is their failure to show any accumulation of phosphate on those plots which have received a regular application of 2 cwt. of superphosphate per acre. In comparison with the untreated plots the percentage of phosphoric acid frequently is lower in those plots that have received superphosphate treatment, suggesting that leaching of superphosphate has occurred on this open-textured soil.

IV. Use of Nitrogenous Manures.

Much field-work has been directed to intensive studies concerning the effect of season and fertilizers on the yield and chemical composition of different pastures. In particular, very detailed studies have been made of the effect of nitrogenous manures on pasture-yield and on its botanical and chemical composition.

In this investigation three applications of calnitro, nitrochalk, ammonium sulphate, and ammonium sulphate plus calcium carbonate have been made during the season at the rate of 1 cwt. per acre on each occasion. So far as the experiment has gone, the yield data are definitely in favour of ammonium sulphate with calnitro in second position. Nitrochalk has fallen considerably behind either ammonium sulphate or calnitro in promoting increase in pasture. Owing to the lower percentage of nitrogen in nitrochalk (approximately 15 per cent.) in comparison with the nitrogen content of ammonium sulphate and calnitro (approximately 20 per cent.), it might have been expected that a smaller increase in yield of dry matter would result from its use. The increase, however, has been much less than might have been expected from the difference in percentage of nitrogen in the manures.

The use of calcium carbonate in conjunction with ammonium sulphate has not resulted in any increase in yield over the full period. It remains to be seen, however, whether the chemical composition of the pasture under the combined lime and ammonium sulphate treatment will show to advantage over pasture treated solely with ammonium sulphate. For a period of 139 days, covering two applications of ammonium sulphate at the rate of 1 cwt. per acre on each occasion, an increase of 312 lb. of dry matter per acre has been obtained over the non-nitrogen treated plots; 1 cwt. of ammonium sulphate, therefore, has given an average increase in yield of 156 lb. of dry matter per acre.

V. Influence of Repeated Applications of Ammonium Sulphate on the Yield, Botanical and Chemical Composition of a Typical Dairying Pasture.

A great deal of time has been devoted to a detailed study of the effect of ammonium sulphate on the yield, chemical and botanical composition of pasture, which in the past has received different manurial treatment. For the purpose of this investigation the Richmond pasture-plots which were the subject of investigation during the previous season have been used. The number of plots was increased so that different aspects of manuring with ammonium sulphate could be studied. The more important features of this detailed investigation are reported below under the following headings: (*a*) Effect of Ammonium Sulphate on Pasture-yield; (*b*) Effect of Ammonium Sulphate on Botanical Composition; (*c*) Effect of Ammonium Sulphate on Chemical Composition of Pasture.

(*a*) *Effect of Ammonium Sulphate on Pasture-yield.* — The yield data show that the value of ammonium sulphate for increasing pasture-production is dependent on a number of factors, as follows:—

(1) The manurial history of the pasture:
(2) Rate and frequency of application of ammonium sulphate:
(3) Time of application:
(4) Climatic conditions.

By far the best return from the use of ammonium sulphate has been obtained on those plots where an application of nitrogenous manure at the rate of 1 cwt. per acre has been made each spring during the last six years. The following figures concerning yield of pasture under particular manurial treatment show the very large increase which has been obtained by the regular use of 1 cwt. of nitrogenous manure per acre.

TABLE I.

Treatment per Acre.	Production of Dry Matter per Acre.
	lb.
Untreated	4,303·1
Ammonium sulphate, 1 cwt.	4,987·7
Superphosphate, 2 cwt.	4,579·4
Superphosphate, 2 cwt.; ammonium sulphate, 1 cwt.	5,203·3
Superphosphate, 2 cwt.; sulphate of potash, ½ cwt.; ammonium sulphate, 1 cwt. ..	5,654·7

NOTE.—Previous to 1928 nitrate of soda was used instead of ammonium sulphate.

While the use of superphosphate has given a very small increase of only 276 lb. of dry matter per acre, ammonium sulphate shows an increase of over 680 lb. of dry matter per acre. The highest yield was obtained from plots where the complete treatment was used.

The splendid increase in yield obtained from the use of ammonium sulphate undoubtedly is connected in part with the establishment of a flora responsive to nitrogenous manures.

The influence of the past manurial treatment on the efficacy of ammonium sulphate in increasing pasture-yield is well illustrated by the following data obtained by the application of 4 cwt. of ammonium sulphate per acre at intervals during the season commencing on the 12th October, and finishing on the 8th August: On the plots which formerly were untreated, 4 cwt. of ammonium sulphate gave an increased yield of 871·4 lb. of dry matter per acre; on plots formerly receiving a complete treatment, 4 cwt. of ammonium sulphate gave an increase of 688·6 lb. of dry matter per acre; on plots formerly receiving superphosphate only, 4 cwt. of ammonium sulphate gave an increase of 601·2 lb. of dry matter per acre; on the plot formerly receiving nitrogenous manure only, 4 cwt. of ammonium sulphate gave an increase of 1,023·5 lb. of dry matter per acre. The highest return per 1 cwt. of ammonium sulphate applied was obtained on the plot formerly receiving solely nitrogenous manure. The next best return per 1 cwt. of ammonium sulphate applied was obtained from the untreated plots. Plots receiving the complete manure or superphosphate gave a much lower return per 1 cwt. of ammonium sulphate applied. It must be remarked, however, that even in the case of the plot formerly receiving solely nitrogenous manure the increased yield with additional applications of ammonium sulphate is very much lower per 1 cwt. of ammonium sulphate than is the case when only 1 cwt. per acre is used in the long-continued manurial treatment of pasture.

A striking illustration of the fact that it is not necessarily the high-producing pastures which give the greatest return from the use of ammonium sulphate is provided in the data presented in Table II. In this table a comparison is made of the effect of five applications of ammonium sulphate on (1) untreated pasture; (2) on pasture which in the past has received a complete manure. As has been noted earlier, the difference in yield of the untreated pasture and that receiving the complete manure is very great. The difference in flora of the two pastures is also very striking. The data presented in Table II show that per 1 cwt. of ammonium sulphate applied a bigger increase was obtained on the untreated pasture than on the pasture which in the past has received the complete manure.

TABLE II.—INFLUENCE OF AMMONIUM SULPHATE ON YIELD OF PASTURE.

Production of Dry Matter in Pounds per Acre.—Series II, Season, 1929–30 (Mown Cuts).

Period.	Days.	Plots 3, 6, and 9.					Plots 4 and 5.				
		No Nitrogen (3B, 6B, 9B).		Five applications of Nitrogen (3A, 6A, 9A).		Increase over No Nitrogen.	No Nitrogen.		Five applications of (Nitrogen 4A1 and 5B1)		Increase over No Nitrogen.
		Period.	Per Day.	Period.	Per Day.		Period.	Per Day.	Period.	Per Day.	
9/8/29–11/10/29 ..	64	814·3	12·7	1,015·8	15·9	201·5	971·1	15·1	1,184·1	18·5	213·0
12/10/29–16/12/29	66	1,831·5	27·7	1,955·6	29·6	124·1	1,965·4	29·8	2,173·1	32·9	207·7
17/12/29–12/2/30	58	1,086·8	18·7	1,456·7	25·1	369·9	1,434·5	24·7	1,574·5	27·1	140·0
13/2/30–8/5/30 ..	85	449·9	5·3	651·7	7·7	201·8	834·2	9·8	998·4	11·7	164·2
9/5/30–8/8/30 ..	92	120·7	1·3	296·3	3·2	175·6	242·4	2·6	331·3	3·6	88·9
Totals ..	..	4,303·2	..	5,376·1	..	1,072·9	5,447·6	..	6,261·4	..	813·8

NOTE.—Plots 3, 6, 9: No previous treatment. Plots 4 and 5 have had 2 cwt. super, ½ cwt. sulphate of potash, and 1 cwt. ammonium sulphate per acre in previous years. During present season plots 4 and 9 received dressing of 2 cwt. superphosphate and ½ cwt. sulphate of potash per acre in July, 1929. Applications of ammonium sulphate at the rate of 1 cwt. per acre were made to stated plots at the beginning of periods shown in the table.

The magnitude of the effect of ammonium sulphate in increasing production of pasture has varied at different times during the season.

In the case of the data recorded in Table II a variation from 124·1 lb. to 369·6 lb. of dry matter per acre was experienced for two different applications of ammonium sulphate on the untreated plots. In the case of the plots which received the complete manure a variation in the increase obtained by a 1 cwt. application of ammonium sulphate was found of 88·9 lb. to 213·0 lb. These variations in the

increase obtained by the use of ammonium sulphate at different times during the year can be explained in part by climatic conditions. Droughty conditions in the autumn and the retardation of all growth during the winter undoubtedly account in some measure for the smaller effect of ammonium sulphate during these periods. The great differences, however, cannot be entirely explained by climatic factors, and it must be assumed that the particular flora of the two sets of plots has been an important factor in determining the magnitude of the increase in dry matter obtained by the use of ammonium sulphate at different periods of the year. The plots containing a higher percentage of rye gave the largest increase under ammonium-sulphate treatment during the spring and early summer periods.

(*b*) *Influence of Ammonium Sulphate on the Botanical Composition of Pasture.*—The frequent use of ammonium sulphate during the season detrimentally affected the flora of all plots irrespective of their past manurial treatment. Burning of clovers and weeds occurred during dry weather. A great reduction in the percentage of these constituents in the flora was apparent on all plots. This reduction in the percentage of clovers and weeds was perhaps most noticeable on the plots which in the past had received no treatment. On these plots clovers and trefoils were always very conspicuous during midsummer and autumn and on this account suppression could be more easily seen. A botanical separation of hay crops cut from the plots that had been treated with ammonium sulphate during the previous season showed that the use of this fertilizer had very materially affected the flora. Some of the more striking features of these botanical separations are shown below in Table III.

TABLE III.—EFFECT OF AMMONIUM SULPHATE ON BOTANICAL COMPOSITION OF HAY.

Series II: Hay was cut on 7th November, 1930.

Treatment.	Grasses.	Clovers.	Weeds.
Untreated	65·4	25·5	9·1
Untreated plus repeated applications of nitrogen	91·2	5·6	3·2
Nitrogen, single application	60·5	20·3	19·2
Nitrogen, repeated applications	92·5	4·9	2·6
Superphosphate and potash	69·3	25·5	5·2
Super and potash plus one application of nitrogen ..	75·0	18·7	6·3
Super and potash plus repeated applications of nitrogen ..	89·7	6·4	3·9
Superphosphate	62·9	24·5	12·6
Superphosphate plus repeated applications of nitrogen ..	90·5	6·3	3·2

The data show that even with one application of ammonium sulphate at the rate of 1 cwt. per acre the percentage of clovers is definitely lowered. Where five applications of ammonium sulphate were made in the previous season the reduction in percentages of both clovers and weeds is very marked. The suppression of clovers and weeds is accompanied by a large increase in the percentage of grasses in the crop. In several cases the percentage of clovers has been lowered from 25 per cent. of the crop to 6 per cent. of the crop. Grasses have shown an increase from 60 per cent. of the crop to over 90 per cent. of the crop. The past manurial treatment of the crops has had little influence on clover-suppression, if repeated applications of ammonium sulphate have been made. Plots formerly untreated and others receiving for seven years a complete manure were affected botanically in a similar way under ammonium-sulphate treatment.

During the year following the conclusion of these detailed experiments with ammonium sulphate the very detrimental effect in suppressing clovers and in opening up pasture sward was clearly marked on all the plots. Where 1 ton of ground limestone per acre had been applied in the season previous to the conduct of the experimental work, the detrimental effect of repeated applications of ammonium sulphate was much less marked.

(*c*) *Chemical Composition of Pasture.*—Data dealing with the effect of frequent applications of ammonium sulphate on the chemical composition of pasture have not yet been compiled, but they show that there is a striking seasonal variation in the composition of pasture, irrespective of its manurial treatment. During the drought periods of February and March a great drop in the percentage of phosphate, nitrogen, and soluble ash occurred on all plots. During periods of high rainfall the percentage of these ingredients stood at a comparatively high level. The effect of manurial treatment can be clearly traced in the percentages of particular constituents in pasture grass. This is well illustrated by the high percentages recorded for phosphoric acid, potash, and nitrogen in the spring period in the case of plots where manures containing these plant-foods have been applied.

The use of ammonium sulphate has again depressed the lime content of pasture in the early spring, but the depression is not so marked as was the case for the corresponding plots during the previous year. Continuous mowing of the plots, resulting thereby in an increase in the clover content, probably is responsible for this less marked effect of ammonium sulphate on the lime content of the pasture-cuttings.

GENERAL.

The following papers and bulletins have been published during the period under review:—

(1) "Influence of Ammonium Phosphate on the Yield and Composition of Meadow Hay," by H. O. Askew.

(2) "Effect of Season and Fertilizer on the Yield of a Typical Dairying Pasture—Part I," by T. Rigg and H. O. Askew.

(3) "Titanium in Some New Zealand Soils and Pastures," by H. O. Askew.

(4) "Effect of Season and Fertilizer on the Chemical Composition of a Typical Dairying Pasture—Part II," by H. O. Askew and L. Bishop.

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

THIRD ANNUAL REPORT OF THE PAKIHI INVESTIGATIONS CONDUCTED AT THE CAWTHRON INSTITUTE.

PERIOD 1ST APRIL, 1930, TO 31ST MARCH, 1931.

During the period under review the experimental plots laid down in previous years have been continued. Several series of new plots have been laid out at Sergeant's Hill to test further points in connection with pasture-establishment on pakihi land, and several blocks of *Phormium tenax* have been planted. In addition, a commencement has been made with the testing of certain exotic trees to determine their suitability for shelter purposes on pakihi land.

PASTURE EXPERIMENTS.

The plots established three years ago are still making excellent growth in every case where top-dressing with superphosphate at the rate of 2 cwt. per acre has been given during the winter. A number of plots sown in the autumn of 1928 have been cut for hay each year, and despite the heavy drain on the plant-nutrients in the soil, by the entire removal of the hay crop, the yield of hay in the season which has just passed was at least 3 tons per acre. In those cases where a top-dressing of superphosphate has not been given a rapid decline in production of hay and in quality of the flora has taken place.

Where pasture has been established for three years a great change has taken place in the nature of the soil. Consolidation of the surface has taken place, and the soil in midsummer is comparatively dry and has lost that spongy feel which is so characteristic of untreated pakihi land.

Use of Lime.—In previous reports the great importance of lime in the treatment of pakihi land has been stressed. In early experiments slaked lime was used in the treatment of pakihi land, but more recently ground limestone was found to give very satisfactory results. In the past season observations have been continued on pasture plots on which different amounts of lime were used. The plots demonstrate that in the initial establishment of pasture 1 ton of ground limestone per acre is as effective as a 2-ton application. Certain plots on which only half a ton of ground limestone per acre was employed gave a very fair result, indicating the possibility of reducing the cost of initial treatment in the establishment of pasture.

Use of Phosphates.—All the pasture experiments continue to show the great importance of combined lime and phosphate treatment of the land in the establishment of pasture. Basic slag and superphosphate have given equally good results for sowing prior to seeding. Nauru rock phosphate, on the other hand, has given poor results during the first two years of pasture-establishment. It must be remarked, however, that during the past season the plots treated with Nauru rock phosphate have shown wonderful improvement. This is particularly marked where a dressing of 10 cwt. of Nauru per acre was used in the initial establishment of pasture.

Seed-bed Preparation.—In previous reports the great success which has accompanied the establishment of pasture on pakihi land which has been simply burnt over and scarified with harrows or disks has been commented on. Plots established two years ago, using this method of seed-bed preparation, still continue to give as good results as plots which were established on land ploughed, fallowed, and thoroughly worked with the disks. Although many additional plots have been laid down on similar lines, in no case has failure resulted in the establishment of pasture. It must be concluded that ploughing and fallowing of pakihi land is not necessary for the successful establishment of pasture. Further experiments which have been carried out during the past season indicate that even scarification of the surface is not essential to successful pasture-establishment. On several blocks ground limestone and superphosphate were distributed directly on the burn of pakihi vegetation. Seed was then distributed and one brush-harrowing was given. A remarkably good "take" of clovers and grasses was secured, and certain plots in the second year after establishment gave a yield of hay equal to 3 tons per acre. In other experiments, made with the object of still further simplifying procedure, superphosphate and grass-seed were distributed direct on to the unburnt pakihi vegetation, which was then run over with the back of ordinary tine harrows. A good take of grasses and clovers was thus secured amongst the pakihi vegetation. After mowing of the crop at the end of the first season an excellent cover of lotus, clover, and grass was obtained. At the end of the second season it was difficult to distinguish between plots sown in this way and those in which burning of the pakihi vegetation accompanied by scarification of the surface had taken place.

Seed-mixture.—Plots which have been established for two or more years show that lotus, clovers, crested dogstail, and fog are the dominant constituents in the sward. A little cocksfoot, rye and paspalum is also present, but conditions do not seem to be very favourable for rapid growth and development of these species. Subterranean clover has been tried, but in no case has a successful stand been obtained. Even on land very liberally limed and phosphated, subterranean clover, under the high rainfall conditions of the West Coast, does not seem to prosper. The experiments indicate that for the initial establishment of pasture on pakihi land too much stress should not be laid on the use of rye. No doubt, as consolidation and aeration of the soil improve, rye and cocksfoot will have more favourable conditions for growth; but in the initial stages of pasture-formation suitable amounts of lotus, white and red clovers, crested dogstail, and Yorkshire fog are required. Based on experiments over a great number of plots, the following mixture can be recommended: Perennial rye, 8 lb.; Italian rye, 6 lb.; cocksfoot, 4 lb.; brown-top, 2 lb.; crested dogstail, 2 lb.; timothy, 2 lb.; Yorkshire fog, 2 lb.; white clover, 4 lb.; red clover, 2 lb.; alsike, 1 lb.; *Lotus major*, 1½ lb.; *Lotus angustissimus*, ½ lb.: total, 35 lb. per acre.

Grazing Established Pasture.

During the past year a 6-acre field of pasture established on a typical block of pakihi land has been grazed by dairy cows. During midsummer production of pasture on the field was extremely high, and for several weeks more than two cows per acre were successfully carried. Under grazing-conditions consolidation of the surface has taken place, and very little damage has been done to the sward by stock even during periods of somewhat high rainfall. The owner of the cows reports that they have milked extremely well during the time in which the cows have grazed this particular block.

Phormium tenax.

During the past year three new blocks of *Phormium tenax* were planted in order to obtain further information concerning the economic possibilities of flax-culture on pakihi land, and concerning the nutrition of *Phormium tenax*. The experiments on *Phormium tenax* comprise (1) different methods of land preparation prior to planting, and (2) the use of different manures in the treatment of the land. Excellent growth is being made on many of the plots, indicating that with proper treatment *Phormium tenax* can be successfully grown on pakihi land. The experiments already have demonstrated the outstanding value of phosphatic manures. The best growth has been obtained on those plots in which lime, phosphate, and sulphate of ammonia have been used. In certain cases the inclusion of potassic manures has given a slight additional advantage. On those plots where phosphatic manures have been omitted little improvement over the growth of the untreated plot has occurred.

Tree-culture.

In view of the importance of shelter-trees in the economic development of pakihi land for dairying, a number of different species of exotic trees were planted last spring in order to test their growth on pakihi soil under different conditions. As far as the experiment has gone, *Pinus radiata*, *Pinus ponderosa*, and *Pinus densiflora* are giving the most promising results of success in their adaptation to pakihi land.

PIG RECORDING.

A grant of £200 made by the New Zealand Meat-producers Board to the Waikato Pig Recording Club enabled pig recording to be continued part time in one group in the Hamilton district. The work was undertaken during the year by the recording officer, who visited monthly some twelve farms, where sows and their litters were weighed, management and feed trials supervised, and general advice given to growers regarding the handling of their herds.

Although the scope of the work was considerably restricted owing to its being possible to make available the recording officer's services for only portion of the time, the results secured were most impressive, and indicate what advances can be made by due attention to management, feeding, and selection. During the past three seasons, during which recording has been pursued, the average litter-weight at eight weeks has increased from 191 lb. to 281 lb., and the weight per piglet from 25 lb. to 40 lb. Among the Berkshire, Tamworth, Large White, Middle White breeds, and the various cross-bred pigs under record consistent increases in litter-weights occurred during the three seasons. As in previous years, the weights of the individual piglets in large litters were equal to those in small ones, and indicate that large litters are good measures of the real productivity of the sows. In management, the use of the creep system has been demonstrated as a highly desirable measure to adopt on economic grounds, while small grass-paddocks and movable shelters have proved superior for breeding sows.

PORK AND BACON.

Arrangements were made through the Waikato Group Marketing Association to despatch to Smithfield a number of marked carcasses of pigs which had been recorded on the farms. These were assessed by a panel of Smithfield butchers, officials of the Food Investigation Board, and, in addition, cooking trials were arranged through the courtesy of Messrs. J. Lyons. The general terms of the detailed criticisms were distinctly favourable to the quality of the carcasses as despatched, while the cooking tests revealed that the flavour of New Zealand frozen pork from these recorded pigs closely approximated that of the best English article. The details of these overseas investigations have provided much information to local pig-farmers, and have served to guide them as to the adoption of such practices as will lead to the production of carcasses suited to meet a high-grade English demand.

WOOL.

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

Massey College.—Dr. Dry has continued his study of the fibre types of the Romney and their development. The information is assisting in providing the basis for genetic and other investigations, and, on the practical side, in placing the breeder in a better position in selecting breeding-animals. Interesting results are available, indicating the possibility of foretelling the future hairiness of an individual sheep. A detailed account of the work is in course of publication, a preliminary account having been published in the *Wool Record* of the 4th September, 1930—"The Fibre Types of the New Zealand Romney Hogget."

Numerous projects are under way in connection with the growth-rate of wool, influence of medullated fibres, methods of selecting representative samples, influence of food on the yolk, &c.

Lincoln College.—This work is concerned mainly with the effect of breeding and feeding on wool characteristics. A valuable paper by Mr. D. J. Sidey is in course of publication.

FUEL RESEARCH.

Advisory Committee: Colonel W. D. Holgate (Chairman), Professor H. G. Denham, Mr. C. C. Davis, Mr. W. Donovan, Mr. W. A. Flavell, Mr. A. H. Kimbell, Mr. H. Vickerman, Mr. T. O. Bishop (Secretary, Coal-mine Owners' Federation), Dr. E. Marsden (Secretary, Fuel Research Committee).

Laboratory Staff: W. A. Joiner, M.Sc. A.I.C.; W. G. Hughson, M.Sc. A.I.C.; A. K. R. McDowell, M.Sc. A.I.C.

During the year the investigation of the low-temperature carbonization of New Zealand coals has been extended to coal of the bituminous class. The Fischer rotary retort, taking a charge of 35 lb. of raw coal, has been employed in these experiments, but some alteration to the condensing and recovery part of the apparatus was necessary. Millerton and Blackball coals, both from the West Coast, were chosen for investigation, and the yields and nature of the products determined. Since both coals contain appreciable percentages of sulphur, more especially Blackball coal, particular attention was paid to its determination in the products of carbonization. The tar-oil was examined by the usual methods, and analyses made of the semi-coke, gas, and liquor. Both Millerton and Blackball are coking coals and yield free-burning smokeless fuels. Millerton coal produces rather a swollen coke, but this could be obviated by blending with suitable non-coking coal. It may be noted that Blackball coal gave a high yield of low-temperature tar-oil—viz., 39 gallons per ton. The carbonization investigations have been completed and a report on Millerton and Blackball coals is now in the press.

One of the staff (Mr. W. G. Hughson) assisted with further trials conducted by the Railway Department on the use of New Zealand coals, and, in addition, a considerable number of coal analyses were carried out at the Laboratory in connection with these. On completion of the carbonizing tests some briquetting experiments were commenced, using carbonized residue from Waikato coal with various binders. These are still in progress.

Since very little is known regarding the composition of low-temperature tar-oils, a fairly comprehensive examination of the tar-oil from Waikato coal has been undertaken and is proceeding at the present time.

COLD-STORAGE RESEARCH: FRUIT.

Advisory Committee: Mr. J. A. Campbell (Chairman), Messrs. F. W. Grainger, L. W. Tiller, A. M. Robertson, R. Sutherland, W. Benzies, F. R. Callaghan, Dr. M. A. F. Barnett, Captain W. Olphert, and the late Captain T. H. Chudley.

It is with regret that the death of Captain T. H. Chudley, a respected member of the Fruit Cold Storage Committee, is recorded.

Overseas' Investigations.—During the past year only a restricted amount of overseas cold-storage investigations was undertaken, and was concerned largely with investigations relating to the carriage of Worcester Pearmains, and to the use of an all-round wrap and oil-paper wraps in the transport of different varieties. These experiments have not reached a stage at which a report can yet be furnished.

Land Store Investigations.—These were continued at Nelson, the work being dealt with by the staff of the Cawthron Institute.

REPORT ON THE FRUIT COLD-STORAGE RESEARCH WORK OF THE CAWTHRON INSTITUTE, 1930–31.

The work for the year can be broadly divided into two sections, one having a direct bearing on the overseas transport conditions for New Zealand fruit, and the other dealing more particularly with the effect of pre-storage factors on the resistance of the apple to the various diseases associated with cold storage.

The experiments of the first section are a continuation of the work of 1929 on the determination of the reaction of some of our export varieties of apples to storage temperature. The Cox's Orange Pippin and the Jonathan have been studied a little more fully than in the previous season, as the indications are that these two varieties are more difficult to carry satisfactorily than are the other main varieties. Cleopatra and Rome Beauty are two additional varieties that have been included in the experiments this year, and small-scale tests also have been carried out with Worcester Pearmain, Lord Wolseley, and Grannie Smith.

Considerable difference has been found in the keeping-quality of Cox's Orange from two different types of soil, but the indications of last year that 38° F. is a safer carriage temperature for this variety than 32° F. or 35° F. have been given further support.

With the Jonathan, deep scald was considerably more severe than was the case last season, and as a consequence the disease was much in evidence at a temperature of 35° F. The fruit stored at 38° F. was almost completely free from the trouble. It would seem, therefore, that until more is known of the conditions under which apples become susceptible to deep scald it would be wise to carry the Jonathan at a temperature rather higher than 35° F.

The Cleopatra and Rome Beauty both appear to be tolerant of a wide range of temperature, keeping well both at 32° F. and at 38° F.

In the small-scale tests the Grannie Smith kept perfectly under all three storage temperatures. The Worcester Pearmain also kept fairly well at all three temperatures and, being of a late picking, developed practically no bitter-pit.

In a private communication, Dr. Barker, of the Cambridge Low-temperature Station, has drawn attention to a peculiar superficial spotting disease which was noticed in England, particularly with the Lord Wolseley variety and with the Cleopatra, on New Zealand apples that were exposed in shop-

windows. Tests made in England at the time showed that the spotting was brought about under the influence of light, direct sunlight being a particularly active promoter. At Dr. Barker's suggestion, the trouble has been investigated on a small scale by the Cawthron Institute both last season and this, and a definite temperature response of the trouble has been found. If a storage temperature of 32° F. is employed, the subsequent development of the trouble on exposure of the fruit to light is much less than when the fruit has been stored at a temperature of 38° F. The use of oiled wrapping-paper has effected only a small decrease in the severity of the disease—probably not enough to warrant the additional expense involved. As regards the response to oiled wrapping, the disease would appear to be much more closely related to Jonathan-spot than to superficial scald.

The second section of the work, dealing mainly with the influence of pre-storage factors, has been continued on lines similar to those now employed by the Cawthron Institute for a number of seasons. Jonathans and Sturmers from trees which have provided material for storage studies for a number of years have again been put into store. By following up in this way the history of the storage characteristics of fruit from specific blocks of trees it is hoped that much will be learned of the effect of orchard, soil, and climatic factors in relation to storage quality.

An indication has been secured that the use of a nitrogenous fertilizer on the Jonathan, unbalanced by other fertilizer constituents, tends to produce an apple rather more susceptible to breakdown in storage than Jonathans not so treated. The use of potash, on the other hand, appears to effect an improvement in the resistance of the Jonathan to breakdown. A similar response has been recorded in other countries with certain of the varieties grown in those countries, but with New Zealand varieties grown under New Zealand conditions the whole field of research along these lines is as yet almost untouched. It seems very probable that widely varying results may be obtained with our varieties. For instance, it is by no means certain as yet that the use of an unbalanced nitrogenous fertilizer on the Sturmer variety is in any way detrimental to the storage quality of the fruit. Delicious, which have received heavy nitrogenous dressings additional to that normally included in the standard manurial programme, in this season's work have shown absolutely no inferiority in storage quality as a result of the treatment. It should be stated here that the grower concerned has regularly incorporated liberal dressings of phosphate and potash in his manurial programme on Delicious. A very definite indication has been given that the use of heavy applications of nitrogen on the Statesman variety, on the other hand, is extremely detrimental to the keeping of the fruit. In fruit from Statesman trees which have received extra nitrogen a very marked increase occurred in the amount of breakdown and of fungal disease, the severity of the diseases increasing step by step with increase in the quantity of nitrogen applied. The relationship of nutrition to storage quality is being studied in rather greater detail in the 1931 storage season, and, ultimately, the Research Orchard should provide additional material for the study of the problem.

The storage tests with fruit from the Cawthron Institute rootstock blocks have been continued, and results are in accordance with earlier findings, particularly in that the superiority in resistance to breakdown exhibited by the Jonathan grown on a specific Seedling stock has again been maintained. Those of the other stocks under experiment that have produced sufficient fruit for storage tests—viz., Northern Spy and a French Crab—have up to the present appeared to be without any marked influence on the storage characteristics of the fruit they carry. In the course of the next few seasons additional material will become available for the furtherance of the rootstock studies.

L. W. Tiller, Orchard Chemist.

FRUIT RESEARCH.

Advisory Committee: Mr. H. Vickerman (Chairman), Messrs. F. S. Pope, Thomas Waugh, J. L. Brown, W. Benzies, T. C. Brash, W. J. Rodger, A. H. Cockayne, J. A. Campbell, T. Rigg, F. Firth, and Professor T. H. Easterfield.

During the year advice was received from the Empire Marketing Board to the effect that the Board was prepared to make a capital grant of £2,350 and an annual grant of £1,860 for the purposes of a scheme of fruit research extending over a five-year period in New Zealand. In consequence, steps have been taken to establish a fruit-research organization in which representatives of the industry will have a voice, and the work of various research organizations which have concerned themselves with fruit will be co-ordinated. A generous grant of £1,250 made by the New Zealand Fruit-export Control Board, together with a subsidy received through the Government, and the Empire Marketing Board funds enabled the purchase of an experimental orchard at Appleby, Nelson. This orchard consists of some 29 acres of apple and pear trees in full bearing, while the remaining area is available for new field experiments which it is proposed to establish.

The orchard is situated on a type of soil which is representative of a large area of land used extensively for fruitgrowing. As the orchard was acquired too late in the season to enable a full scheme of research to be inaugurated, it was used merely for a series of spray experiments, while a careful record was made of the individual tree yields which were essential as a preliminary to the interpretation of any further work that will be done.

In the meantime, arrangements have been completed for a co-ordination of the research investigations to be undertaken by the staffs of the Cawthron Institute, Plant Research Station, and the Horticulture Division, and a scheme of experiments concerned with disease problems, manurial, and nutritional problems, and rootstock problems has been decided upon. These investigations will be conducted at the Research Orchard, the Plant Research Station, Cawthron Institute, and at a number of selected points throughout the fruitgrowing areas of the Dominion.

It is further intended that these investigations shall be closely linked with the cold-storage researches at present being conducted at the Cawthron Institute, and also, it is hoped, in association with overseas organizations.

A grant made to the New Zealand Institute of Horticulture has enabled the citrus survey to be continued on the rootstocks imported, and worked over with the buds of selected varieties which are likely to prove successful under New Zealand conditions. These new stocks have now reached the stage when they can be removed from the nursery and planted out in tried areas at selected points in the Auckland Province.

LEATHER RESEARCH ASSOCIATION.

Annual Report.

Advisory Committee: Messrs. J. E. Astley, A. E. Lawry, D. Phillips, W. Donovan. Research Chemist: Mr. P. White.

The work carried out during the year was arranged so as to continue the policy of the association as adopted in previous years. The practical application of the results of research work and the investigation of factory problems were regarded as being the most important aspect of the association's activities.

The present economic conditions demand that the efficiency of all the processes in the factory shall be as high as possible, without the wearing-values of the leather being deleteriously affected. Consequently, most of the factory problems investigated have been along these lines. The problem of economizing in materials, time, and labour has been considered from the chemical standpoint. It is being more and more realized that the physical properties of leather are equally important as the chemical properties. Chemical analysis has its value from the economic point of view, but other methods of examination also are necessary. The microscope is a valuable aid to partially follow the actual conditions of the fibres during the course of tanning. Microscopical examinations of leather in process of manufacture, and the finished article, have been made in conjunction with chemical analyses, with a view to correlating as far as possible the chemical with the physical aspects.

As in all scientific investigations, there must be close co-operation between the factory and the laboratory. As in previous years, visits have been made to the tanneries. These have been in a consultative capacity, and those firms which have received most benefit are those which have taken advantage of the facilities available.

Every effort has been made to keep in touch with the foremen and operatives, so as to imbue the spirit of inquiry amongst as many as possible.

What is considered as routine work—that is, the examination of raw materials from the monetary aspect—has been slightly developed during the year. It is essential to know the actual values of the materials purchased; but it is even more necessary to know something about their properties. Many of the substances used are proprietary articles and at various times have to be modified to suit changing conditions. This cannot be done by rule-of-thumb methods until something is known about their constitution.

In conjunction with the British Leather Research Association, investigations of the best conditions for curing hides have been continued. So far it has been established that the presence of a small quantity of sodium fluoride in the curing salt has a beneficial effect in preventing the growth of the red halophilic bacteria. On freshly cured hides the leather does not appear to be deleteriously affected by this chemical. The result on hides stored for some months, when cured by this method, is being determined before any definite conclusions are reached.

An investigation into the cause of greasy hides has shown that this defect is due to improper methods of flaying and curing. Having determined the cause, investigations are now proceeding to, if possible, find out a remedy, other than that of altering the conditions of curing.

The work on the wearing-values of sole-leather has proceeded, using both practical and laboratory tests. The association is indebted to the Government institutions which have carried out the practical tests. Some of the conditions affecting the wearing-values have been determined, and, as far as possible, factory methods have been altered to produce leather which will give longer wear when worn on the shoe-soles. Microscopical and chemical analyses have been made in conjunction with these tests, and to a certain extent the results have been correlated. The theoretical aspects of wear have been considered, and, arising out of this, experimental leathers have been made. These are now being tested to determine the improvement, if any, that has been made on wearing-value.

Contact has been maintained with the boot-factories, so as to obtain direct information as to the quality of leather being produced in so far as it affects the boot-manufacturer. The information thus obtained has been valuable to the tanner, not only in presenting a means of remedying faults, but in the production of leather suitable for different conditions of work. The boot-manufacturers are relying on the New Zealand tanners to supply the whole of their requirements of leather, with the exception of kid, fancy, and patent types. This entails modifications in the manufacture of the leather to produce goods which previously have been imported. In addition to helping the tanner, the visits to the boot-factories have been helpful to the boot-manufacturer. Problems in connection with leather have been discussed, and as a result minor operations which had a detrimental effect have been altered or omitted.

During the year work has been continued on pelt problems. In conjunction with the British Leather Research Association, trial shipments of pelts were sent to England. The reports on these have materially increased the amount of knowledge available on pelt-processing.

One of the most pressing problems which requires to be solved is that of butcher strain. This has been widely discussed both in relation to its prevention as well as its cause. Opinions differ, but data have been collected which appear to demonstrate that a great deal of the trouble is avoidable, provided conditions could be so economically altered as to enable a more reasonable amount of care to be given to flaying. The experimental work carried out in the processing of skins has demonstrated that better methods are available. Where the results obtained have been applied on a practical scale a keener demand for the product has been experienced. As a result of the improvement in the quality of New Zealand pickled pelts in the last few years, already one new market has been obtained. With additional improvements the existing markets are capable of being expanded much further.

RADIO RESEARCH.

Advisory Committee: Mr. A. Gibbs (Chairman), Professor R. Jack, Professor P. W. Burbidge, Mr. J. M. Bingham, Dr. M. A. F. Barnett.

Due to the difficult financial conditions, no extension has been made in the programme of radio research. During the year work has been continued at Auckland University in the study of "atmospherics." A continuous recorder has been developed from the records of which information is being obtained regarding the diurnal and seasonal variations in the incidence of atmospherics.

A fairly extensive programme of reception tests was organized in connection with the total solar eclipse in October, 1930, with the object of studying the effect of the eclipse on the propagation of wireless waves. Special transmissions were arranged from stations in New Zealand, Fiji, Samoa, and Tahiti, and, in addition, use was made of the regular transmissions from stations in Hawaii and California. Reception was arranged at a number of stations in New Zealand and in the islands of the Pacific, and the tests covered long-, medium-, and short-wave lengths. The results obtained, which have been described in detail in the *Journal of Science and Technology* (Vol. 12, No. 6, page 321), clearly indicated that the effect of the eclipse on wireless waves was equivalent to a partial transition to night-time conditions in areas adjacent to the path of totality.

STANDARDS AND STANDARDIZATION.

Proposed Standards Laboratory.—Due to the present financial depression, no advance has been made in connection with the building and equipment of a Dominion Physical Laboratory.

Standardization.—The Secretary of the Department attended the meeting of the Committee on Standards and Standardization of the Imperial Conference of 1931, at which a number of important recommendations were adopted in connection with problems of standardization throughout the Empire. Further discussions on the subject have been held in New Zealand, and arrangements are being made for Mr. le Maistre, the chief executive officer of the British Industrial Standards Association, to visit this country towards the end of the year. The growing importance of some reasonable measure of standardization in New Zealand has long been recognized, but it is proposed to postpone the setting-up of a local Standards Association until after the visit of Mr. le Maistre.

FOREST BIOLOGICAL RESEARCH.

Advisory Committee: Mr. C. E. Foweraker (Chairman), Messrs. N. G. Gribble, A. J. Seed, F. W. Foster, Owen Jones, C. M. Smith, Professor T. H. Easterfield. Director of Research: Dr. D. Miller.

The forest biological research scheme has been financed by grants received from the New Zealand Timber-growers' Association (£800 per annum), the State Forest Service, and the Department of Scientific and Industrial Research. Work on entomological and mycological problems affecting the exotic timber species of New Zealand was commenced during the year, the work being directed by Dr. D. Miller, of the Cawthron Institute.

The Cawthron Trust Board erected buildings at Nelson to provide laboratory and office accommodation for the entomological staff, and arrangements have been made by the Department for the lease of these premises.

The Forest Biological Research Station was officially opened by the Hon. H. Atmore on the 18th February, and the accommodation has proved eminently suitable for the purposes for which it was intended.

The entomological work during the year was concerned largely with studies of various species of bark-beetles, the chief among which was *Hylastes ater*, a pest recently discovered in various districts, especially where *Pinus* plantations had been partly destroyed by fire or by indiscriminate cutting. The studies of this insect have been in the direction of ascertaining measures whereby its spread could be restricted, and its ultimate complete destruction envisaged.

Further investigations have been concerned with the control of the horntail borer, *Sirex*, by use of the parasite *Rhyssa persuasoria*. The work with *Rhyssa* has not proceeded sufficiently far to give any indication as to its effect in controlling *Sirex*, as at present acclimatization problems with this insect have not been completely overcome. In addition, a further parasite, *Ibalia*, is being imported for trial against horntail borer in New Zealand.

Importations of parasitical species also are being made from Australia in an endeavour to control eucalyptus gall insects and weevils. During the year an insect survey of the exotic plantations of the North Island was completed, and an estimate obtained of the relative numbers and spread of both useful and harmful species. Attention was also given to the relation of bird-life to the insect fauna of both our indigenous and exotic forests, and as a result endeavours will be made to encourage increases in the numbers of such birds as play a useful part in forest development.

Consideration was also devoted to quarantine measures whereby imported timber would be subjected to such supervision and treatment as would reduce to a minimum the danger of importation of harmful insect species by this means. The putting into operation of a satisfactory quarantine system presents certain practical problems which are still receiving the consideration of the Committee.

During the year the investigations of the life-history of spruce aphis have been completed, and it has been revealed that the defoliation of spruce is caused as much by the presence of another insect, the conifer spinning-mite, which works in close association with the aphis, so that any control measures proposed would require to envisage both of these species of insects.

Owing to the importance of mycological problems to the successful development of forestry, during the year arrangements were completed for the training of a qualified forestry graduate under Dr. Cunningham, Mycologist to the Plant Research Station. Mr. Birch, of the State Forest Service, was selected for this work, and has been engaged upon fundamental mycological studies preparatory to making a survey of the fungous flora occurring in both forestry nurseries and established plantations.

RECONNAISSANCE SOIL SURVEY OF THE CENTRAL NORTH ISLAND TERRITORY.

Distribution of Volcanic Showers.

Although the soil survey has been in progress for less than a year, much valuable information has been obtained concerning the widespread distribution of volcanic ash over the whole central territory from Kawhia Harbour to Napier, on the one hand, and from the Bay of Plenty to Wanganui on the other. While much of the volcanic ash has been traced to active eruptions in the Rotorua–Taupo zone, the work which has been done has clearly demonstrated that active eruption of Mounts Egmont, Tongariro, and Ngauruhoe have very materially contributed to the ash coating in particular localities of the territory.

The field-work which has been done by Messrs. Grange and Taylor has shown that volcanic ejectamenta from two centres in the Rotorua–Taupo zone and from Mount Egmont cover very large areas of the North Island and determine to a great extent the characteristic properties of the soils over large areas of country. The Taupo deposit had its origin in the vicinity of Lake Taupo, and in the north-west sector overlies older volcanic deposits from the Rotorua zone. The Taupo deposit is clearly of comparatively recent date, and in the vicinity of Lake Taupo is of considerable thickness. It covers the whole of the territory from Te Kuiti in the west to Napier in the east. During the present year much detailed mapping has been accomplished in order to determine the western boundary (6 in. thick) of this important soil-forming volcanic shower. The boundary has been traced from Mamaku, in the north, and has been found to pass close to Arapuni, and then south through Wharepuhunga to a point about seven miles east of Te Kuiti. From there the boundary of the Taupo deposit passes through Kopaki, and then runs a few miles west of the Main Trunk Railway to a point seven miles west of Taumarunui. The southern boundary of the Taupo deposit has not been accurately determined, but from the preliminary work carried out by L. I. Grange, it is considered that a line drawn through Rangataua to Moawhango and Petane roughly determines the southern limit of a 6 in. deposit of Taupo ash. The country north of Napier as far as Gisborne and Matawai is known to be covered with Taupo ash. The exact limit of deposition on the eastern side of the Island has not yet been determined.

The older volcanic deposit underlying Taupo in the western sector of the central territory has been traced to a centre in the vicinity of Rotorua. This important soil-forming volcanic deposit has a wide distribution between Arapuni and Kawhia Harbour. Very large tracts of country to the west of a line drawn through Arapuni, Wharepuhunga, Te Kuiti, and Taumarunui are covered by this older volcanic deposit. It is probable that the Mokau River approximately determines the southern boundary of well-defined deposition. In the Waikato Valley a great deal of the earlier ash coating has been removed or great resortment of ash from different sources has taken place. Owing to the great development of this earlier volcanic deposit in the Mairoa territory, fifteen miles west of Te Kuiti, the name "Mairoa" has been selected in the nomenclature of this soil-forming volcanic shower.

Preliminary field-work has been undertaken concerning the distribution of volcanic ash from Mount Egmont. It has been found that a wide area of country to the east of Mount Egmont, extending from Wanganui almost to the Mokau and Ohura district, is covered by volcanic ash from Mount Egmont. Time has not permitted the mapping of the boundary of the Egmont volcanic showers, but they are known to extend as far east as Raetihi.

The prosecution of the field-work has shown that volcanic ash of a more recent date than the Mairoa deposit covers extensive areas to the north and east of Rotorua.

At least three showers of very distinctive properties cover portions of this territory. These deposits have been called "Mamaku," "Kaharoa," and "Tarawera," respectively. The area covered by the Mamaku shower is situated to the west of Rotorua. This shower appears on the surface of a comparatively small extent of country, the more recent deposits of Taupo and Kaharoa overlying the greater part of the Mamaku shower. The Kaharoa deposit has a comparatively wide distribution, and extends from Rotorua to Tauranga and probably as far east as Matata and Whakatane. The southern boundary of the Kaharoa deposit passes close to Waiotapu and Te Whaiti.

The Tarawera shower, of quite recent origin, overlies the Kaharoa deposit between Tarawera Mountain and Te Teko. In the vicinity of Lake Rotomahana the deposit consists of a greyish mud of fine texture, but farther to the east the deposit is composed largely of basaltic lapilli and has a very open texture.

In the vicinity of Taihape a much-weathered volcanic deposit, dark brown in colour, covers considerable areas of country to the south of the Taupo soil boundary. Observations have shown that this brown weathered deposit underlies the Taupo shower over a large extent of country. A great deal of evidence has been obtained, showing that the source of this deposit was Tongariro Mountain, and on this account the name "Tongariro" has been applied in the mapping of soils. Although the main area of Tongariro deposit responsible for soil-formation occurs south of Rangataua and Kuripapango, there is much evidence suggesting the presence of Tongariro ash as a thin coating over the Mairoa shower in the Rotorua–Arapuni and Ngaroma sector.

The volcanic deposit from Mount Ngauruhoe covers a more limited area of country around the mountain. It overlies Taupo ash, and is thought to extend in the west as far as Taumarunui.

Stock-ailment on Volcanic Deposits.

The prosecution of the field-work has shown that the various localities which have been definitely recognized as being associated with bush sickness occur solely on three of the volcanic deposits which have been identified. These volcanic deposits are—(1) Taupo, (2) Mamaku, (3) Kaharoa.

Kopaki, Ngaroma, Lichfield, Atiamuri, and Reporoa, where bush sickness or ailments with similar symptoms to bush sickness have occurred, all come within the Taupo boundary. Mamaku, which has been known for many years to have been affected with bush sickness, is located on the Mamaku shower, which is covered by a superficial coating of the Taupo ash. Bush sickness likewise is associated with Kaharoa shower, and has been reported both at Kaharoa itself and Te Puke, and in early days from Tauranga. All of these places lie within the known limits of the Kaharoa shower. So far as observations have been made, bush sickness has not been found on the Mairoa, Tongariro, Egmont, Ngauruhoe, and Tarawera deposits.

Dopiness in sheep characterizes certain areas of the Mairoa shower west of Te Kuiti. The experiments conducted under the auspices of the Department of Scientific and Industrial Research show that this difficulty can be overcome by top-dressing pastures with lime and superphosphate. It is probable that a large extent of country between the Mokau River and Hamilton will be greatly improved by this treatment.

Field Characteristics of Volcanic Soils.

The more recent volcanic deposits, owing to distinctive colour, texture, and structure, can readily be recognized in the field. Some difficulty, however, has been experienced in the identification of the older weathered deposits of Mairoa, Tongariro, and Egmont. Soils derived from these showers are somewhat similar in colour and general structure. A study of the minerals contained in the soils, combined with chemical analysis, has proved so far the only method which can be safely used in their identification.

The older deposits, particularly Mairoa and Tongariro, have a loamy texture, are brown in colour, and frequently exhibit a soapy feel when worked between the fingers. The more recent deposits of Taupo, Kaharoa, and Tongariro exhibit little weathering of the particles, which are comparatively hard and angular. These deposits give rise to grey-coloured soils, frequently of a sandy or silt texture.

Examination of the extensive deposits from the Taupo centre reveals the fact that distinct layers can readily be recognized in the volcanic ejectamenta. This is particularly marked in the vicinity of the vent from which volcanic material was ejected. A very coarse layer of large fragments occurs at the bottom of the deposit. This is succeeded by a layer of particles of much smaller size, comparable to sand-grains. A third layer of fine particles of the silt size overlies the two lower layers. As might be expected, the thickness of the different layers varies greatly in different parts of the territory covered by the deposit. The coarse layer is several feet thick in the vicinity of Lake Taupo, but is entirely absent at points on the outskirts of deposition. The intermediate layer extends beyond the limits of the coarse layer, while the top layer of silt has a very wide distribution indeed. The presence of a coarse layer underlying the topsoil at no great depth profoundly modifies the moisture conditions in the topsoil and greatly affects crop-production, unless the rainfall is particularly high.

Texture of Volcanic Soils.

As might be anticipated, there occur important differences in the textural qualities of volcanic soils. The mechanical analyses which have been made show that soils derived from the Mairoa and Tongariro deposits may be classed as silt loams or sandy loams. In different localities, however, Mairoa soils exhibit important differences in degree of compaction. As far as can be judged with the limited information at our disposal at the present time, the degree of compaction appears to be connected with rainfall conditions. Under light rainfall compaction is small, and the soil and subsoil are loose and floury. In localities with high rainfall both soil and subsoil are well compacted, and offer considerable resistance to penetration with the soil-auger.

Soils derived from the Taupo and Kaharoa deposits are much coarser in texture than the Mairoa soils, and it is only on the outskirts of the areas covered by these deposits that the soils come even into the fine sandy-silt category.

Mechanical analyses of soils derived from the Taupo deposit show that there is a definite grading of particles in the topsoil. The texture of soils in the vicinity of Lake Taupo places them in the coarse-sand category. In the direction of Napier the texture becomes finer, until at Napier itself the soil must be placed in the silt-loam category. The mechanical analyses have also shown that, in addition to this horizontal grading of particles, there is a vertical grading, the top 0–3 in. invariably having a finer texture than lower spits.

Particular attention has been paid to the determination of mechanical analyses of soil-samples from known bush-sick areas. The analytical data of these soil-samples show that the soils are somewhat coarse in texture, falling into sand or sandy-silt groups. Although this correlation of somewhat coarse texture with incidence of bush sickness does not prove that all coarse-textured volcanic soils give rise to bush sickness, it does suggest that a coarsening of soil-texture aggravates the incidence of bush sickness on particular volcanic deposits.

Chemical Characteristics of Volcanic Deposits.

Fusion analyses of representative samples taken from the different volcanic deposits reveal marked differences in chemical composition. The Ngauruhoe, Tongariro, Tarawera, and Egmont showers are relatively high in lime. The Mairoa shower is very low in this constituent, and the Taupo, Mamaku, and Kaharoa soils occupy an intermediate place in regard to lime content. Ngauruhoe, Tongariro, and Egmont soils are high in magnesia, while the Taupo, Mamaku, and Mairoa soils are poorly supplied. Ngauruhoe, Tongariro, and Egmont soils show in the fusion analyses large reserves of phosphate, but the other volcanic deposits tend to be low in this plant-food, the Tarawera and Kaharoa soils being conspicuously low. One noticeable feature connected with the analytical data of the fusion analyses is the relatively low content of iron in the Taupo, Mamaku, and Kaharoa soils. The Mairoa, Tongariro, Egmont, and Tarawera soils are very much higher in iron, frequently containing three or four times more iron than the first group which has been mentioned. The analyses have shown that the low content of iron is associated with low percentages of titanium. It is interesting to note that the three deposits with low iron and titanium percentages are affected with bush sickness.

A number of soil-samples taken from the different volcanic deposits have been analysed by the conventional methods adopted for the study of soils. The results of the determinations show that in every case the top 0–3 in. of the soil is much richer in organic matter, nitrogen, and available plant-food than the underlying spits of the topsoil. Very frequently there is a drop of 50 per cent. in the percentages of plant-food constituents in the lower spits compared with the top 3 in. In a number of cases the spit taken at the depth of 3–6 in. frequently gave little better figures for available plant-food than the subsoil taken at a depth of 9–18 in.

The analytical data show that the Mamaku and Kaharoa soils are very low in available phosphoric acid. Typical samples of the Mairoa soils taken at Mairoa, fifteen miles west of Te Kuiti, also show a somewhat lower content of phosphoric acid. In all three cases the figures suggest that liberal treatment with phosphatic manures is desirable. Soil-samples from the Taupo deposit at Horohoro and Kopaki are comparatively well supplied with available phosphate. The highest percentages of available phosphoric acid were found in soil-samples taken at Te Kawa, Kihikihi, Pukeatua, and Tirau. The high percentage of available phosphoric acid in the Te Kawa – Tirau sector suggests that the soil is not derived solely from the Mairoa deposit.

With few exceptions, the supply of available potash is good in all the soils examined. In the case of the Kihikihi samples the percentage of available potash is astonishingly high. The lime-requirement figures show that many soils have a high degree of soil-acidity. Mairoa soils show the highest lime-requirement figures, being closely followed by soils in the Te Kawa, Kihikihi, and Tirau sector. The Kaharoa and Mamaku soils show the lowest lime-requirement figures, but even these suggest high unsaturation of this constituent.

Exchangeable bases have been determined in a selected number of the volcanic soils. The results of these analyses show that the top 0–3 in. of soil is much richer in exchangeable bases than lower spits in the topsoil or in the subsoil. In comparison with data for Nelson soils, the volcanic soils are high in exchangeable potash. This is particularly true of both the Kihikihi and Mairoa samples. A sample of the Taupo deposit at Horohoro, near Rotorua, is sharply differentiated from other volcanic soils by reason of its low content of exchangeable lime and magnesia. The percentage of exchangeable soda in this Taupo sample is higher than other soil-types, but the percentage of exchangeable potash tends to be low. Samples from other soil-types have much higher figures for replaceable lime and magnesia.

General.

In this report it has been possible to give only a brief outline of the detailed field-work which has been done by Messrs. L. I. Grange and N. H. Taylor, of the Geological Survey, who were seconded to the Reconnaissance Soil Survey. Mr. F. T. Seelye, of the Dominion Laboratory, has been responsible for the fusion analyses which are quoted in this report. Chemical and mechanical analyses have been undertaken at the Cawthron Institute by Messrs. A. H. Sim and L. Hodgson.

T. Rigg,
Officer in Charge of the Central North Island Soil Survey.

FOOD-VALUES.

The following work is carried out under Professor Malcolm at the Medical School of Otago University :—

Miss H. M. S. Thomson investigated the influence of varying proportions of lime and iodine in growth and reproduction of animals. She found that more iodine was required for successful pregnancy and lactation than for more maintenance and growth ; also that an excess of lime as well as a deficiency of lime had an unfavourable influence on the storage of iodine in the body.

Mrs. Airini Fisher, in feeding rats and pigs on diets rich in milk-sugar, such as whey, found that above a certain level of intake the sugar was excreted in the urine.

Miss M. G. Frengley, in a research on New Zealand cheese made at the Dairy Research Institute, found that the nutritive value was high owing to the digestibility of the protein and to the presence of vitamin A and D in the cheese-fat. From the human-food-value point of view no difference could be detected between cheese made from raw milk and that made from pasteurized milk.

Miss Herrick, in a research extending over two years, followed the distribution of vitamin D in milk during the process of buttermaking (Massey College). The butter contains all the vitamin D of the milk, except for the small amounts lost in the fat of separated milk and of buttermilk.

Part of a research was also carried on by Miss Wilson on the nutritive value of some New Zealand milk-products specially designed for infant-feeding.

Full accounts of the above work are in process of publication.

BUILDING REGULATIONS COMMITTEE.

Shortly after the disastrous earthquake in Hawke's Bay the Government set up a Building Regulations Committee under the joint auspices of the Departments of Public Works and Scientific and Industrial Research. An officer of this Department acted as secretary to the Committee. The Committee was instructed to prepare a report embodying such recommendations as it thought fit, with a view to improving the standard of building-construction in the Dominion in relation to earthquake-resistance. The need for such improvement was vividly illustrated in the appalling loss of life and property as a result of the Hawke's Bay earthquake.

The work, in addition to local investigations, has involved the collection and sifting of a great deal of data from overseas—notably from Japan and California.

PUBLICATIONS.

During the year three new bulletins were published as follow:—

No. 27: "Treatment and Disposal of Dairy Waste Waters," by F. H. McDowall.
No. 28: "Wheat Research Institute—First Annual Report."
No. 29: "Low-temperature Carbonization of New Zealand Coals—3. Millerton and Blackball Coals," by W. A. Joiner.

RESEARCH SCHOLARSHIPS.

Three National Research Scholarships, with an annual value of £110, plus a certain additional amount for the purchase of books and apparatus, have been awarded during the year.

The holders of these scholarships, and the researches upon which they are respectively engaged, are as follow:—

I. R. Sherwood, Auckland University: Synthesis of Diterpenes.
H. D. Purves, Otago University: Biochemistry of the Sulphur Compound of New Zealand Pastures.
E. W. Hullett, Canterbury College: Chemistry of Ragwort. (Extension for six months.)

IMPERIAL AGRICULTURAL RESEARCH BUREAUX.

The organization of the eight Imperial Agricultural Research Bureaux has now been brought fully into operation, the local correspondents dealing with a large amount of material which is being compiled at the Bureaux headquarters.

During the year a considerable number of inquiries have been forwarded to the Bureaux headquarters for detailed information on specific points as required by local investigators.

"NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY."

The *New Zealand Journal of Science and Technology* has been regularly issued during the past year at intervals of two months. The *Journal* continues to function as a means of permanently recording the results of investigations conducted in a large number of spheres in New Zealand.

Extensive use has been made of reprints from the *Journal* itself in the dissemination of the results of researches to those most interested.

The publication of the *Journal* enables a large number of exchanges of overseas scientific journals to be made available to local investigators.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

(1) Pasture Investigations.

Investigations of pastures have been carried out under two separate headings—

(*a*) *Complete Farm under Control.*—The supervision and management of the entire mixed farm intensively worked from the point of view of net returns has been carried out. The results definitely show that by efficient utilization of pastures and other fodders not only can the numbers of stock carried be increased, but the net returns of a farm can be materially increased.

(*b*) *Control of Pastures: Manurial Trials.*—Some twenty-seven half-field grass manurial trials with different fertilizers on various types of pastures, soils, and in different localities are under observation and controlled grazing. The results show that (1) a very definite increase in the carrying-capacity can be obtained by efficient utilization—*i.e.*, controlled grazing of pastures; (2) the top-dressing problem in Canterbury has just been touched on; and (3) the measuring of returns from fertilizers in Canterbury on some good soils and pastures, calculated by the increase in carrying-capacity in one year alone, showed a profit. On most farms, however, interpretation of the trials must take cognizance of: (i) Cumulative effect—pasture-improvement; (ii) mineral content—quality; (iii) permanent pasture—the avoidance of the high cost of pasture renewal; (iv) out-of-season grass.

(2) Wool Research.

During the year under review Mr. D. J. Sidey has been absent in England and Scotland studying wool-research methods and inquiring into manufacturers' demands. Mr. Sidey has prepared a detailed report of his investigations, which has been submitted to the Council of Scientific and Industrial Research and is to be printed.

Consequent on Mr. Sidey's absence, there has not been much progress in this branch of research. However, the breeding trials have been continued, and promise very interesting results. The weighing of the fleeces from our stud flocks has been continued, and the results serve to stress the need for continuing this work on a wider scale. There is no doubt but that very considerable benefit would accrue to the sheep-breeding industry if some form of wool-testing were commenced in this country.

(3) Pasture Manurial Trials.

During the year pasture manurial trials comparing the effects of different times of applications upon the response to manures have been continued as before.

(4) Farm-implement Research.

Last season a number of grain-drills were obtained from the manufacturers and a preliminary trial of these made. Results indicate that there is considerable room for improvement in even the best of these implements, and the information gained will form a useful starting-point when the improvement is seriously undertaken by the makers.

(5) Engineering Department.

Some of the greatest difficulties in civil engineering work arise from a lack of knowledge of that important material, soil. The safety of building-foundations, the pressures on retaining-walls and tunnel-linings, and the condition of lands for drainage or irrigation are but a few of the questions involved, and it was with these in view that some work was commenced in vacation period by the Engineering Department. Owing, however, to lack of time, little has been accomplished beyond the collection of literature and an attempt at gaining the necessary technique. Classification is being carried out at the Canterbury Agricultural College, while the engineering features will be tested at the School of Engineering, Canterbury University College. Analyses made by the Bonyon hydrometer method show that, with certain precautions, fast and consistent work is possible, particularly in the colloid fraction.

(6) Chemistry Department.

(*a*) *Iodine Research on Sheep.*—In connection with work being carried out by Mr. Scott on the treatment of sheep and lambs with potassium iodide a number of analyses were carried out during August, 1930, on the iodine content of blood, and thyroid samples of treated and control sheep.

(*b*) *Investigation of the Mineral Content of Pastures in Canterbury.*—This work may be divided up under two headings—

(1) Pure strains of grasses and clovers: Samples from a number of pure strains of clovers, rye-grass, cocksfoot, Chewings fescue, and brown-top have been collected over a twelve-monthly period. Analyses of the mineral content to show the species variation and seasonal variation have yet to be carried out.

(2) The effect of different manurial treatments on the botanical composition and mineral content of natural pasture in Canterbury: Eighteen different manurial treatments have been selected for investigations. A considerable amount of analytical work has been done, and it is hoped very shortly to be able to publish some of the results obtained. The analyses already carried out indicate that it is not only advisable, but also essential, that under Canterbury conditions the use of a lick containing lime and phosphate—*e.g.*, bone-meal or steamed bone-flour with salt—should be used for stock.

(7) Animal Nutrition.

SHEEP.

The following work has been in progress :—

(1) *Winter Feeding Trials of Sheep.*—Four mobs of ewes have been wintered on grass, straw, and hay, plus the following supplements : (*a*) ½ lb. oat-sheaf chaff ; (*b*) ¼ lb. oat-sheaf chaff and 2 oz. of meat-meal ; (*c*) ¼ lb. oat-sheaf chaff and ½ oz. of Cystinos ; (*d*) ¼ lb. wheat, ¼ lb. peas, ¼ lb. oat-sheaf chaff, and 2 oz. meat-meal. Hay replaced straw late in the season, and ensilage was used for three weeks before lambing. No turnips or green feed were used.

(2) *Effect of Winter Feeding on Lamb and Wool Production.*—The lambs from the above ewes were weighed at birth and subsequently at intervals till disposed of, in order to discover the effects (if any) of different winter feeds. Wool-weights were also taken.

(3) *Production from Intensively Grazed Grass.*—Records were kept of live-weight production per acre of differently manured paddocks intensively grazed.

(4) *Fattening of Lambs on Grain and Grass.*—The lambs referred to above were fattened on grass and grain, and records of the value of such feeding kept.

(5) *Effect of Bluestone Administration (for Worms) on Growth-rate of Lambs.*—Some of the lambs above were dosed periodically with bluestone, and records of growth-rates were kept.

(6) *Effect of Iodine on Growth-rates.*—A mob of ewes, half of which are dosed weekly with potassium iodide, have been kept under observation since November, 1929. Lamb and wool production and general health as influenced by iodine are being recorded.

PIGS.

Work under this heading has been directed mainly towards an investigation of the relative efficiencies of pigs as pork or as bacon. Twenty-five sows have been kept and the progeny used for the above purpose. Costs of keeping sows and producing weaners have also been worked out. Feeding trials with a meat-meal containing finely ground bone have been carried out.

(8) Plant-breeding—Herbage Plants.

All selections and progeny lines of cocksfoot, rye-grass, and red clover are now being grazed by sheep. The plots have been fenced to allow the different lots to be grazed when necessary. By this means the reaction to sheep-grazing is determined. That it is an important factor is clear, in that, out of 334 cocksfoot selections tested under grazed and ungrazed conditions, seven were grouped as grade 1 under both methods ; on being grazed, six have come up from grade 2 to grade 1, four have come up from grade 3 to grade 1, while twenty have gone down from grade 1 to lower grades. The remainder were no good under either method.

Cocksfoot.—The offspring of twenty-one selections, shelter-pollinated, have been tested as spaced plants and their reactions to grazing noted. There are marked differences between the offspring of different selections, some selections producing over 50 per cent. of grade 1 plants, others not producing any.

An additional 70 selections from different soil formations in the South Island have been shelter-pollinated and the seed sown, the plants to be transplanted in the spring. The best offspring producers have been self-pollinated for further selection and inbreeding.

Yields from pure sowings of different lots of cocksfoot have been obtained (nine four periodical cuttings), and show distinct differences in yielding-capacity :—

	Air-dry Matter per Plot (Average of Three Plots). Grm.
Commercial, Canterbury Plains	330
Old pasture, Canterbury Plains	460
Canterbury roadside	566
Commercial, Southland	515
College pedigree strain C 233	625
College pedigree strain C 13	403
Commercial, Akaroa	497
Y 100	322
Y 101	500

Two hundred and fifty pounds of College pedigree strain C 23 was harvested, and four small trial plots put down in four localities. In addition, 10 acres has been sown pure for seed-production.

Rye-grass.—Work on rye-grass has been continued along the same lines as with cocksfoot. The offspring of seventeen selections have been tested. An additional thirty-one selections from different parts of the South Island have been shelter-pollinated and the plants transplanted as spaced plants.

Nineteen plants of Italian perennial were grown last year, and selfed, sib back-crossed, and often pollinated seed obtained. The plants have been planted out as spaced plants. Yield trials with different lots of perennial rye-grass demonstrated the existence of good and bad lines of commercial seed. In general, seed from old pastures, whether from Southland, Canterbury, Hawke's Bay, or Poverty Bay, was good, and there was no difference between any of them. On the other hand, many lines from yearling stands were badly mixed with Italian rye-grass, one line being pure Italian.

Red Clover.—The work with this species has consisted in testing out progeny lines produced by crossing different pairs of parents. Twenty offspring lines have been so tested and ten new crosses have been made.

(9) Farm Economics.

The work comprises in the main—

(1) A survey of the cost of wool-production on the tussock country of the South Island. This survey comprised an area of almost one million acres, and covered returns from over a quarter of a million sheep. It had the support of the Sheepowners' Union, and the results in the present form were published by that union. It is intended at a later date to publish the results in a more popular form by including a summary of average or normal results of capital requirements, and receipts and expenses, and most profitable methods of management on the various classes of land dealt with. The survey was assisted by students W. S. Allan and R. A. Sherwin.

(2) Farm costing: Farm-costing work has been continued in so far as time has been available. R. A. Sherwin has completed a cost account for a farm comprising mainly heavy cropping and grazing land, the returns giving valuable information as to the relative profitableness of crops and sheep on this type of country, and also showing the cost and the profitable nature of a small area of mangels. In a similar manner, another student, L. A. Hayman, costed out the cost of potato-production. The cost for the use of a new type of combination digging and bagging machine, which digs, grades, and bags in the one operation, was compared with the ordinary method of harvesting potatoes. The costs for the use of the header harvester have been further followed up.

(3) Budgeting: As an outcome of the necessity for budgeting, shown by the results of the survey made of wool costs of production, and the necessity for a drastic readjustment of expenditure, a bulletin on budgeting has been issued in conjunction with the Canterbury Chamber of Commerce, and a sample budget form made available to farmers.

(4) Farm accounts: On account of the many inquiries received with regard to farm accounts, a farm account-book has been compiled and issued at cost price. This account-book aims at an encouragement of farm accounting by those farmers who do not now keep accounts on simple and uniform lines, and lines which will enable a farmer with the least writing to discover where the money handled for the year has come from and gone to, and how much he has improved his position, or otherwise, in that period. It is proposed to follow this up at a later date by a book on the method of using farm accounts to assist management, land-purchase, land valuation, and settlement.

DOMINION LABORATORY.

ANNUAL REPORT.

Dr. J. S. Maclaurin, having reached retiring-age, resigned the Directorship during the year, and was succeeded as Dominion Analyst by Mr. W. Donovan. Appreciative reference to Dr. Maclaurin's work has been made on p. 3.

The work during the year consisted almost entirely of chemical analyses and investigations carried out on behalf of Government Departments. The number of samples received from the various Departments was as follows: Customs, 384; Justice (Police), 47; Geological Survey, 129; Main Highways Board, 541; Mines (including prospectors' samples), 267; Post and Telegraph, 72; Health, 3,495; Public Works, 46; public bodies, 32; Railways, 92; Stores Control Board, 35; other Departments, 195; miscellaneous, 206; total, 5,541. Health includes—Milks, Wellington City supply, 1,689; milks from country districts, 797; human milks (Plunket Society), 285; waters, 94; samples for goitre research, 294; foodstuffs, &c., 336.

Comment on the Work.

Justice Department (Police).—Several cases of supposed poisoning were investigated. The finding of strychnine in a body by the Government Analyst, Auckland, led to a trial for murder, in which a conviction was obtained. Analyses were made in Wellington and Christchurch to support charges of counterfeiting.

Geological Survey.—Very careful chemical work carried out in connection with a survey for soil deficiency established the presence of distinct volcanic showers of varying fertility in the areas concerned, and indicated a possible correlation with other areas. A number of superior rock analyses were also carried out.

Health Department.—Judging from the low percentages of adulterated milk in the samples taken, the milk-supplies of the four main centres are, on the whole, satisfactory. More supervision in country districts would appear warranted. There was little serious adulteration in other classes of food-stuffs examined.

Main Highways Board.—There was a considerable increase in the number of samples of roading-material examined for the Main Highways Board.

Other Departments.—In most cases the work carried out, though useful to the Department concerned, calls for little comment.

Gas-inspection.

Gas was regularly examined for heating-value and for purity in the four main centres, and in most of the larger towns of the Dominion.

RESEARCH.

Incidence of Goitre.—Research work was continued during the year on the relation of iodine content of soils, waters, and foods to the incidence of goitre. The iodine content of a large number of samples of thyroids, blood, urine, milk, and eggs has been determined. The research is not yet complete.

Coal.—In addition to the work carried out under the Coal Research Association, the blending of some New Zealand coals with a view of extending their use for gas-making was investigated.

Sheep Sickness.—It was considered possible that cyanogenetic glucosides were present in the pasture from an area affected with sheep sickness, but careful examination did not reveal any trace of cyanides.

Oleo Resins from Pine.—An examination of turpentine oil and resins obtained locally by bleeding *Pinus radiata* and *Pinus pinaster* was made for the Forestry Department. The turpentine was substantially in accordance with B.E.S.A. Specifications.

Limestone for Agricultural Use.—An investigation of the relative availability of hard and soft limestones when applied to soil would indicate that hard limestone, if sufficiently finely ground, is equally as available as soft.

Bananas from Cook Islands.—An investigation to ascertain the best conditions of ripening was undertaken during the year and is nearing completion.

Clay.—Careful analyses and firing tests of clays not previously examined were made during the year.

Salinity of Sea-water.—Careful determinations have been continued at the Dunedin Laboratory.

Frozen-meat Industry.—One of the staff was detailed to assist in the special investigation on the freezing, storage, and transport of New Zealand lamb, carried out under Dr. E. Griffiths, and, when the work in the Dominion was completed, went to England in charge of recording apparatus on one of the boats carrying selected frozen carcasses. Another member was loaned to the Dairy Research Institute for two months for urgent investigations.

W. DONOVAN.

GEOLOGICAL SURVEY BRANCH.

TWENTY-FIFTH ANNUAL REPORT (NEW SERIES).

CONTENTS.

DIRECTOR'S REPORT.

DURING the 1930–31 field season, which ended on the 31st May last, Mr. H. T. Ferrar carried out topographical and geological mapping in the Te Kuiti Subdivision, Mr. M. Ongley and Mr. J. H. Williamson in the Eketahuna Subdivision, and Mr. H. E. Fyfe, for a time assisted by Dr. Marwick, in the Amuri Subdivision. Messrs. L. I. Grange and N. H. Taylor investigated the distribution and thickness of the volcanic-ash showers of the Mamaku, Putaruru, Cambridge, Ngaroma, Te Kuiti, Taumarunui, and adjoining districts. These ash showers, which are derived from several centres, cover large areas in the North Island, and the soils of the areas they cover are altogether or largely derived from them.

The Director (Dr. J. Henderson) made official visits to Waimana, Okoroire, Great Barrier Island, and Pahi, in the North Island, and to the Greymouth and Owen coalfields, in the South. He also visited Arapuni on several occasions, and, with Messrs. Ongley and Grange, spent a fortnight in the Napier district immediately after the earthquake. Mr. Ongley later was occupied for a month in exploring the same district. He, with Mr. Williamson, also examined the copper-bearing area near Maharahara.

During the season approximately 869 square miles were geologically surveyed in detail. Of this area, 335 square miles was in the Te Kuiti district, 328 square miles in the Eketahuna district, and 206 square miles in the Amuri district. Owing to shortage of funds, work in all the subdivisions was restricted, and Mr. Ongley's absence from his regular work still further reduced the area mapped in the Eketahuna Subdivision. Messrs. Grange and Taylor examined the soils of a large area in the Hauraki district and in the King-country, but did no detailed geological mapping.

The manuscript of the Dargaville–Rodney Subdivision is being typed; those describing the Motueka, Kaitangata-Green Island, and Rotorua-Taupo subdivisions should be ready before next field season, and those on the Murchison, Tongariro, and St. Bathans subdivisions well forward.

Shortage of money delayed for many months the printing of Dr. Marwick's bulletin on the molluscs of the Gisborne district. This report is now printed and shortly will be issued. Dr. R. S. Allan has furnished an account of the fauna of the Reefton beds, which are of Devonian age, and this will be published as soon as money is available. The members of the staff have contributed several papers to the *New Zealand Journal of Science and Technology*. These are "Wattle-growing in Natal" and "Gold in New Zealand," by J. Henderson; "Maori Terraces," by M. Ongley; "Diatomite—Principal New Zealand Occurrences and Uses," "Volcanic Rock at Lake Rotoiti," and "Volcanic-ash Showers," by L. I. Grange; and "The Relation of Geology to Sheep Sickness in the Mairoa District," by N. H. Taylor.

A great deal of correspondence has been attended to, many requests more or less connected with the work of the Geological Survey have been answered, and samples of rocks, minerals, and ores examined. This part of the work of the Geological Survey was heavier than usual owing to the increasing interest taken in prospecting.

During the year Mr. G. E. Harris, Draughtsman, drew for photographic reproduction seven maps to accompany different bulletins. He also prepared twenty-five block drawings, twenty-eight field sheets for Te Kuiti, Eketahuna, and Amuri Subdivisions, a number of tracings, and other miscellaneous work.

This year very few books were purchased for the library. Many valuable exchanges were received, and the estate of the late Lady Hector donated a valuable collection of early official reports relating to the geology of New Zealand and the discovery of the goldfields. Last year's report omitted to state that the beneficiaries of the late Dr. J. Allan Thomson had presented a considerable number of scientific works, chiefly dealing with petrology and allied subjects.

SPECIAL REPORTS.

1. TE KUITI SUBDIVISION.

(By H. T. Ferrar.)

Introduction.

During the past field season the geological survey of the Te Kuiti Subdivision was continued in such a way as to link up districts, that previously had been mapped, with the isolated areas east of the railway specially surveyed last season on account of the Mineral Content of Pastures Research Committee (see last year's annual report). As soon as these special areas had been connected with earlier work the survey was continued systematically. Field-work was resumed on the 11th November, 1930, near Waimiha, at the north-east corner of the Tongaporutu-Ohura Subdivision (see N.Z. Geol. Survey Bull. No. 31), and was carried northward over Pahi, Pakaumanu, and Mangaorongo Survey Districts to the southern boundary of the already mapped Puniu Survey District of the Huntly-Kawhia Subdivision (see Bull. No. 28). Work at Otorohanga was suspended on the 31st May, 1931, after 335 square miles had been mapped.

General Geology.

The area surveyed contains three distinct rock-formations—namely, distorted conglomerate, sandstone, and claystone beds of Triassic age; almost horizontally bedded limestones and sandstones of Tertiary age; and a thick but dissected sheet of consolidated rhyolitic tuff erupted in late Pliocene or early Pleistocene times.

The Triassic rocks are littoral deposits that occur as fault-blocks uplifted independently of their internal structure. These rocks so resemble the oft-described greywackes that form the elongate mountain-ranges of the Dominion that no further description is necessary here. The Tertiary sediments are likewise marine deposits which rest with marked unconformity on the greywackes. They are an extension eastward of the Te Kuiti, Mahoenui, and Mokau beds described in former reports on adjacent areas. The occurrence of infaulted Tertiary beds in the Owawenga valley in Pakaumanu Survey District shows that an important line of structural weakness passes through the district.

During late Pliocene and Pleistocene times earth-movements caused fissures to open in the basement rocks, through which vast quantities of rhyolitic tuff were ejected. At Ngahape there is a small flow of basalt. The rhyolitic material, like that ejected at Katmai in Alaska, shows no distinct craters, and was probably erupted through a number of vents, not one of which has as yet been located. The now consolidated material forms tablelands, fills depressions between block mountains and spreads out on the Waikato lowlands. The tuff usually contains angular fragments of obsidian and pumice, which, being hot and sticky when ejected, adhered to form a massive rock. In some places the tuff is bedded and contains waterworn boulders of pumice and occasionally of greywacke, as if deposited from an aqueous slurry; in other places it has given rise to lacustrine clays. In some places it is an incoherent sand that, when deposited, was warm enough to slide off hillsides and "flow" along valleys; in other places there is abundant dune material.

Normal terrestrial conditions followed the eruption of the tuff. The once uniform sheet was dissected, and gravels, sands, and clays derived from it were deposited in patches. Subsequent disintegration and weathering of rhyolitic material has given rise to white, yellow, and brown earths of inconstant thickness, above which a thin covering of recent pumiceous ash (Taupo pumice) is conspicuous.

Synopsis of Mineral Resources.

The district under review has been subjected to igneous activity and earth-movements which are usually the immediate prelude to primary mineralization, but in the present case no minerals of high intrinsic value have made their appearance, although the presence of gold and mineral oil has been reported from time to time. Vulcanism, however, has supplied vast quantities of rhyolitic tuff suitable for constructional purposes, and of white pumice sands that can be used for making pumice concrete should such material be required for towns liable to earthquake shocks. The rhyolitic tuff is easily quarried, and there are great masses of this rock close to the railway between Waimiha and Puketutu railway-stations.

Coal-seams were found in three localities, but only one—namely, that near Tahaia—is worth working; its prospective value is small. High-grade limestone is scarce in the area just surveyed.

Soil and subsoil profiles were examined in order to establish a basis for their classification in terms of full profile, and an attempt was made to trace a connection between the soils and the incidence of debility in stock.

2. EKETAHUNA SUBDIVISION.

(By M. Ongley and J. H. Williamson.)

The Eketahuna Subdivision extends along the east coast of the North Island from eight miles north of Cape Turnagain to four miles south of Castle Point and reaches inland fifty miles to the Tararua Range. Inflammable gas issues from the ground in several places, and some of the rocks smell of oil, indicating that payable oil may occur. Much money has been spent, without success, in trying to produce oil, and it is expected that a geological examination will help.

Topography.

The Tararua Range, 3,500–2,000 ft. high, trends east of north along the west of the subdivision, and has at its foot a depression ten miles wide and 400 ft. above sea-level, along which runs the railway past the chief settlements and the towns, Eketahuna and Pahiatua. East of this lowland are the parallel Waewaepa Range (2,000 ft.) and Puketoi Hills (2,600 ft.). Between the Puketoi Hills and the coast there is a series of high steep-sided ridges with accordant summits, evidently remnants of a dissected plateau.

Structure.

The major features of the subdivision trend east of north parallel with the coast and the main range, and consist of a set of alternating ridges of Cretaceous beds and valleys filled with Tertiary beds. The topography corresponds with the structure—the ridges are anticlinal, the valleys synclinal. The folds, however, are corrugated, and are really anticlinoria and synclinoria. The Tertiary beds in the synclines are well bedded and not tightly folded, so they can be readily mapped and their structure elucidated; but the Cretaceous beds in the ridges are, at best, poorly bedded and are tightly folded, so that they afford only scant evidence, in places insufficient to show the structure. Further, the boundary between ridge and valley is not in all places evident. At many places strong faults are shown by wide crush-zones; at others it is impossible to be sure of the faulting, the only evidence being a steep bluff of hard Cretaceous bed standing up as a strike ridge over the eroded softer Tertiary beds. Where the evidence is good these steep faces are found to be fault-line scarps of bedding faults, in places passing into flexures.

The structure is most readily described by beginning at the coast and crossing the grain of the country inland. At Cape Turnagain the middle of a syncline is occupied by beds of limestone (Te Aute limestone) underlain on both flanks by beds of mudstone and tuffaceous sandstone (Mapiri beds), which were found to be 1,500 ft. thick on the west limb. These are underlain by more massive mudstone (Morere mudstone), 2,500 ft. thick, and these in turn by much broken Cretaceous chalky limestone, mudstone, and greensandstone. The Tertiary formations are parallel, and separated only by thin pebble-beds marking the erosion intervals. They dip gently (5°–10°) near the middle of the syncline, and gradually steepen on the flanks to 80°, and are, in places near the Cretaceous rocks, overturned and highly contorted. On the coast 60 chains north of Whangaehu the Tertiary beds are seen dipping 80° east. They have a conglomerate of Cretaceous boulders at the base, and are underlain by crushed and distorted Cretaceous beds, broken and compressed into steep and vertical folds. Ten miles to the south along the strike the same Tertiary beds are much contorted, and dip 80° westward below Cretaceous beds with the same attitude. Near the contacts the Tertiary beds are typically steep and broken; away from them they dip gently in wide, open folds. This shows that the stresses were relieved by movements at the contacts of the strong Cretaceous and weak Tertiary beds folding them steeply, overturning them, breaking them along wide belts into breccia and pug. While the Tertiary beds are steeply folded only near the Cretaceous, the Cretaceous beds generally are tightly folded. The syncline that has its trough at Cape Turnagain, conforming to the regional strike, trends west of south, and is filled with Tertiary beds up to four miles west of the axis. There it is bordered by a parallel anticline four miles wide, of steep, vertical, and overturned Cretaceous beds. West of this again is another synclinal filled with Tertiary beds, vertical and broken at the contact with the Cretaceous and flattening out towards the axis at Te Awa Putahi, where again remnants of Te Aute limestone occur along the middle of the syncline. In the north this is a simple syncline eight miles wide, but in the south it is composite, with anticlinal axes trending north at Ti Tree Point and Mount Arthur. Its western margin also is not simple, but is broken by salients of sharply folded Cretaceous rocks jutting in from the west, and Cretaceous rocks, west of Weber, nearly surround a small north-north-east syncline of Tertiary strata.

The next Cretaceous anticline west of the Tertiary synclinorium is five miles wide, and has on its west another Tertiary syncline whose western limb is the conspicuous dip-slope forming the east side of the Puketoi Hills. On the west side of the Puketoi Hills the beds dip westward in extensive dip-slopes, showing that the range is anticlinal; but this part was not examined in detail. The beds are faulted or form a syncline between the Puketoi Hills and the Waewaepa Range, three miles to the west. In this range the greywacke core is exposed in a belt two and a half miles wide along the anticlinal axis, and the Tertiary beds continuously dip off the west limb for ten miles and pass under the alluvial plains of Pahiatua, which occupy the syncline. West of Pahiatua the beds rise to the west for three miles, then turn over in an anticline and dip westward for a mile, where they are cut off by the fault along the east of the Tararua Range. This fault dies out as the range descends northward, and the Tararuas are spanned by an asymmetrical arch of Tertiary beds.

Thus the strip of country on the northern edge of Eketahuna Subdivision, forty miles wide from east to west across the strike of the beds, contains nine anticlinal ridges, mostly of pre-Tertiary rocks, and nine synclinal valleys with floors and sides of Tertiary beds. The Tararua Range, on the west, is an asymmetrical anticline with a long gentle western limb and a steep short eastern limb, and has a greywacke core. The next anticline is broken along its west side. The next has a gentle west limb ten miles long and a steep east limb two miles long, and likewise in places has a greywacke core. This indicates that the beds were folded by pressure from the west. The other folds are symmetrical, strongly compressed in the synclines, and, as already mentioned, even to the coast the anticlines are bordered by vertical and overturned beds.

GEOLOGY.

The rocks comprising the country consist of the following sets:—

Thickness.	——	Series.
700 ft.	Terrace and river gravels; coarse conglomerate and lignite; soft massive mudstone	Waipaoa ?
2,500 ft.	Arenaceous mudstone; pebbly limestone	Petane.
	Limestone	Te Aute.
1,500 ft.	Soft arenaceous mudstone; mudstone with beds of white crystal tuff ..	Mapiri.
3,000 ft.	Mudstone and sandstone, with conglomerate beds	Tutamoe.
	(Unconformity.)	
1,000 ft	Massive mudstone with frail shells	Ihungia ?
	(Unconformity.)	
1,500 ft.	Light mudstone with thin sandstone; fine white sandstone with fucoids ..	Weber=Wheao.
	(Erosion interval.)	
3,000 + ft.	Pink and light-coloured limestone; light-bluish mudstone; light sandstone spotted with glauconite; white siltstone; chocolate mudstone; light shaly mudstone and sandstone; dark mudstone with *Inoceramus*; light coarse pebbly sandstone with 2 ft. pebble-beds; hard dark mudstone with thin sandstone	Mangatu and older Cretaceous.
5,000 + ft.	Greywacke and argillite	Pre-Cretaceous (unfossiliferous).

These formations have been followed in the field and mapped. The Cretaceous beds probably belong to several formations, but no section shows how to divide them. Also, no fossils have been found in the greywacke. In places, too, it is difficult to assign, with certainty, the Tertiary beds to a formation.

The geology may be summarized by stating that unconformably above the tightly folded greywacke are steeply dipping and contorted Cretaceous sandstones and mudstones 3,000 ft. thick, overlain by 10,000 ft. of unindurated shallow-water marine sedimentary rocks which are separated by several breaks into the formations listed and folded into anticlines and synclines.

Evidence of some value in the interpretation of the subdivision as an oilfield has been obtained. The beds constitute a petroliferous province, the strata and folding being suitable. Several vents of natural gas have been tested and found to be dry. The mapping shows that the wells at Waipatiki were bored in a syncline.

3. AMURI SUBDIVISION.

(By H. E. FYFE.)

The greater portion of this subdivision is in the Marlborough Land District, but a small area comprising the Waiau, Terako, Towy, and Hawkswood survey districts is in the north of Canterbury Land District. Work was commenced on this area during mid-November, and until mid-February the writer was assisted by S. J. H. Sylvester, B.Sc. From mid-March to the end of May J. Marwick, D.Sc., assisted with the field-work. The 206 square miles so far mapped are confined to portions of the above-mentioned survey districts, and to portions of the Acheron, Greenburn, and Hundalee districts.

PHYSIOGRAPHY AND STRUCTURE.

The two principal mountain-masses of the subdivision are the Inland Kaikoura and the Seaward Kaikoura ranges, mountains of the fault-block type. Cloudy Range and Sherwood Range are the southern continuation of the Seaward Kaikoura, and are separated from the lowlands to the east, the northward continuation of the Hurunui–Waiau depression, by the great Kaikoura Fault of McKay. East of this fault the continuity of the depression is interrupted by minor elevated earthblocks. The Mount Parnassus block and its northern extension determines the eastern boundary of this depression.

The bulk of the mountain-masses consists of pre-Cretaceous rocks, and the Cretaceous and Tertiary strata flank the lower slopes of some of the highlands and occupy portions of the relatively depressed areas. The general north-east strike of the younger rocks and of the Kaikoura Fault is slightly oblique to the more northerly strike of the pre-Cretaceous rocks.

Broadly speaking, the structure west of a line from Whale Back to Isolated Hill may be considered as a wide syncline with axis striking north, obliquely truncated by the Kaikoura Fault on the north-west and by a fault-zone trending north-east from Isolated Hill, and much complicated by faulting and minor folding. At Combe Hill an anticlinal fold is overturned to the west.

GEOLOGY.

Pre-Cretaceous Rocks.—The basal rocks consist of banded greywackes and argillites probably of early Mesozoic age, intensely folded and, in some localities, highly sheared and fractured. Some of the beds are decidedly calcareous, and are then usually concretionary. In places they are interbedded with pillow-lavas. A conglomerate containing pebbles of granite, diorite, porphyritic rocks, red argillite, and greywacke crops out at several localities. A few calcareous pebbles resembling closely the

material of the calcareous concretions embedded in the greywacke occur sparingly in the conglomerate. Usually poorly preserved leaf-impressions are abundant near this bed, which may be an interformational conglomerate. Dykes of basic to intermediate composition intersect these sedimentary rocks.

Cretaceous Rocks.—The Cretaceous rocks consist of basal conglomerates and sands with interbedded sandy mudstones and argillaceous sandstones. Laterally the coarser sediments grade to sandy mudstones containing thin impure limestone bands which occasionally exhibit cone-in-cone structure. Coal fragments are scattered throughout all these beds, and in the mudstones may be sufficiently plentiful to form layers 2 in. or 3 in. thick, but nowhere has anything approaching a workable seam been noted in them. In the mudstones are concretions that contain fragments of saurian bones, and overlying it is a greensand that at one point contains a phosphatic layer and at another a Cretaceous faunule resembling that from the lower sandstones of Herring River in the Clarence Valley.

Amuri Limestone.—Only in the neighbourhood of Monkey Face and the northern end of Whale Back are the beds correlative with the Amuri stone typical of that rock. Elsewhere it is represented by calcareous sandstone or argillaceous sandstone, all more or less glauconitic, the more glauconitic facies presenting a mottled appearance due to the presence of numerous fine worm-borings with a non-glauconitic filling. This bed has a similar distribution to that of the Cretaceous rocks.

At the headwaters of the Counting Stream an andesitic, or possibly more acid, rock overlies the Cretaceous greensand. Its relation to younger beds could not be ascertained, though the presence of the Amuri limestone in this locality is indicated by drift material.

No fossils indicating the age of the Amuri limestone and beds with it were found. About 25 chains south of Isolated Hill Trig. the upper surface of the glauconitic calcareous sandstone which here represents the Amuri stone is capped by an indurated band of sandy limestone 6 in. to 8 in. thick, bored by marine organisms and containing phosphatized nodules. To the east of Mount Cookson Trig. a greensand appears to overlie the limestone, and at other localities tuffs or basaltic flows overlie. No marked erosion surface has been observed at the top of the Amuri stone, and fossil evidence in proof of unconformity is wanting, but the general tenor of the evidence strongly suggests unconformable relationship with the overlying strata.

Cookson Beds.—These consist of breccias and stratified tuffs with basaltic and basanitic flows and pillow-lavas. At many points impure limestone bands are interbedded with the tuffs. The flows are highly vesicular, and contain abundant analcite and usually calcite or opal. Zeolites are also abundant in some flows and dykes. One igneous conglomerate band, at least, is interbedded with the flows, and marks an erosion interval during a period of quiescence in vulcanicity. The tuffs have almost the same distribution as the rocks previously described, but they have not yet been observed north of the Conway. The flows are less widely distributed. The Cookson Beds are thought to be of Waiarekan age.

Isolated Hill Limestone.—An igneous conglomerate caps the igneous rocks at many localities, and at many points it is set in a calcareous matrix. As the boulders decrease in number the conglomerate grades to a bryozoan limestone. The limestone is from 150 ft. to 200 ft. thick at Mount Cookson and is as widely distributed as the tuffs; it is markedly lenticular. There is an abundant and readily available supply of this stone, which should prove to be high-grade agricultural lime. The limestone is probably of Ototaran age.

Sugar-loaf Beds.—At the limestone gorge of the Lottery, Waiau Survey District, a greensand from 16 in. to 36 in. thick rests on the phosphatized surface of the Isolated Hill stone, and is overlain by a conglomerate band, 8 in. to 16 in. thick, containing angular pebbles of the limestone and sub-angular igneous pebbles. The section is terminated by a fault. Other sections proving disconformity below the sugar-loaf beds also occur. Concretionary sandstones and argillaceous sandstones overlie the greensand or conglomerate, and interbedded is a more resistant band which grades to the arenaceous limestone that crops out as the Sugar-loaf Hill, south of Waiau Township. Deposition continued till a thickness of about 1,400 ft. of sandstone accumulated, when the erosion of previously deposited beds resulted in the formation of a conglomerate band containing pebbles of sandstone bored by marine organisms, and rewashed fossil and saurian bone fragments. This conglomerate crops out on the south bank of the Waiau-uha, a mile and a half east-north-east from Isolated Hill. The Sugar-loaf beds probably represent the Hutchinsonian and Awamoan stages.

Bourne Conglomerate.—The position of this bed in the sequence is uncertain. It accumulated after the deposition of the Sugar-loaf sandstones began, but it might be older or younger than the Sugar-loaf limestone. It is limited to a comparatively small area about a mile east of the confluence of the Mason and Lottery, and it consists of blocks of Isolated Hill limestone and greywacke, up to 18 ft. across, with smaller fragments of tuff and igneous rocks. It crops out close to a fault, and its origin is probably to be ascribed to the accumulation of blocks derived from movement along this fault during the deposition of the Hutchinsonian or Awamoan beds with which it is embedded.

Highfield Beds.—Argillaceous sandstones overlie the conglomerate band on the south bank of the Waiau-uha, and these are succeeded by gravels and sandstones. They are contemporaneous with similar sandstones and gravels that crop out elsewhere. Some Pliocene fossils were obtained from these beds. At all the localities where the gravels have been observed in contact with the sandstones there is no marked angular unconformity. In the gravel cliffs bordering the Mason about half a mile north of Waiau the Highfield gravels dip at steep angles and the younger Lyndon gravels rest on their truncated edges.

Lyndon Beds.—These beds consist of gravels and loosely consolidated sandstones. They unconformably overlie the older beds, and have themselves been involved in warping and fault movements. The older gravels of the present river system truncate them.

Late Pleistocene and Recent.—Terrace and river gravels, and the lake silts of the Charwell comprise these deposits.

4. RECONNAISSANCE SOIL SURVEY OF THE CENTRAL PART OF THE NORTH ISLAND.

(By L. I. Grange and N. H. Taylor.)

From the 14th November, 1930, to the 24th May, 1931, the writers were engaged on a reconnaissance soil survey of the volcanic-ash showers of the central part of the North Island. This work is under the supervision of Mr. T. Rigg, Assistant Director and Chief of the Agricultural Department of the Cawthron Institute. In January an excursion was made to Te Papa Parish, south of Tauranga, to advise whether certain unimproved sections were likely to be "bush sick." The month of May was largely devoted to a detailed survey of abandoned farms in Ngaroma district, south-east of Te Awamutu.

The broad belt of country extending south from Hamilton to National Park Railway-station, east to Mamaku, and west to a north-and-south line through Mairoa was selected for the season's work. In a short paper one of the writers* described the following volcanic showers—Ngauruhoe, Taupo, Rotorua, Mairoa, and Tongariro—occurring in this area. Data, mostly additional to that contained in that paper, are set out below for each of these deposits, and two more, the Egmont and Hamilton showers, are also described.

Ngauruhoe Shower.

Ngauruhoe ash, the youngest of the deposits mentioned, extends farther to the west and north-west of the volcano than was at first thought. The sandy soil, at National Park Railway-station, to a depth of 3 in. to 4 in. from the surface, is formed from this ash, and the top 2 in. of the soil at Oio, Owhango, and Taumarunui contains fragments of Ngauruhoe andesite. A fusion analysis of the top 3 in. of the soil from Piriako Hill shows that there is a considerable admixture of andesitic ash. Stock grazed in the area covered by Ngauruhoe ash does not suffer from malnutrition. The ash covers a considerable area of the Taupo pumice which is known to be unhealthy.

Taupo Shower.

The Taupo shower, rhyolitic in composition, was blown from vents active on the site occupied by Lake Taupo. During the present survey the boundary where the ash is 6 in. thick when deposited from the air was accurately mapped in the districts to the north and west of the source. This was easily done, as the shower has a coarse texture, that of a sandy silt and sand, whereas the deposit it covers is a sandy or silty loam, and its colours—grey, light brown, and creamy yellow—are distinctive. The 6 in. boundary-line is two miles south of Putaruru Township, whence it extends westward to a point on the Te Awamutu - Arohena Road about twenty miles from Te Awamutu. South-west it crosses the Main Trunk Railway near Puketutu and runs southward to a mile or so east of Tuhua (west of Okahukura) and to the Wanganui River seven miles west of Taumarunui. The deposit thins rapidly near its outskirts. On the Tokoroa–Putaruru Road it decreases from 18 in. to 6 in. in a distance of two miles and a half. At a mile or so beyond the 6 in. boundary one cannot detect any Taupo ash in the soil. At three miles from the 6 in. boundary in the Taumarunui district the top soil contains practically none of the hypersthene crystals that are so abundant in the Taupo deposit. There is an unexpected irregularity in the thickness of the Taupo shower in the Wharepuhunga and western Ngaroma districts. At Wharepuhunga the 6 in. boundary-line bends sharply towards Lake Taupo and deviates to the south-east at least three miles inward from an otherwise smooth curve. For eight miles still farther south-east from this re-entrant, and over a width of about four miles, the Taupo shower is at most 7 in. or 8 in. thick, whereas on either side it is 18 in. or more. On rolling country in the western portion of the Ngaroma district at the south-east end of this second re-entrant the ash is in many places between 2 in. and 3 in. thick. The reason for this irregularity is not definitely known.

Except where covered with Ngauruhoe ash or removed by erosion or slumping, the Taupo pumice is the parent material of the soil over the area lying towards Lake Taupo from the 6 in. boundary-line. The soil profile of the upland forested areas, where the rainfall is heavy, is different from that on the lowlands. The upland type is found at Mamaku, Ngaroma, and east of Kopaki. A profile at Ngaroma is:—

2 in. dark sandy silt. (Top.)
3 in. grey sandy silt.
5 in. dark-brown cemented sand, sandy silt, and creamy-yellow sand.

An example of a lowland profile is that at Lichfield:—

4 in. black silt.
4½ in. mottled light-brown and creamy-yellow compacted silt.
4 in. creamy-yellow sand.

In places a poorly developed grey layer, apparently due to more active leaching, is present in the lowland soil profiles. Sheep and, to a less extent, cattle become "bush sick" when grazed on soils derived from Taupo pumice. The disease appears to be most acute in the Mamaku, Ngaroma, and Kopaki districts, where the grey layer is well developed, and is not acute in western Ngaroma, where the pumice is between 2 in. and 3 in. thick. In the last-mentioned locality grass roots readily penetrate the underlying sandy loam, and perhaps there obtain substances that cannot be obtained from the Taupo pumice alone.

* L. I. Grange: Volcanic-ash Showers. N.Z. Jour. Sci. & Tech., Vol. 12, No. 4, pp. 228-40; 1931.

Rotorua Showers.

The Kaharoa shower, the youngest of the prehistoric Rotorua deposits, has been traced northward as far as Tauranga. At Te Papa, about nine miles south of Tauranga, the profile in this ash is—

1 in. dark coarse sand. (Top.)
2 in. light-grey coarse sand.
6 in. light dirty-brown coarse sand.

On the Kaimai Hills (west of Tauranga and north of Mamaku) the surface shower shows—

1½ in. dark sand.
4½ in. light-grey sand.

The Kaharoa shower at Kaimai resembles the Taupo shower, but cannot be correlated with it, for the 6 in. boundary of the Taupo pumice lies eighteen miles south of its nearest exposure. The Kaimai soil is probably derived from the fine-grained outskirts of the Kaharoa shower. Possibly some of the grey ash on the Oturoa Road, four miles north of Mamaku, belongs here.

The Kaharoa and Taupo showers are the only deposits known to give rise to "bush sick" soils. Both are geologically recent, coarse in texture, and rhyolitic in composition. On these unhealthy showers the sickness is most acute on the upland areas where the rainfall is heavy and the leaching active.

Mairoa and Egmont Showers.

The material called the Mairoa shower forms the soil north and west of the 6 in. boundary of the Taupo pumice in the districts mapped this season. Examination of many road-cuttings and pits, and the separation of heavy mineral residues, have shown that the Mairoa deposit is really composed of several ash-showers, and chemical analyses support this opinion. The writers have not given names to the different ash-showers. Brown ash to a depth of as much as 15 in. below the surface in the Matiere, western Taumarunui, and Kaitieke districts contains, in general, large augite and hornblende crystals, and only a few of hypersthene. The feldspars are well zoned. In all these characteristics the Mairoa shower agrees closely with undoubted Egmont ash occurring at Stratford and Te Wera. The Egmont shower contains about 8 per cent. of iron oxide (slightly more than the Mairoa shower) and between 2 and 2·5 per cent. of lime (more than the Mairoa shower). Comparison with unweathered andesite from Mount Egmont shows that large amounts of lime, magnesia, and soda have been leached from the Egmont ash. The Egmont ash is not always brown in colour. At Waitaanga, eight miles west of Ohura and 1,325 ft. above sea-level, where the rainfall is high and the leaching active, the profile is—

2 in dark sandy loam.
2 in. grey sandy loam.
5 in. dark-brown sandy loam.

This profile resembles that developed on Taupo and Kaharoa showers, where rainfall is heavy.

In the northern part of the district in the Putaruru and Tirau districts the profile is—

3 in. black sandy loam.
6 in. loose brown sandy loam containing many lumps of pumice.
13 in. loose lighter-brown sandy loam.

The top 9 in. of the soil (3 in. and 6 in. layers) contains hypersthene, augite, and hornblende in about equal amount, whereas the underlying 13 in. layer contains, roughly, 65 per cent. of hypersthene, 25 per cent. of augite, and 10 per cent. of hornblende. From this difference in mineral composition and from the presence of pumice lumps in the upper 9 in. of soil, two showers evidently occur here. Fusion analyses show that both the 3 in. and 6 in. layers are rhyolitic in composition.

In these districts rhyolite soil is healthy for stock. There is, however, one important respect in which this soil differs from those on Taupo and Kaharoa showers, and that is its uniformly high content of phosphoric acid (determined by fusion method).

In the Mairoa, Te Kuiti, and Te Rau-a-moa districts the hypersthene content of the top 9 in. is less than in the Putaruru district. Probably some of the Egmont material reaches these districts. A grey layer was observed on the Te Rau-a-moa upland where the rainfall is high, and Mairoa deficiency disease has been reported.

Hamilton Shower.

The section below the Mairoa ash near Te Awamutu is—

15 in. brown loam.
10 in. cream sand.
10 ft. dark-brown heavy loam.

In several localities the Mairoa ash and the brown loam have been eroded, and the soil is formed from the dark-brown heavy loam derived from volcanic ash, called the Hamilton shower in this account. The heavy loam forms the soil on the low hills at Hamilton and southward to within four miles of Te Awamutu. It is exposed on the steep greywacke hills south of Te Awamutu and on some of the steep slopes on the rolling country in the vicinity of this town. Hornblende is the only ferromagnesian mineral in this shower.

Tongariro Shower.

On the north and west sides of Tongariro Volcano the Tongariro andesite shower is not the parent material of the soil; it is covered with Ngauruhoe and Taupo deposits. It is, however, a soil-forming deposit to the south-east of Waiouru. Hypersthene forms between 40 and 75 per cent. of the ferromagnesian minerals in the soil, the remainder being principally augite. Hornblende makes up only a few per cent.

5. PALÆONTOLOGICAL REPORT.

(By Dr. J. Marwick.)

During the past year considerable time was spent in putting through the press Palæontological Bulletin No. 13, which deals with the Tertiary mollusca of the Gisborne district.

In co-operation with Dr. H. J. Finlay, of Dunedin, a start was made on the description of the Wangaloa fauna of Kaitangata and Boulder Hill, Dunedin. This work indicates that the fauna from the Castle Hill shaft, Kaitangata, previously regarded as equivalent in age to the Wangaloan, is considerably younger, and is best classed in the Bortonian (Eocene). The Wangaloa fauna contains so many Cretaceous elements and has so little in common with the known Eocene fauna that it is best regarded as uppermost Cretaceous.

Work was continued on the Cretaceous and Tertiary fossils of the Dargaville-Rodney and Motueka Subdivisions, and also on the Triassic of Kaitangata Subdivision.

In September, 1930, through the kindness of the late S. J. H. Sylvester, a week's visit was paid to Castle Hill, Trelissick Basin. The time was somewhat limited, but fossil collections made with Mr. M. Ongley's assistance will help materially towards the understanding of the geological history of North Canterbury.

Two and a half months, from March to May, were spent in the Waiau district with Mr. Fyfe's party. Geological mapping occupied most of this period.

6. OKOROIRE HOT SPRINGS.

(By J. Henderson.)

The Okoroire Hot Springs are on the east bank of the Waihou River at a point about three miles south of east from Okoroire Railway-station. There are several springs, of which the chief are numbered No. 2 and No. 4. The latter is the larger and rises at river-level through the sand forming the bottom of a swimming-bath. This pool has a temperature of about blood-heat, and its discharge amounts to about 750 gallons per minute. Gas rises in small amount with the water, and a sample the writer collected was found by the Dominion Analyst to contain gases in the following percentages: Nitrogen, 82·7; oxygen, 0·1; carbon dioxide, 9·4; methane, 6·2; and ethane, 1·6.

The spring feeding No. 2 bath is decidedly smaller, the discharge from the pool being but 10 gallons per minute. Its temperature, according to Dr. Herbert ("Hot Springs of New Zealand," p. 134; 1921), is 113° Fahr.

The water from No. 2 Spring escapes from a cleft in a somewhat altered fine-grained rhyolite tuff at a point about a chain from, and 10 ft. to 15 ft. above, the vent of No. 4 Spring. This rhyolite tuff, which closely resembles the vitric tuff of Arapuni, extends up the bed of the Waihou for some 5 chains and down-stream for an unknown distance, the river forming a series of narrow gorges in the resistant rock and tumbling in picturesque cascades. Above the outcrops of tuff the stream flows at grade in a relatively narrow valley entrenched about 70 ft. in the loose pumiceous sands and silts of an extensive fluviatile plain which stretches north to Matamata, and is in fact part of the southern end of the Hauraki Plains. In this locality, south-west toward Tirau, and north-west past Hinuera Railway-station, the alluvium of the plain surrounds the low hills of an old land surface it has partly buried, and extends for miles along wide valleys between rolling downs. Probably the Waikato formed the Matamata flats when it flowed through the Hinuera valley (L. Cussen, Trans. N.Z. Inst., Vol. 21, p. 409; 1889). The writer (N.Z. Jour. Sci. & Tech., Vol. 1, p. 59; 1918) pointed out that the Waikato had built an extensive flood-plain from Arapuni eight miles down-stream to Pairere, where the river makes a right-angled turn to the left, away from the Hinuera valley, of which the wide floor directly continues the flood-plain. It should be noted that the heights above sea-level given in the paper cited are all about 50 ft. too high, and that the floor of the Hinuera valley where it leaves the Waikato is about 300 ft., and not 350 ft. as stated. This point is thus 90 ft. higher than Matamata (211 ft.), from which it is distant, down the Hinuera valley and across the Matamata plain, about ten miles. The writer has traversed more than half of the intervening flats, which by report continue without change or terrace step throughout the whole distance. The grade from Matamata to the head of the Hinuera valley works out at 9 ft. per mile, the same as the grade of the plain from Matamata to Waharoa about four miles to the north. The evidence that the Waikato flowed through the Hinuera valley and built the Matamata flats before its course was diverted past Cambridge and Hamilton is very strong.

7. COAL NEAR WAIMANA, WHAKATANE COUNTY.

(By J. Henderson.)

The steep broken hills of the Urewera country surround an area of river-flats and rolling downs at Waimana, a village on the Opotiki Road seven miles south-east from Taneatua. These hills of strongly folded greywacke and argillite, closely resembling strata of the Tararua and Ruahine ranges, rise in crests and narrow steep ridges from 900 ft. to 1,200 ft. above the sea. The evenness of the sky-line from a distant aspect suggests that the hills have been carved from an uplifted peneplain, and the straightness and steepness of the eastern edge of the hills from Whakatane to beyond Taneatua suggests a fault-scarp. The fracture-planes in the rocks of the cliffs at Whakatane and along the gorge of the Waimana up from Taneatua support the latter supposition.

Moroera Stream, rising in bush country about four miles south-west of Waimana, is a small branch of the Raroa which joins the Waimana near the village. A fault striking north-east and dipping east at about 70° crosses obliquely the head of this stream and several of its eastern sources. The greywackes and argillites here strike north-north-east and dip steeply west. The fault was examined at two points in the main stream and in two small branches from the east, and at each place contained fragments and lenticles of crushed coal, some of the latter being 2 ft. long and 6 in. across. Most of the numerous movement-planes of the narrow fault-zone are black with coaly matter. There is nothing to indicate the amount of movement along the fault. Streaks of carbonaceous matter interbedded in the rocks were observed, but no coal-seams, and Mr. A. K. Luttrell, who owns the land and has done some prospecting, has not found one. The coal, as shown by the analyses below, is of excellent quality, but the chances of a workable seam being found are extremely poor. The early and middle Mesozoic rocks of New Zealand at many points contain carbonaceous bands and even lenses of coal a few inches thick and somewhat extensive, though hitherto unsuccessful prospecting has been undertaken in several localities. Mr. J. M. Cadigan, in 1911, did some prospecting in the Raroa basin, probably in this very locality. Other work has been carried out near Kaitoke, in the Rimutaka ranges, near Waiwera in Otago, and at several points in Southland.

The Moroera flows in a narrow valley entrenched about 300 ft. in rolling downs that represent an older valley-floor. The physiographic history of the area is probably complex, for a few chains south of Mr. Luttrell's house soft pumiceous silts and fine sands interbedded with carbonaceous muds and peaty layers, the whole about 100 ft. thick, form part of the downs. Except to the north-east, Mesozoic rocks rise above these fluviatile and swamp deposits which seem to have accumulated in an ancient valley.

The following analyses of the coal from the Mesozoic rocks and of the lignite from the pumiceou silts were made by the Dominion Analyst :—

	1.	2.	3.
Fixed carbon	22·27	49·62	56·67
Volatile hydrocarbons	25·50	35·29	33·47
Water at 105–110°	19·10	1·82	1·78
Ash	33·13	13·27	8·08
	100·00	100·00	100·00
Sulphur	0·51	1·56	0·97
Coking-properties on heating in a closed vessel	Non-coking	Slightly swollen	Swells and forms fairly firm coke.

No. 1 : Lignite, sent by Mrs. H. E. Luttrell.
No. 2 : Coal from Moroera Stream, sent by Mrs. H. E. Luttrell.
No. 3 : Coal from Raroa Stream, sent by Mr. J. M. Cadigan, 1911.

8. GREAT BARRIER COPPER-MINE.

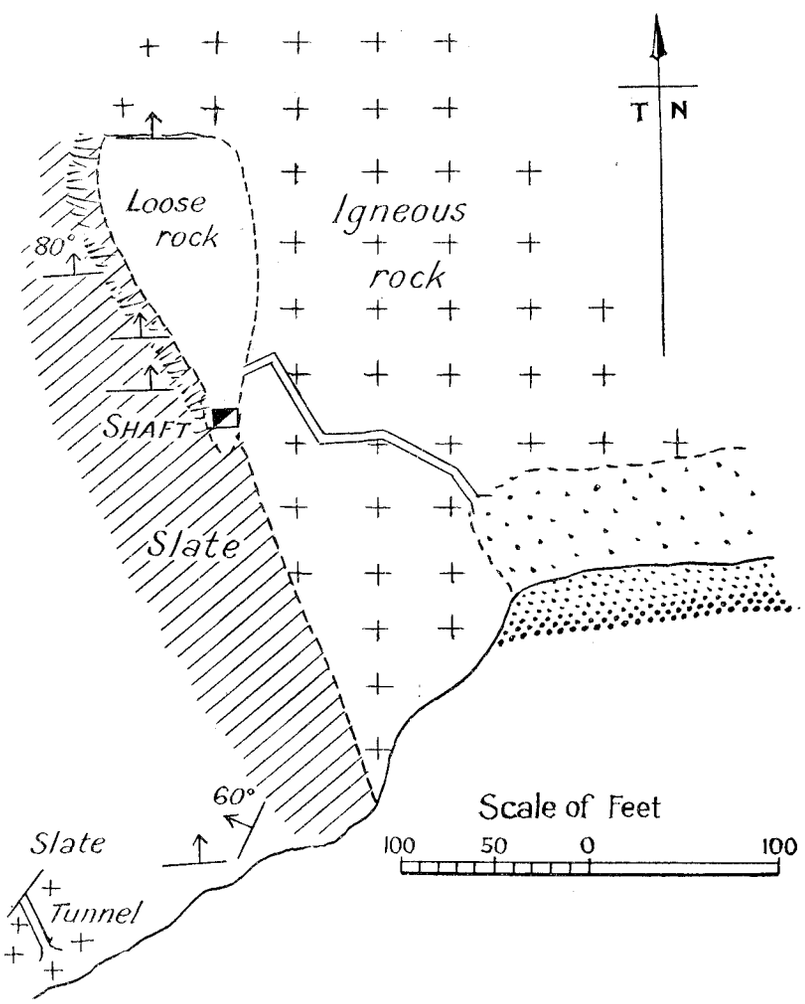
(By J. Henderson.)

Captain F. W. Hutton (Rep. Geol. Explor. during 1868–69, pp. 1–7 ; 1869) and Professor J. A. Bartrum (Trans. N.Z. Inst., Vol. 53, pp. 115–27 ; 1921) have described the geology of the Great Barrier Island. In December, 1930, the present writer spent three days at or near the old copper-mine and is able to add a few details to the accounts Hutton and Bartrum have given.

The northern part of the island is formed of steeply dipping greywackes and argillites, probably of old Mesozoic age. From the mine, which is at the north-west corner of the island, to the Aiguilles, at the north-east corner, the cliffed rocky coast shows innumerable dykes of igneous rocks. Most of those seen near the mine were of intermediate composition, and were no doubt intruded while the andesites so prominent on Hauraki Peninsula were being erupted ; Great Barrier Island is obviously on the same crustal ridge as the peninsula and the range that continues it southward. At Miner's Head and at several points on the sea-cliffs eastward the rocks show decidedly the green and blue stainings of copper minerals. The copper deposit must have been found in the early days of colonisation, for E. Jerningham Wakefield records that he saw ore from it in 1843, and that 100 tons of ore was later shipped to Sydney (" Adventure in New Zealand from 1839 to 1844," p. 578 ; reprint by Whitcombe and Tombs, 1908). Hutton notes that the deposit was actively worked between 1857 and 1867, and records that 2,323 tons of ore of unstated grade was produced during this decade from 3,200 cubic fathoms mined (about 8,000 tons).

The ore, which consists of shattered and silicified argillite, contains numerous nests, pockets, and veinlets of chalcopyrite, the whole more or less strained by copper carbonates. A large chamber, approached by an adit 150 ft. long and a few feet above sea-level, has been excavated in the narrow peninsula forming Miner's Head. The chamber is about 150 ft. long and averages 40 ft. wide. The roof has collapsed, and except at its southern and narrow end a great mass of broken rock covers the

floor. The slightly overhanging western wall of silicified argillite strikes north-north-west. It is stained with copper salts, and three decided east-west "heads" dipping steeply north shatter the rock near them. This shattered rock contains much chalcopyrite. The east wall of the chamber strikes north, and is smooth and vertical. It consists of the igneous rock Bartrum names pegmatite or granitic granophyre. The north side of the chamber is formed of the same igneous mass, the wall of which here dips at 60°. Probably the molten rock forced itself along fractures crossing the shattered sedimentaries at right angles. At the south end the eastern and western walls converge, and about 8 ft. of crushed and silicified argillite with veinlets and films of chalcopyrite shows in the face. There is a shaft near this point, at present filled with water which has a metallic taste but is not sea-water. According to Hutton, this shaft is at least 72 ft. deep, and ore 9 ft. thick is showing at this depth.



PLAN OF COPPER-MINE, GREAT BARRIER ISLAND.

The deposit is in a narrow peninsula, the ridge where the workings have collapsed being about 200 ft. above the sea. The descent on the northern side is precipitous, and landing on the shore possible only in calm weather. The cliffs in this locality were seen from a boat, and copper-stainings show strongly on both sides of the cove on the north side of the headland, but there seemed to be no definite lode. On the south side of the headland the large dyke penetrated by the adit to the chamber continues along the shore for 3 chains before the sedimentary rocks outcrop. There is little crushing at the contact and no copper-stains. About a chain farther south-west two strong "heads" are prominent. Two chains farther on a short tunnel is driven through igneous rock to shattered slates showing copper-stains. On the south side of the peninsula there is no definite lode.

A few other observations were made. On the north side of Mine Bay, 60 chains south-east of the mine, a short adit 100 ft. long follows a contact on the north side of a dyke which strikes west-north-west and dips steeply north. There is a little pugged rock and some copper-stains. A wide zone of intensely crushed sedimentary rock outcrops on the south side at the head of Mine Bay. A large dyke showing occasional copper-stains crosses the headwaters of two small tributaries from the north to the creek entering Mine Bay. Close to the north side of the main creek, about 60 chains from the sea, an adit, now collapsed, cuts a well-marked fracture in sedimentary rocks. This, which contains a good deal of pug and shows copper-stains, strikes nearly west and dips south at about 65°.

Evidently the magma that supplied the many dykes contained copper. This was concentrated in the residual solutions, and escaped to the surface along the contacts of the igneous and sedimentary rocks. The igneous rocks had solidified, and the solutions altered them widely and in places deposited

copper minerals in joint-planes and along contacts. The mass of shattered slate forming the re-entrant in the dyke at the old mine formed an exceptionally easy channel for the solutions, and an unusual amount of alteration and of ore-deposition took place.

A few samples were taken from the chamber of the old mine. A general sample 8 ft. across the face at the south end of the workings the Dominion Analyst found to contain 1·03 per cent. of copper; a sample of ore from the " head " near the shaft contained 7·74 per cent. of copper and 3 oz. 9 dwt. 7 gr. of silver and less than 3 gr. of gold per ton. A veinlet, an inch thick, of solid mixed sulphides of iron and copper contained 22·93 per cent. of copper.

There is no means of determining what percentage of copper was contained in the rock mined, which in the ore shipped was reduced, probably by hand picking, to less than a quarter. Assuming that the ore shipped consisted of one-third rock and that no rich secondary copper minerals were present, the copper being in mixed sulphides similar to that assayed, then the ore shipped would contain about 15 per cent. of copper. On present-day standards this would be rich copper ore, for in the United States and elsewhere ore-bodies containing but 1 per cent. are profitably mined; but such ore-bodies are enormous, and mining and transport for fuel and by-products are cheap.

The first essential is to ascertain the size and value of the deposit; to do this the ore-body must be explored in depth and sampled. The contact of the dyke and the sedimentary rock should be prospected for other possible ore-bodies.

9. MAHARAHARA DISTRICT.

(By M. Ongley and J. H. Williamson.)

The Tararua-Rimutaka Range has been examined for minerals since 1861, and since 1887 traces of copper have been known at Maharahara in a set of red hematitic siliceous greywacke beds. The red beds extend from the Bay of Plenty to Cook Strait and along the Southern Alps and Kaikoura Range, and in places in them traces of copper have been found. As McKay wrote in 1891 in his report " On the Maharahara Copper-mine, Woodville, Hawke's Bay " (published in the Reports of Geological Explorations for 1892–3, No. 22; 1894): " These cherty hæmatite rocks may thus be said to contain copper throughout the whole range of mountains that forms the main geological axis and backbone of the North Island, and thus appears to be a stratified deposit, containing a small percentage of copper, which at Maharahara is more than the usual percentage." It is not known that the beds as a whole contain more copper at Maharahara, but it was found that in places the copper was concentrated in rare small lumps of iron-pyrites. A similar concentration near Cape Runaway with lumps of pyrite 20 ft. long was examined and reported on briefly in the annual report of the New Zealand Geological Survey for 1923. Where the rocks are faulted and crushed the metallic content is concentrated into masses of pyrite. No igneous intrusions have supplied additional copper, but the copper has been partly concentrated along the crushed beds. No concentration of value is known, and, though it is possible that some may yet be found, it is improbable. There is no true lode; the pyrite is scattered in lumps along the crushed beds, and all the evidence so far shows that the pyrite masses are small and separated by much barren ground.

As mentioned by McKay in 1891, there was an idea that the Maharahara ore was a slip from the range behind. He discredited this suggestion, and the evidence shows he was correct.

Hector discussed the discontinuous nature of the deposit, and said (Rep. Geol. Explor., p. xxvi, No. 20; 1890), " Mineral deposits of this kind are very difficult to trace and expensive to follow and require the ore to be very rich." Yet the field cannot be condemned, for the work so far has all been in the oxidized zone, and no information has been gained as to what lies below. Until the unchanged part is reached there is a chance of finding payable ore.

A list of geological literature on the district is given in the annual report of the New Zealand Geological Survey for 1914.

10. A NOTE ON THE NORTH END OF THE TARARUA RANGE.

(By M. Ongley and J. H. Williamson.)

While working at Pahiatua we observed the profile of the crest of the Tararua and Ruahine ranges, and while at Maharahara we took the opportunity to walk along the mountains towards the Manawatu Gorge and observe the structure. From near Pahiatua the crest of the ranges appears smooth, and gently sloping to the north from a long distance south of the gorge to some three miles north of it, with no sag at the gorge itself. A point three miles north of the gorge is the lowest part of the curve of the crest. From there it rises again to the north in a continuous somewhat steeper curve.

Looked at from the range north of the gorge, the crest, south of the gorge, is seen to be a smooth even surface, curving away to the west in a long gentle limb, dipping about 10°, and to the east in a shorter steeper limb dipping about 40°.

As the rocks of which it is composed are nearly vertical beds of greywacke and argillite, this even surface can only be an old plane of erosion folded into this shape.

Where this old eroded plane descends to the north it passes under an arch of fossiliferous Pliocene sediments which completely spans the range, so that no other rock is exposed. The structure here is a simple asymmetrical anticline of Pliocene beds, shorter and steeper on the east, plunging northward to the lowest point, and dipping away continuously into the low country on the flanks.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR.

New Meteorological Office at Kelburn.

During the year quarters designed especially for the use of the Meteorological Office were constructed on the Observatory Reserve at Kelburn, thus fulfilling a long-standing requirement. Though of economical construction, the building has proved suitable and convenient. The office is near to the meteorological enclosure, so that it is possible to make more frequent observations and to give the instruments closer supervision without loss of time. Some of the instruments are recording actually in the office building, and it is of great assistance to the forecaster to watch them and also the changes taking place in the atmosphere. Better facilities are available for the storing of records, and working-conditions generally are more suitable.

The new building was occupied at the end of September, and was opened officially by the Hon. A. J. Stallworthy, Minister of Health, on the afternoon of the 29th October.

Forecasting.

Amongst the retrenchments necessitated by the financial depression was the discontinuance of the despatch by telegraph of the midday forecast to a considerable number of the smaller towns. It was with great regret, also, that we were forced to abandon the evening broadcast by wireless from the Wellington Radio-station of weather reports for shipping. During the greater part of the year a special report and forecast has been issued from 2YA at 3.30 p.m. indicating existing conditions and the probable developments over as long a period in advance as the conditions of the day permitted. This issue was originally designed especially for the assistance of sheep-farmers at shearing-time, but its use has extended to many other agricultural activities. Numerous unsolicited tributes to the value of this forecast have been received. We are indebted to the Radio Broadcasting Co. of New Zealand, Ltd., for their co-operation in the issue of such reports.

Private demands for forecasts from aviators, farmers, shipping interests, and invalids desiring to avoid bad weather have very much increased.

Observing-stations.

One new climatological station was established during the year, at Waihopai Power-house, in Marlborough. Though no stations have been dropped, difficulty has been experienced in maintaining some of them. Fifteen new rainfall-stations have been established, and nine have lapsed. Owing to expenses connected with the transfer to the new building and to the reduced funds available, very little inspection was done during the year. It is pleasing to note that neither at Napier nor at Hastings did either observer or equipment suffer serious damage from the disastrous earthquake. At Hastings the observations were kept going continuously.

Again I wish to tender thanks to those observers who have continued to furnish us with satisfactory returns.

Upper-air Observations.

Observations of winds in the upper air have been continued at Wellington, and the results of pilot balloon ascents have been telegraphed daily also from Christchurch. The Christchurch reports have been found very valuable for forecasting purposes, and our thanks are due to the Surveyor-General and Mr. H. F. Skey, Director of the Christchurch Observatory, for their co-operation. Observations were continued also throughout the year by Mr. F. H. Sagar at Auckland. Mr. Sagar's work was done with the aid of a Research grant. Visibility observations are made at a number of stations.

Owing to the absence of Messrs. Andrew Thomson and R. G. Simmers for the greater part of the year, it has not been possible to make any marked advance in the direction of the provision of meteorological data for aviators.

Mr. Chichester in planning his solo flight by seaplane to Australia was most anxious regarding the weather-conditions on his journey to Norfolk Island, and, to a less extent, to Lord Howe Island, owing to the smallness of his objective and the susceptibility of a light machine to damage in any seaway. It was possible to give him advice, which proved accurate, as to when to start and also while at Norfolk Island. It was unfortunate that unavoidable delay resulted in his encountering a storm while his seaplane was anchored at Lord Howe Island, serious damage resulting.

Miscellaneous.

During the year two articles on the climate and weather of New Zealand have been called for. The first was for "The New Zealand Pilot," a British Admiralty publication. Hitherto the meteorological information had been prepared in England from New Zealand publications and from reports by shipmasters and others. The information called for includes very complete data regarding pressure, temperature, wind, and rainfall, according to a general plan, from a number of meteorological stations. It was obvious that much of the data previously published was defective. In some cases the observations themselves have been valueless owing to the use of defective instruments or unsatisfactory exposure, while in others no account has been taken of changes in the site of the station. As an example, it may be mentioned that the Wellington station has been in various sites, at which the rainfall has varied between 55 in. and less than 40 in. These changes of site have been disregarded when determining the average rainfall as given in previous publications. At another station pressure readings have been made regularly since 1862, giving a record which, if the observations were reliable,

would be exceedingly valuable for the study of climatic relationships and seasonal variations. On investigation, however, it is found that out of sixty-eight years of records only twenty have been made with satisfactory instruments. The remainder are practically valueless, and must have led numerous investigators to erroneous conclusions. It has been necessary, therefore, to make a critical investigation of old records in order to sift out data that was homogeneous and reliable. This is a long process, and very much still remains to be done.

The second of the articles referred to was the New Zealand portion of a "Handbook of Climatology" which is being published in numerous parts by a German organization. This handbook will cover general climatology and separate accounts of the climates of all regions of the world. I had been asked to write the New Zealand portion. Again very complete data based on a uniform scheme were called for, and once more it was found with great regret that much of the New Zealand data did not meet the standard required.

The only way to ensure that records such as those of climate shall be reliable is to see that the making of the records is supervised by qualified persons, and that when made they are published and thoroughly intercompared and discussed. In the case of meteorological work periodical inspections are necessary. And it will not be possible to secure satisfactory results unless local authorities realize the value of the data, and the need for long series of observations on permanent and satisfactory sites. Much money has been wasted in the past on inadequately controlled observations. Good observations, if they are properly published and the information they give expounded, pay for themselves many times over. Enormous sums are, for instance, wasted in municipalities through lack of complete meteorological data. For the efficient and economical design of drainage schemes, especially, precise information is wanted. The importance of adequate climatological observations is urged with particular emphasis here, because it is a matter which it is difficult for the general public to appreciate. Nor is it realized what sacrifices are made by the voluntary observers who, out of public-spirited interest, give their time on Sundays, week-days, and holidays to the making of these observations.

During the preparation of the more general articles on climate, much information was extracted regarding particular aspects. Some of this has been published in the following papers, which have appeared in the *New Zealand Journal of Science and Technology*:—

"Hourly Sunshine at Wellington, July–December, 1929," by D. C. Meldrum.

"Thunderstorms in New Zealand," by E. Kidson and A. Thomson.

"The Annual Variation of Rainfall in New Zealand," by E. Kidson.

In addition, the material is now ready for the preparation of monthly rainfall maps as soon as funds are available for their publication. Notes will shortly be ready, also, on the annual and diurnal variation of pressure and temperature at Wellington; on the winds at Auckland, Wellington, and Sockburn; and on the frequency of hail, snow, and fog in various parts of New Zealand.

Mr. Andrew Thomson has been absent during the year, first, at the Apia Observatory, Samoa, of which he again took charge for a short period, and, later, in Europe. He has taken leave without pay in order to study the latest methods of research in the upper air, of forecasting, and of providing meteorological information for aviators.

Mr. R. G. Simmers was once more seconded for work with Sir Douglas Mawson's Antarctic expedition in the "Discovery." Mr. Simmers was successful in completing a valuable programme of meteorological work.

In connection with the International Load-line Convention for Merchant Ships, information was supplied from this Office, which was of assistance in enabling the New Zealand representatives to secure exemption of the greater part of the New Zealand coast from winter load-line restrictions.

In conclusion, I wish to acknowledge the cordial co-operation of my staff throughout the year's work. Our thanks are due also to the Post and Telegraph Department for their ready assistance.

Brief Summary of the Weather for 1930.

The principal characteristics of the weather in 1930 were low rainfall and low temperatures. There have been few colder years experienced in New Zealand since 1864. The year 1902 was colder, and 1884 and 1912 were about equally cold. It was the eastern districts that felt the cold of 1930 most severely. At Wellington and Christchurch, and probably also at Napier, the temperatures were the lowest ever experienced. Even at these places the departure from the average was only about 2° F., and it will probably be a surprise to most people to find that so small a change should produce so much discomfort as was actually experienced.

The cold years mentioned have all been dry years, and it is the general, though not invariable, rule in New Zealand that low temperatures are associated with low rainfall, and *vice versa*. 1930 was one of the driest years on record; indeed, in the western half of the South Island it was by far the driest. In the North Island, both 1919 and 1914 were rather drier. 1915 was another very dry year, especially in eastern districts, Canterbury, particularly, having its lowest recorded rainfall in 1915.

The unprecedented shortage of water in Westland and the area surrounding Lake Coleridge led to a serious reduction of the power available from the Lake Coleridge hydro-electric scheme during winter and spring.

As regards the individual months, January was a very wet one, and good rains were experienced in most districts in August, November, and, to a less extent, September. In the remainder rainfall was generally below average, the deficiencies being especially large in February, March, and April.

Snow and hail were of unusually frequent occurrence during the year, though the depth of snow accumulated on the ranges was not excessive. The three months September, October, and November were the coldest of those names ever experienced in the Dominion.

Though both the 1929–30 and the 1930–31 seasons were retarded, stock and crops, on the whole, did quite well. In Hawke's Bay and Poverty Bay, however, there were considerable losses of sheep.

DOMINION OBSERVATORY.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR YEAR ENDED 31ST DECEMBER, 1930.

BUILDINGS AND EQUIPMENT.

THE buildings and equipment have been kept in good order and condition. The Observatory ground has been kept in good order by the Wellington City Corporation.

ASTRONOMY.

Astronomical Observations.

Observations of the meridian transits of stars and the sun have been made for the purpose of controlling the time service. The meridian transits of the sun are made 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 mean time signals were received at the Observatory :—

Station.	Call Sign.	Hour (G.M.T.).	Number.
Honolulu	NPM (long wave)	00	264
Nauen	DFY ,,	00	283
Malabar	PKX ,,	01	53
Annapolis	NSS (short wave)	03	11
Annapolis	NSS (long wave)	08	8
Bordeaux	FYL ,,	08	56
Rugby	GBR ,,	10	1
Bordeaux	FYL ,,	20	19
Total	..	..	695

Scientific time signals were also received at the Observatory from Nauen on eighty-five occasions.

The radio time signals received at the Observatory generally agreed with the Observatory clock within one second of time. Differences from 1 to 2 seconds, however, have been observed in the following cases: Honolulu, NPM, three times; Nauen, DFY (mean time), once.

It has not been possible to make much use of the British time signals from the Greenwich Observatory, transmitted by Rugby Radio, owing to the very unsuitable times of transmission, at 9.30 p.m. and 5.30 a.m., N.Z.M.T.

Time Service.

The time service has been maintained and the regular signals have been transmitted daily. The total number of time signals sent from the Observatory was 1,931. Of these, 461 were sent by wireless telegraph, 506 were sent by special circuit to the Telegraph-office, 362 by the signal lights at the Observatory, 100 by switching off lights at the Harbour Board building at Auckland, 95 by dropping the time-ball at Lyttelton, 20 by telephone, and 387 by wireless transmission through the Radio Broadcasting Co., Station 2YA.

No radio time signals were sent on 1930, March 30, owing to no officer being on duty. On 1930, August 4, three of the signals failed owing to linesmen working between the Observatory and ZLW wireless-telegraph station. On 1930, November 11, two of the signals failed owing to an interruption in the city power-supply.

The present programme at the Observatory provides for the following time signals, most of which are sent by the Observatory standard clock. The error of the standard clock is usually less than one-half second of time :—

Automatic Time Signals—

(1) To the General Post Office and to the Railway Department, 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 on Government holidays.
(6) Radio time signals through the Radio Broadcasting Co. of New Zealand, Ltd., Station 2YA, daily, at 4 h. and 8 h. G.M.T.
(7) Radio time signals through the Wellington Radio Station ZLW, on Tuesday and Friday evenings at 8.30 p.m., except on Government holidays.
(8) Radio time signals through the Wellington Radio Station ZLW, every day at 10.30 a.m.

Up to the 1st September, 1930, the radio call sign for the Observatory was ZLO, but owing to the fact that the station was shown as having the call sign ZLY in the International List the call sign was amended to ZLY on and after 1st September, 1930. 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.

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 32 seconds slow on 1930, November 7, and 29 seconds fast on 1930, October 28.

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 7·5 seconds slow on 1930, July 11, and 9·5 seconds fast on 1930, April 3.

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 to the Wellington City Council's 9 in. equatorial telescope. The camera is available for any particularly interesting groups of sun-spots.

Numerous observations of the sun are made by members of the Solar Section of the New Zealand Astronomical Society, and the records obtained are available for use at the Observatory. These observations are sent to Zurich, where they are used for international work in determining the Wolf-Wolfer relative sun-spot numbers.

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 from Professor E. W. Brown, F.R.S., for more observations of occultations, the following New Zealand observatories have expressed their willingness to make the necessary observations: Christchurch, Dunedin, Hawera, Nelson, New Plymouth, Wanganui, Wellington. Accurate time signals are sent out from the Dominion Observatory on two evenings a week at 9h. G.M.T., and every day at 23h. G.M.T. Additional automatic time signals have been broadcast through Station 2YA, Wellington, since June 21 at 4h. G.M.T. and 8h. G.M.T. 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, as there is no staff available for this duty.

The occultation of stars were observed at Wellington on July 2, August 2, and September 5. An observation was also made at New Plymouth on May 4.

Auroræ.

During the calendar year 1930 only one display of the aurora australis was observed. This was at Christchurch on September 19.

Zodiacal Light.

Observations of the zodiacal light are made by members of the Aurora and Zodiacal Light Section of the New Zealand Astronomical Society, and the results are available for study at the Observatory. Observations were made at Wellington and Auckland during the year.

Meteors.

SUMMARY OF METEORS FOR 1930.

Place.	New Zealand Date.	Notes.
	d. h. m.	
Auckland	February 9 13 12	Daylight meteor.
Cambridge	February 10 — —	Very brilliant.
Wellington	February 20 — —	Very brilliant.
Wellington	March 1 4 30	Very brilliant. Exploded.
Cook Strait, Auckland, Hamilton	June 18 22 15	Very brilliant.
Wellington	July 1 22 5	Very brilliant. Exploded.
Christchurch, Geraldine, Te Kuiti	July 16 22 25	Very brilliant
New Plymouth	July 20 20 15	Exploded.
Wellington	July 23 20 42 to 21 7	Observations made at Observatory only faint meteors recorded. Six meteor-paths plotted.
Oamaru	July 30 23 0	Brilliant, detonating.
Wellington	November 8 20 20	Brilliant.

Rumbling noises which were heard in the Ohaupo district on June 13 were attributed to an earthquake, but after an intensive investigation Mr. R. A. McIntosh, F.R.A.S., of Auckland, found that this was due to a brilliant meteor which fell at 6.30 p.m. There are no records of an earthquake at the Dominion Observatory at this time.

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 E. 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.

Owing to their faintness and unsuitable positions in the sky, none of the comets reported was observed.

Total Solar Eclipse of 1930, October 21–22.

The first action taken with reference to this eclipse was in October, 1929, when the New Zealand Government authorized Dr. L. J. Comrie, Superintendent of His Majesty's Nautical Almanac Office, London, to borrow the 19 ft. coronagraph and the 12 in. coelostat and to forward them to New Zealand. The coronagraph was lent by the Royal Irish Academy and the coelostat was lent by the Royal Astronomical Society. The apparatus was received in Wellington early in April, 1930. Other apparatus in Wellington was also adapted and fitted for use at the eclipse.

On 30th May, 1930, the President of the New Zealand Astronomical Society was advised that owing to the altered financial situation the Government could not undertake to provide the whole cost of an Eclipse Expedition. The Society acted promptly on this notice and decided to issue an appeal for contributions. The Government was approached again by the Society, through the President, Sir Thomas Kay Sidey, and agreed to subsidize voluntary contributions on a £1-for-£1 basis up to £200, being £100 grant direct and £100 through the New Zealand Institute. The friends of the Society responded to the appeal, and sufficient funds were obtained to enable the Eclipse Expedition to proceed.

The instruments were erected at the Dominion Observatory, Wellington, and practices were undertaken. His Excellency the Governor-General, the Right Honourable Lord Bledisloe, the Patron of the Society, showed great interest in the work of preparation, and visited the Observatory and inspected the equipment.

The cash donations were supplemented by generous donations of goods and services, with the result that the expedition was enabled to leave Auckland in September for Suva on the R.M.S. "Niagara." At Suva the expedition transferred to H.M.S. "Laburnum" and was landed safely by that ship at Niuafo'ou. The members of the expedition were: Dr. C. E. Adams, F.R.A.S. (leader); Dr. William C. Burns; Mr. R. W. de Montalk, F.N.Z.I.A.; Mr. F. Gawith, F.R.A.S.; Mr. P. W. Glover, F.R.A.S.; Mr. C. B. Michie, F.R.A.S.; Mr. P. L. Overton.

The expedition found a large American expedition already at the island, and received great assistance and every courtesy from the Americans. The New Zealand expedition erected instruments and adjusted them in time for the eclipse. The programme was drawn up by the Permanent Eclipse Committee of the Royal Society and the Royal Astronomical Society and was as follows: (1) To photograph the solar corona in order to fill the gap that would otherwise exist in the series of corona photographs, especially as there would be no expedition from England to observe this eclipse; (2) to photograph the flash spectrum and the spectrum of the corona.

This programme was carried out satisfactorily, and four photographs of the corona, two of the flash spectrum, and four of the spectrum of the corona were obtained. All the photographs are excellent, and fully justify the action of the Society in sending the expedition to Niuafo'ou.

After the eclipse was over the Americans very generously transported the expedition back to Suva on the American warship, the "Tanager." From Suva the expedition returned to Auckland by R.M.S. "Niagara."

It was owing to the actions of our friends that the expedition was such a success. Every one with whom we came in contact helped us in every possible way, and we thank them heartily for their kindness.

Dr. L. J. Comrie has been asked to obtain a technical report on the corona photographs. Dr. S. A. Mitchell has been asked to report on the spectrum photographs.

At Wellington, where the eclipse was partial, twelve photographs were taken with the 9 in. telescope and a moving picture of the eclipse made through the 5 in. of the Wellington Philosophical Society.

Summer Time.

The Summer Time Act, 1929, 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, 12th October, 1930, and ending at 2 a.m., New Zealand standard time, on Sunday, 15th March, 1931.

Seismology.

During the year 1930 the two Milne–Shaw seismographs have continued to record earthquakes. The Milne seismograph was removed to Arapuni Hydro-electric Works in July, and has since given some valuable information of earthquakes in the North Island. The records from the Milne twin-boom seismograph at Suva have been useful in supplementing the records at Wellington, and other stations.

During the year the following new seismological instruments were added to the Observatory equipment:—

(1) A Galitzin–Wilip vertical seismograph with galvanometric and photographic recording was installed in October. A spare recorder was supplied with this seismograph.

(2) An Imamura strong-motion seismograph with smoked paper recording was also installed in October.

(3) A pair of Ishimoto silica clinographs were delivered in September. Unfortunately, the silica threads of one of the pendulums was found to be broken when unpacked. It is hoped that the broken thread may be repaired locally. The pendulum, which was intact, was set up in September for recording E.–W. tilt.

(4) Two Wood–Anderson short-period seismographs with recorders arrived from California in December, and steps were immediately taken to have one of these instruments set up at the Observatory. Lack of space will prevent both the Wood–Anderson seismographs being installed in the Observatory cellar. A third Wood–Anderson instrument is now available and will be set up as soon as possible.

While at the solar eclipse on the Island of Niuafo'ou in October, Dr. T. A. Jaggar, of the Volcano Observatory, Hawaii, presented me with a local shock-recorder for use at the Observatory. The recorder was brought to Wellington when the Eclipse Expedition returned. Special thanks are due to Dr. Jaggar for his generous gift.

Besides the instrumental records, much valuable information has been obtained from reports of the effects of earthquakes felt in various parts of the Dominion. These reports are prepared and forwarded to the Observatory by officers of the Post and Telegraph Department, officers of the Marine Department, and also by a number of private observers. The information from these reports is used in the determination of earthquake epicentres, and also for the preparation of maps showing the distribution of seismic intensity.

In co-operation with other seismological stations, preliminary reports of the most important earthquakes have been issued each month. These reports facilitate the rapid determination of epicentres.

The complete seismological report up to 1929, September, was published during the year as Bulletins E. 21 and E. 22.

Earthquake reports were received from forty-seven observatories during the year 1930.

The addition of several new instruments has brought about a considerable increase in the seismological work of the Observatory.

Earthquakes in New Zealand, 1930.

Seismic activity was less severe in the year 1930 than it was in 1929, although the number of shocks experienced was greater in 1930. The total number of separate earthquakes reported for the whole of New Zealand during 1930 was 748, about 90 per cent. of which originated in the Takaka or Murchison districts of the South Island, where earthquakes have continued with varying intensity ever

since the severe shock of 17th June, 1929. Thirty-eight shocks reached or exceeded R.-F. 6 at Takaka, where they were usually more severe than in other parts of the district. During the latter half of the year activity in the South Island showed signs of diminishing, until November, when a fresh outbreak of strong shocks caused some alarm to residents in the Takaka district.

A severe earthquake occurred on the east coast of the North Island on 12th February, the centre of the disturbance being near Porangahau, where the shock exceeded R.-F. 8, and considerable damage was done to property. Several after-shocks were experienced, but the disturbance subsided within one month.

The following table gives a summary of the earthquakes felt and reported during the year 1930 :—

Month.	Number of Earthquakes reported.				Maximum Intensity (R.-F. Scale).	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Total Shocks.		
January ..	2	66	1	67	6	Kahurangi Point.
February ..	28	47	4	71	8	Waipawa, Porangahau.
March	4	45	..	49	6	Takaka, Murchison.
April	7	74	2	79	7	Gisborne.
May	2	56	1	57	6	Takaka, Tophouse, Murchison.
June	6	60	2	64	6	Takaka.
July	10	47	4	53	6	Westport, Murchison.
August	16	66	1	81	6	Takaka.
September ..	12	50	1	61	5	Several places in both Islands.
October ..	13	43	2	54	7	Farewell Spit.
November ..	7	50	2	55	8	Takaka.
December ..	18	44	5	57	7	Takaka.
Totals ..	125	648	25	748	8	Waipawa, Porangahau, Takaka.

The above table shows that, out of the 748 shocks during the year, 125 were felt in the North Island, 648 in the South Island, and 25 in both Islands. Intensities were abnormally high throughout the year, although R.-F. 8 was not exceeded.

The maximum intensities experienced in each of the years 1921 to 1930 (inclusive) were as follows :—

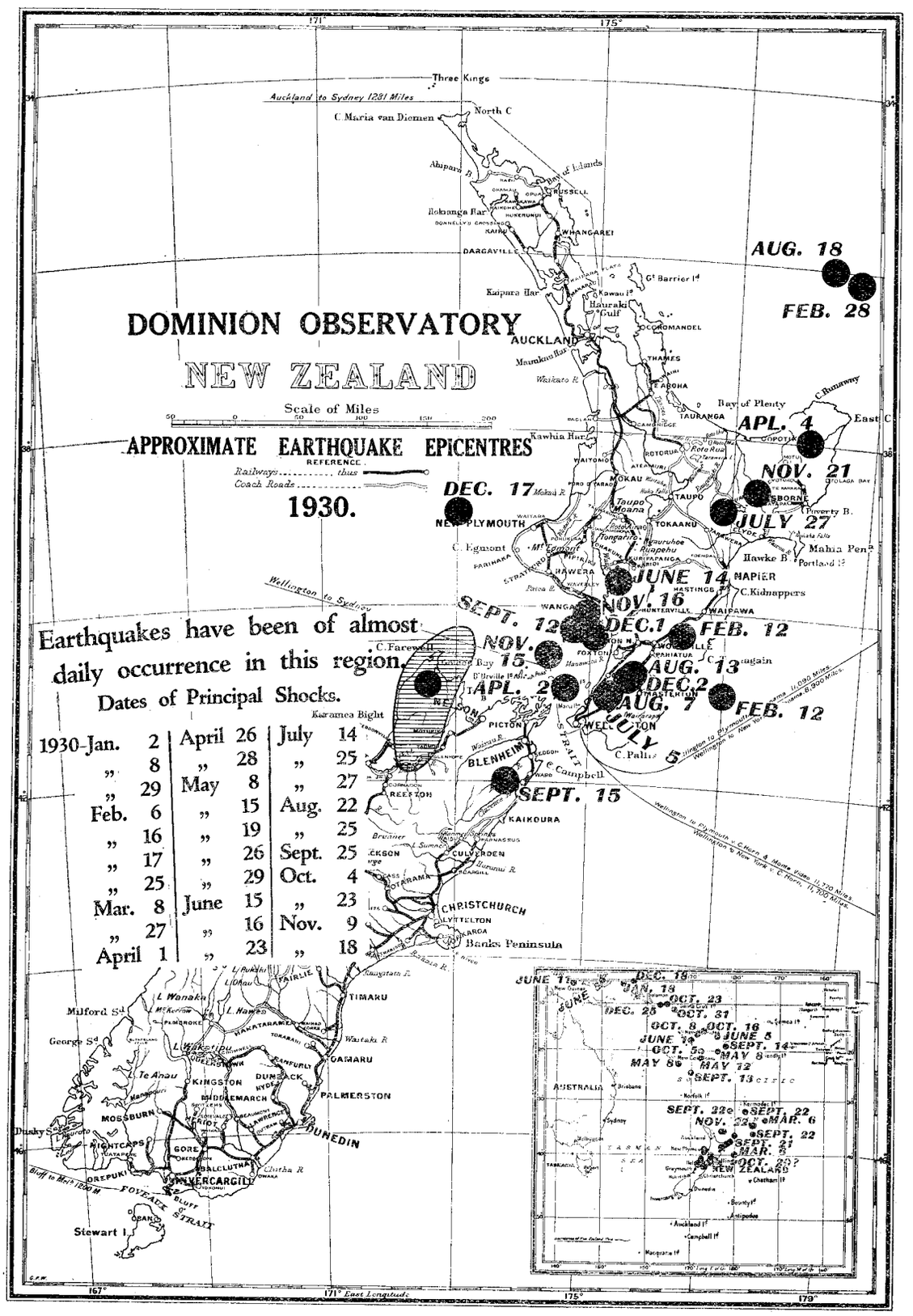
Year.	Maximum Intensity (R.-F. Scale).	Year.	Maximum Intensity (R.-F. Scale).
1921	8	1926	8
1922	8	1927	8
1923	6	1928	8
1924	7	1929	10
1925	8	1930	8

The following table gives the number of earthquakes in 1930 whose maximum intensities fell in various numbers of the Rossi-Forel scale :—

Month.	R.-F. Intensity.										Totals.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
January	..	3	21	21	18	4	..	..	..	..	67
February	1	10	26	20	6	7	..	1	..	..	71
March	..	4	13	18	7	7	..	..	..	..	49
April	..	9	26	23	18	2	1	..	..	..	79
May	1	7	15	16	13	5	..	..	..	..	57
June	2	5	3	33	17	4	..	..	..	..	64
July	1	2	13	17	16	4	..	..	..	..	53
August	..	10	18	29	20	4	..	..	..	..	81
September	5	6	25	16	9	..	..	..	..	..	61
October	..	5	15	22	10	1	1	..	..	..	54
November	..	4	16	18	10	5	1	1	..	..	55
December	..	3	23	15	9	3	4	..	..	..	57
Totals	10	68	214	248	153	46	7	2	..	..	748
Per cent. ..	1	9	28	33	21	6	1	1	..	..	..

The table indicates that intensity 4 was the most frequently observed.

The accompanying map shows the approximate epicentres of the most important earthquakes in 1930. The epicentres were determined from the seismological records of the Observatory in conjunction with non-instrumental reports. The small inset map shows the epicentres in the south-west Pacific. The epicentres outside New Zealand were determined from the seismograms at Wellington and Suva in conjunction with seismological reports from the following stations: Sydney, Riverview, Melbourne, Adelaide, Perth, Apia, Batavia, Manila, Taihouku, La Plata, Strasbourg, United States Coast and Geodetic Survey, Jesuit Seismological Association.



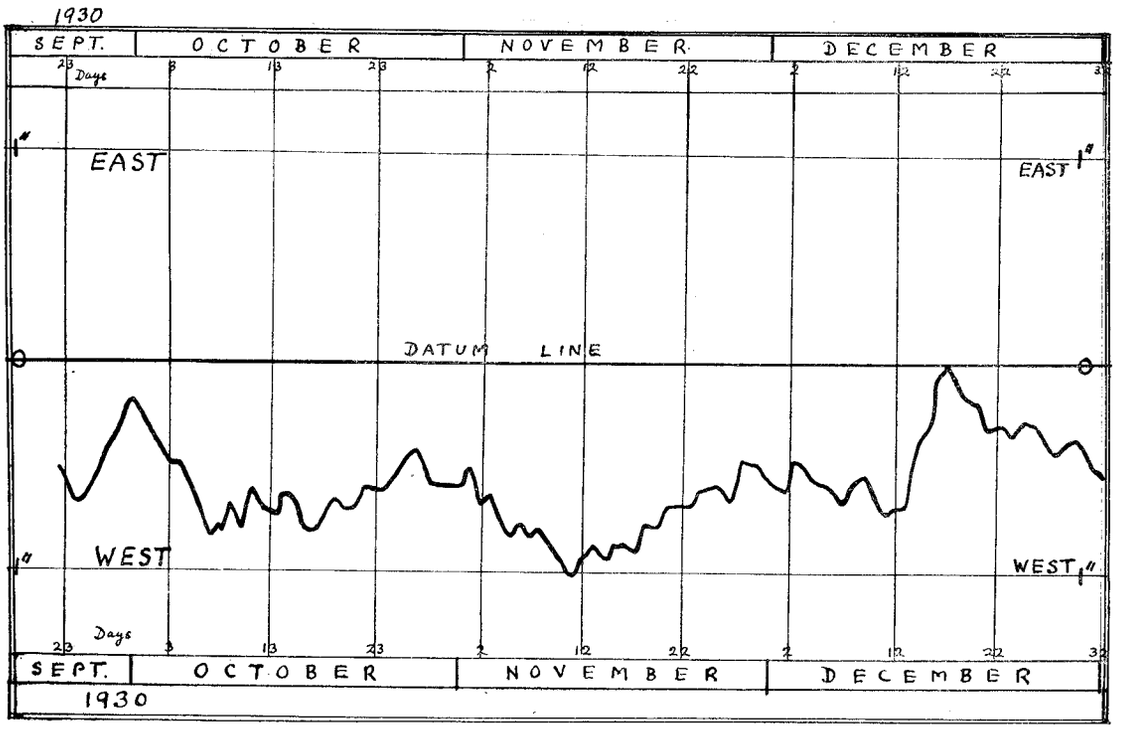
EARTHQUAKE EPICENTRES, 1930.

Tilting of the Ground.

The east-west component clinograph was installed in September, 1930, in the Observatory cellar. The graph showing tilting of the ground at Kelburn has been constructed by plotting daily mean values from the clinograph records.

The graph may be interpreted as representing the movements of the upper end of a rod fixed firmly in the ground in a vertical position so that it partakes of any movement of the ground in its vicinity.

The records available so far are not sufficient to enable any definite conclusions to be drawn as to real earth-movements. It will be necessary to eliminate the effects due to meteorological conditions, and also to determine whether the movements indicated are local or widespread.



TILTING OF GROUND AT KELBURN, WELLINGTON: E.–W. COMPONENT.

GENERAL.

Publications.

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

E.–20.—Earthquake Report for 1929, January to March.
E.–21.—Earthquake Report for 1929, April to June.
E.–22.—Earthquake Report for 1929, July to September.

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

Meteorological Records.

The following are the meteological records for 1930:—

Barometer (height above sea-level, 415 ft.)—
Maximum reading, 30·19—May 10th and 11th.
Minimum reading, 28·83—September 29th.
Temperature (in transit-room)—
Maximum reading, 65°·6 F.—February 9th.
Minimum reading, 52°·9 F.—July 29th.
Temperature (in clock-room)—
Maximum reading, 65°·0 F.—February 16th.
Minimum reading, 55°·2 F.—July 28th.

STAFF.

The staff for 1930 was as follows: Mr. R. C. Hayes, Professional Assistant, Mr. I. L. Thomsen, clerical cadet. Mr. P. W. Glover was engaged at the Observatory from July 31st to September 20th, and was concerned with the preparations for the Eclipse Expedition. Mr. A. G. C. Crust assisted during the year when the other officers were absent at University lectures, and also took a part in the overtime work at the Observatory.

It will be seen that the activities of the Observatory have increased very much of late.

C. E. ADAMS,
Dominion Astronomer and Seismologist.

Dominion Observatory, Kelburn, Wellington, N.Z.,
14th May, 1931.

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