1930.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(REPORT OF THE).

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

Hon. E. A. RANSOM,— 3rd September, 1930.

I have the honour to submit herewith the annual report of the Department for the year 1929-30.

E. MARSDEN.

ANNUAL REPORT.

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

The personnel of the Council is as follows:—

Mr. George Shirtcliffe, O.B.E. (Chairman), Wellington.
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 (Secretary).

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

Permanent service—	£
Dominion Laboratory (with branches)	15,955
Geological Survey	7,857
Meteorological Office	9,847
Petrological Laboratory	864
Apia Observatory	2,624
Dominion Observatory	2,358
Research investigations (including contributions and statutory grant £3,700 to Lincoln College)	40,522
Head Office, publications, Research Scholarships, and miscellaneous	5,847

The assistance of the Empire Marketing Board (£6,033) and industries (£9,200) is gratefully acknowledged. The help from the latter is an earnest of their appreciation of the necessity of the work attempted, and it is pleasing to note that funds are under offer for other activities.

The Department has been functioning a little over three years, and, in the research activities which it has undertaken, is emerging from the pioneering stage when an organization was being built up gradually. As has been found elsewhere, progress to those actively engaged has seemed slow, yet, considering the scale of the efforts, a retrospect shows that very general progress has been made in a number of directions and along such lines as are of material use to industries. Moreover, through contact with research organizations overseas, interchange of workers, and the establishment of the Imperial Agricultural Research Bureaux, a wider outlook of research has developed, and a considerable measure of Imperial unity attained. In organization, every effort has been made to facilitate team work and yet to take advantage of the enthusiasm and initiative of the individual worker, the mainspring of all successful endeavour in science.

The main result of the Department's activities has been the tendency to replace the speculative point of view on many questions by the more solid basis of facts as obtained by survey or experiment, so that we can now build steadily on the foundation laid. A review shows that the nature of the advances made have been real rather than striking, and this is as might be expected when progress is attempted on organized lines. There is a tendency to gauge results by pounds, shillings, and pence, and although this method is distasteful to the scientific worker and is not always a real criterion of progress, which is more truly measured by advance in conceptions and ideas, it appears necessary to take stock even after the relatively short period of activity of the Department and review the progress attempted and made in the investigations which have been inaugurated. The main new activities during the year have been the development of the Imperial Research Bureaux, forest biology, and investigations regarding standardization; and the organization by committees of interested parties in this and other regards has proved satisfactory.

(1) *Seed and Plant Research Station.*—At this station, conducted in co-operation with the Department of Agriculture, perhaps the largest measure of progress has been made on investigations having an almost immediate bearing on farm practice. The main advance has been the practical realization of the importance of strains in connection with the Dominion's grasses and clovers. Valuable results have followed excellent team work of the systematic botanist, agrostologist, plant-geneticist, and specialist in experimental technique. The strain investigations concerned with perennial rye-grass, white clover, red clover, and cocksfoot indicate that selection of the right type of grass or clover is all-important.

Desirable types of rye-grass have been isolated, and a quantity of seed is now available for further propagation. The adoption of true perennial rye-grass on our better lands will mean a more permanent pasture of high productivity, and hence lessened necessity for regular ploughing and replacement, and a greater response to top-dressing. The rapid replacement of inferior pastures by those comprised of the suitable grass strains isolated by the station is, therefore, a means whereby farmers can increase the stock-carrying capacity of their land, and this, together with the adoption of a system of intensive grassland-management throughout the Dominion, will do much towards increasing exports and influencing general prosperity; nor must the possibilities of building up a promising export trade in grass and clover seeds of the best reputation be overlooked. This will be possible with the adoption and extension of the seed-certification system, based on productive capacity, which is now being employed by the station.

Knowledge of the right methods of top-dressing is now being rapidly amassed as a result of the carefully conducted experiments at the station and throughout New Zealand. The importance of lime in improving the returns from other fertilizers has become very apparent. The good results arising from applications of nitrogenous manures with phosphates and lime, in the direction of prolonging the grazing season, in providing fresh green feed at those seasons of the year when usually there is the greatest dearth, have been clearly demonstrated. One of the most striking features of the work is that showing the great and economic response secured when concentrated manures are applied to pastures comprised of certified strains of rye-grass and clover.

Good progress has been made towards the knowledge of control of some of the most serious fungoid diseases of fodder crops. Dry-rot of turnips, club-root of turnips, sclerotina of lupins and peas, collar-rot of peas, are being studied, and, in the case of the first-named, disease-free seed is being raised in districts isolated from possible infection. Liberal dressings of lime at definite specified dates, together with the use of disease-resistant strains of swedes and turnips, have been found a fairly effective means of minimizing loss through club-root.

(2) *Mineral Content of Pastures.*—These investigations have been carried out in conjunction with the Cawthron Institute and the Department of Agriculture. The variation of the mineral content of typical pastures throughout the year has been determined, and much information obtained regarding the importance on stock-health of the lime, nitrogen, and other minerals found in pasture grasses. The necessity for a balanced fertilizer mixture comprised of lime and phosphate has been demonstrated over a very large belt of country. The correlation between stock-anæmia and soil-structure has been worked out, and we have now a much better knowledge of the relation of bush sickness and other malnutrition troubles to soil conditions. The cause of Xanthine calculi in sheep has been traced to a lime and phosphate deficiency. The degree of absorption of lime, sulphur, and phosphate by lucerne has been investigated. A survey of the iodine content of certain soils and waters has been made.

(3) *Pakihi Land.*—The workers at the Cawthron Institute have discovered a means of converting non-productive pakihi soils into at least good second-class land by simple methods of cultivation together with the application of lime and artificial fertilizer.

(4) *Dairy Research.*—The Dairy Research Institute at Palmerston North, with the associated laboratories at Hawera and Hamilton, has made considerable progress in providing a groundwork of chemical and bacteriological knowledge of our milk and milk-products. New methods of analysis and testing have had to be devised, and standardized methods of grading milk have been worked out,

the extent of butterfat losses in manufacture has been determined under various conditions, much quantitative information has been obtained in the problems of maturation of cheese, and considerable progress has been made in the understanding of the problems of open texture of cheese, although a full solution of the problem has not yet been found. Valuable statistical work has been carried out on production yields in relation to various factors of climate, breed, &c.

The following points of immediate application in the industry have been determined: (1) Milk which develops acid excessively slowly is liable to the production of open-texture cheese, a matter which could be overcome by the use of only the purest milk, and an active and pure starter; (2) excessive salting of cheese-curd proves very detrimental to the "body" of the resulting cheese; (3) the utmost care should be taken in the packing of cheese-hoops in order to avoid open texture.

(5) *Flax Research.*—On the botanical side good work has been accomplished in the development of primary hybrids of high yield and disease-resistance. The application of these to actual practice is necessarily a long process. The response of flax to cultivation and manuring is now much more understood. Little definite progress has as yet been made in combating yellow leaf, a disease which threatens the existence of the industry, but much groundwork has been covered. Another pressing question appears to be the development of better utilization of flax, and some progress towards this end has been made by the working-out of methods of bleaching, the testing of fibre-strength, and tests of decorticating-machines. Samples of papers made entirely from phormium-fibre have been prepared by the Bureau of Standards, Washington, and exhibit desirable qualities for commercial purposes.

(6) *Fuel Research.*—In co-operation with mine-owners and the Mines Department a fairly full survey has been made of the composition and nature of the fuel resources of both Islands. The yields of sub-bituminous coals under carbonization have been worked out, and the results have been largely instrumental in leading to the erection of a plant in the Waikato for briquetting of slack coal. Similar work on bituminous coals is well in hand, and we are now in a much better position to appraise new developments in coal-utilization.

As a by-product of the work of the fuel-research laboratories, the introduction of more efficient appliances for locomotives by the Railways Department (Rosebud grate, &c.) has been expedited, with very considerable national savings.

(7) *Pig Industry.*—In co-operation with the Agricultural Colleges and bacon-manufacturers, a fairly comprehensive survey of feed conditions in relation to pigs has been made, and considerable information obtained as to the relation of diets to rate of growth and to quality of pork and bacon.

The value of "pig recording" has been established by actual trial in three typical districts.

A fuller knowledge of the influence of freezing and holding temperatures on quality of pork and bacon has been obtained, while much information has been obtained of direct value in bacon-manufacture—*e.g.*, methods of bacon-curing, disinfection of stores, &c.

(8) *Leather and Skins.*—In the leather industry a Tanners' Research Association has been formed, and a laboratory established for investigation of the technique of tanning processes, elimination of waste in the industry, testing of leathers, working out the tanning value of New-Zealand-produced barks, &c. The progress made can best be gauged by quoting a resolution passed at a general meeting of the Association in June, 1930:—

> "That this meeting desires to place on record the valuable assistance given by the Research Association in (1) raising the standard of leather produced, (2) raising the efficiency of production, (3) improving the co-operation between the tanners and the different branches of the leather consumers. That this resolution be published as an indication to other industries of the benefits to be obtained from the application of research."

Considerable preliminary work has been carried out on the processing of sheep-skins at freezing-works, and important improvements in treatment have been effectively followed up by appraisement by British tanners. The work has led to process modifications by certain works with a view to production of a better article. The cause of "red stain" in hides has been traced to bacteria introduced in the salt-supply used in the curing process.

(9) *Wheat.*—By co-operation of millers, growers, and bakers, and Lincoln and Canterbury Colleges, an active programme of work in wheat has now been in operation for two years. A systematic organization for dealing with selection, breeding, and trial of varieties of wheat from all parts of the world has been established. While this work necessitates a long period for fruition, yet, pursued to its logical development, it is fairly certain to lead to beneficial results, apart from its insurance against loss through the growing of faulty varieties on an extended scale.

A protein survey of the wheats of Canterbury and Otago has been carried out, and a knowledge obtained of the baking-qualities of the leading varieties of wheat grown in various districts of New Zealand. A system of grading wheats and flour, based on New Zealand quality requirements, has been worked out, and this has proved a useful guide to both miller and baker. The influence of degree of ripeness of wheat on the ultimate loaf-appearance has been determined.

In conjunction with the Department of Agriculture, a fairly full knowledge of the influence of manurial treatment of wheat yield and quality has been obtained. A system of wheat-certification has been elaborated. A fairly full investigation of the economics and conditions of wheat-harvesting by the header-harvester method has been carried out by the Wheat Research Institute. In conjunction with Lincoln College, a simple method of moisture-testing of wheat has been developed.

Much work has been carried out on the value of milk and malt improvers in the making of bread. In addition, many minor investigations in the milling and baking processes have been completed. The results of these investigations have been conveyed to those concerned, and are exerting an influence towards modification of milling and baking practice in a number of instances.

(10) *Wool.*—Investigations in wool have been carried out at Massey and Lincoln Colleges, and the Romney Marsh Breed Society have assisted in provision of finance.

The problems of wool are so complex that it is a real satisfaction to be able to record that work has so far progressed that there is now a new realization of the fundamentals of the problems involved, and that sufficient spade-work has been accomplished on which to build a practical programme of definite advance. Definite information has been obtained on the nature of the inheritance of medullated fibre, the significance of certain hairy fibres appearing in the birthcoat of lambs on the character of the ultimate fleece of the adult sheep, the thickening of fibre-tip after shearing in certain conditions, and the extent to which the chemical composition of wool-grease is modified by rain and exposure.

Definite progress has been made in tracing manufacturers' troubles to various conditions of breeding and environment in New Zealand, so that the somewhat uncertain position in this regard may be clarified and more reliable advice given to growers.

(11) *Cold Storage and Transport.*—Recognizing the importance of the technical problems of storage and transportation of our food products to the Home market, fairly extensive investigations on cheese problems have been carried out during the past two years. The appropriate temperatures for conveyance of our main lines of apples and pears have been worked out at Cawthron Institute, and the response of apples to different conditions of temperature and humidity. The relation of soil and climate characteristics to wastage-rate in fruit has been in part determined.

Much data has been obtained and is in process of compilation regarding the effect of transport conditions on meat, cheese, and fruit; and the hearty and active co-operation of representatives of the meat, dairy, and fruit industries ensures that practical application of this knowledge is being and will be made.

(12) *Noxious Weeds.*—Considerable advance has been made in the exploration of the possibilities of weed-control under various conditions by insects, and fair promise of worth-while results in the case of ragwort, gorse, and piripiri is indicated. These investigations are necessarily prolonged from the point of view of absolute safety.

The above synopsis deals with the main lines of investigation that have been inaugurated. Considerable progress is also recorded in work on the vitamin content and values of various stock-foods at Otago University, utilization of New Zealand building-stones, necessary organization for standards and standardization, investigations connected with forest biology, &c., as well as the innumerable relatively minor investigations in relation to secondary industries carried out at the Dominion Laboratory.

As has been stated above, however, the results of scientific endeavour cannot well be assessed in material standards, and an enumeration such as the above is more for the purpose of endeavouring to satisfy the lay mind. True progress is measured by the increasing co-operation of industry and science for the common good, the realization by industrialists of the scientific or research method, and the appreciation of scientific workers that they can play their part in the national well-being and prosperity.

GEOLOGICAL SURVEY.

Since last year's report was presented the Geological Survey has issued a bulletin on "The Soils of Irrigation Areas in Otago Central," wherein the soils of an area of 1,177 square miles are described and mapped.

Field-work that has continued for several seasons is now completed in the Wairoa and Murchison oil-bearing areas, and nearly completed in the Rotorua-Taupo volcanic zone. The examination of the Te Kuiti Subdivision, begun late in 1928, will be continued next year. This district is in the eastern portion of the region that, at a geologically no distant date, was covered by great showers of volcanic ash to a depth sufficient to influence the characteristics of the soil. On many farms the stock do not thrive, although when first settled, some twenty-five years ago, the district was renowned for its productivity. The problem is complex, but enough is now known to show that the geological factors entering into soil-formation are here exceptionally important, and it is proposed to continue and even extend the intensive field and laboratory work already carried out.

The past year was one of unusual seismic activity, and earthquakes occurred in several widely separated districts at different times. They were most serious in western Nelson, where considerable damage was done to towns, farms, forests, roads, harbours, &c. Several officers of the Geological Survey examined parts of the area shortly after the severe earth-movement of the 17th June, 1929. Further exploration has since been carried out, and a report compiled from many sources will be issued as time permits.

Since 1906, when the Geological Survey was reconstituted, it has carried out detailed explorations, for the most part in districts containing or likely to contain minerals of economic value. Most of the goldfields and large parts of the country known as likely to contain deposits of coal or oil have now been mapped. This work was undertaken to help the mining industry, and, except for short sections on the soils of each district customarily included in the bulletins and a comprehensive report on the limestones of New Zealand, the Geological Survey did little directly to assist farming until work in Otago Central and Te Kuiti was undertaken. Now, however, that intensive farming is becoming more general and the need for the better understanding of soil-characteristics more obvious, it is desirable that a systematic soil survey be put in hand. But soil experts are by no means agreed as to the principles to be followed in soil-classification, and the decision to constitute a soil survey as part of the Geological Survey, for the time being at least, was arrived at only after most careful consideration. Shortly summarized, soils are divided on the bases of geology, climate, and texture; and each has its advantages. In New Zealand where, on the whole, soils are youthful, and where, as has been clearly shown in several widely separated localities, there is a close general relationship between the underlying rocks and farming practice, geology undoubtedly provides the most satisfactory basis of classification. Even at Te Kuiti, where the rainfall is high and where volcanic ash mantles the surface to a depth of several feet, conditions likely to cause texture to have predominating influence, the underlying rocks profoundly affect the productivity of the soil.

DOMINION LABORATORY.

The growing appreciation of the value of scientific services is shown in the increasing demands made upon the staff and facilities of the Dominion Laboratory.

During the year the actual number of samples dealt with was only slightly in excess of the previous year, but considerably more work of an advisory nature was undertaken.

One of the aims of the Laboratory is to ensure that, while all members of the staff have a wide general knowledge, each officer shall be a specialist in some particular branch of chemical work. The experience of the last few years has fully justified this policy, as the Laboratory has been able to meet successfully a wide range of problems submitted to it for investigation.

The testing of supplies for Government Departments is one of the chief activities of the Laboratory. Almost every Department makes extensive purchases of various materials during the year, and it is important to ensure that all these materials possess the requisite qualities. This work is of a highly important nature, as the two following examples will show:—

The very large quantities of bitumen employed in modern roadmaking must comply with rigid specifications, and the road, as laid down, must contain the correct proportions of carefully graded rock, sand, &c., usually known as "filler." The use of faulty materials or incorrect mixing leads to grave risk of breakdown of the roads under service conditions. All supplies, therefore, as well as the road mix actually laid down are tested regularly in the Laboratory. In this way, too, knowledge of highway-construction, the durability of various ingredients under different conditions, and the correct procedure to be adopted in establishment and maintenance is being extended regularly.

A large amount of solder and jointers' metal is used by the Post and Telegraph Department in their telegraph and telephone work. Many of the joints made are underground or in other comparatively inaccessible positions, so that repairs in case of failure are troublesome and expensive. Consequently the solders are regularly analysed, and any showing definite impurity are rejected.

In the search for petroleum it is important to ascertain the nature of the gas which rises up in the various bores. Careful analyses were made during the year of gas from several bores in Taranaki and East Coast districts, but in no case was there any indication of the association of petroleum with the gas.

Complete analyses of various pumice-showers have proved of great assistance in the investigation of the deteriorated soils of Mairoa.

The Laboratory examines a wide range of foodstuffs for the Department of Health. During the year a special investigation was made of the occurrence of lead in soda-water. As a result, metal containing lead and joints made with solder are not permitted in soda-fountains. In this way the public is protected against injury to health likely to arise from the consumption of harmful foodstuffs or the utilization of substances whose composition may in any way affect the health of the user.

The Laboratory also renders expert service to industries, especially where there appears possibility of promoting the extension of use of supplies of raw materials for manufacture. In addition, preliminary investigations are made in those directions where industries may utilize to a greater extent modern scientific developments. As examples of this work may be quoted a series of investigations made on the properties of New Zealand clay deposits with a view to their use in the manufacture of roofing-tiles. At the same time the question of blending different clays in ways most appropriate for the preparation of bricks, tiles, and pipes was tried out experimentally and manufacturers advised as to the best proportions of the respective clays to be used.

In order to make available to the bacon industry the latest scientific developments in curing methods, factory sanitation, and to give manufacturers and farmers some idea of the influence which feeding and processing exerted upon the final product, one officer was seconded to deal thoroughly with the technical side of the industry. Several reports have now been published dealing with these aspects of the industry.

It has been the policy of the Laboratory to utilize the best methods of technique, and to examine and improve upon standard analytical methods wherever possible. In general, it may be said that very considerable changes and improvements are now being made in technique from year to year in all parts of the world. The importance of this matter in connection with examination of dairy-produce is of great moment in New Zealand. Consequently the Laboratory was represented at a meeting of dairy chemists held at Massey Agricultural College during the year, when methods of analysis were fully discussed and the adoption of standard methods agreed upon.

A major line of research, dealing with the relation of iodine to goitre incidence in New Zealand school-children, was continued in co-operation with the Department of Health during the year. The iodine contents of soils and waters in certain typical districts was ascertained and correlated with the incidence of goitre in the school-children in these areas. The results have been published in Bulletin No. 18, "Goitre in School-children." The investigation is being continued, and may have an important bearing on the elucidation of the involved problem of endemic goitre.

METEOROLOGICAL OFFICE.

The Meteorological Office has two principal functions. The first is the collection of statistics regarding the weather of the past, that sum of weather experiences which together go to make up our climate. Every individual forms from his own experiences and what he has learnt from others an idea of his local climate, and in the past it was on such estimates that human activities, especially those of the man on the land, were based. But human impressions depend upon many factors, and human memory is short. We constantly hear complaints that the climate in a particular district is changing; that certain winds have never been so persistent before; and so forth. The apparent change in climate is frequently due to the individual's increasing susceptibility to cold as his age advances. And, generally, it is found that precise records from standard instruments, so exposed

as to ensure that the readings at different places will be comparable, are necessary if we are to get a reliable indication of climate and its variations. In this respect, therefore, the Meteorological Office has to provide the public memory of the weather. Were the Meteorological Office to cease to perform this function, many private individuals and companies would try to collect the information for themselves. There would be a lack of continuity in policy, and few long records would be obtained. Instruments would be of various types, of varying degrees of reliability, and exposed in different ways. The results would, consequently, not be directly comparable. The work would, indeed, be done inefficiently and uneconomically. There is, then, need for a Government Department which will concern itself with the collection of weather records. Rainfall is perhaps the weather factor with which all are most concerned, and the first thing we wish to know is how much rain can be expected in the course of a year, and on how many days it falls. The Meteorological Office has tried to provide this information by means of maps showing the average rainfall and the average number of rain days per annum in New Zealand. All the available information has been made use of in the preparation of these maps, but much more is needed. All want to know to what extent the rainfall is liable to exceed or fall short of the average in any one year. Then, again, from the point of view of the productivity of the soil, winter rains are of comparatively little importance. The character of the harvesting season, the yield from crops, and the abundance of pasture may depend mainly on the rainfall in two or three months. Similarly, a period of three months in summer with little rain is sufficient to cause serious deficiencies in the power derived from hydro-electric schemes. Our worst dry spells seldom last more than about three months. Therefore it is hoped that it will be possible before long to give the same information regarding monthly rainfalls as for the annual totals.

In connection with water-storage, drainage, and river-control problems it is required to know what is the heaviest rainfall which may be expected to fall in short periods of from a few minutes to a few days. The publication in convenient form of this information would be a very valuable work. And so on for other factors, such as temperature, humidity, sunshine, &c. The aim of the Meteorological Office is to publish data at frequent intervals as they come in, and then to collate, summarize, and discuss them so as best to bring out their significance, and to present them in the form in which they will be most useful to those requiring them.

The other principal function of the Meteorological Office is to issue predictions of the nature of the coming weather for as long a period ahead as conditions and existing knowledge seem to warrant. Since the efforts of the meteorologist in this direction are continually before the public, it is apt to be considered his sole duty, but the collection of statistics is really the more important. Any request for a forecast is always answered to the best of our ability, and a list of the purposes for which, in the course of a year, inquirers need forecasts would be both varied and extensive. Naturally, however, there is always a tendency to seek from the meteorologist a prediction for a longer period than it is safe for him to venture.

In tropical and subtropical countries, there has been some success in devising methods by which seasonal forecasts may be prepared—that is, of anticipating, for example, by what amount and in what direction the rainfall in the critical period of the year may differ from the average. Even in tropical countries, however, comparatively little practical advantage has been derived from these forecasts, while in temperate regions there has been practically no material gain. There is nothing yet known which would lead to the expectation that seasonal forecasts of any high degree of accuracy are likely to be possible in New Zealand in the near future. The present financial year has given a good illustration of the complexity of the problem. There have certainly been persistently low temperatures since June last, but in the more important factor of precipitation there have been rapid variations from one extreme to the other. In October, and, in some districts, as late as November, the dry conditions were causing serious alarm. There were numerous prognostications of a dry summer, with its consequences of low milk-yield, poor crops, &c. Next followed a very wet spell, lasting into the middle of January. The forecasts were now all for wet weather and great difficulties in harvesting. Yet in February another very dry spell commenced, and harvesting-conditions became almost ideal. The dry weather continued rather long, and again there were fears of drought and dearth of feed for stock. To have forecasted the season accurately would have required extraordinary precision. Conditions passed back and forth from one extreme to the other, yet, on the whole, the season was a remarkably good one, and the rainfall not far from the average. Had a difference of two months occurred in the incidence of the wet and dry spells, there would have been a different story to tell. But many people are extremely uncritical of seasonal forecasts, and any straw is grasped at. It is scarcely ever possible to give in a few words a description of the characteristics of a season which will satisfactorily cover so large an area, for instance, as that embracing Australia and New Zealand, owing to the great variation from place to place. Yet one frequently finds a seasonal forecast issued in the most general terms and without specifying any particular district, being regarded as confirmed if its predictions appear to be borne out in any particular locality. The field, therefore, is one which it is very easy to exploit. But, although we wish to emphasize that seasonal forecasting is not yet possible, it is clear that the meteorologist must give earnest attention to so important a problem. In this connection, the first need is for the long and accurate statistics which have been referred to earlier. In New Zealand these are, to a large extent, lacking. Observations have been made at some places for long periods, but they have been vitiated through changes of observation-site, periods of broken or careless records, or the use of unsatisfactory or unsatisfactorily exposed instruments. It is only through public interest that this state of affairs can be remedied. The next need is for an understanding of the meteorological processes of the world as a whole. For this reason it is desirable to support world organizations, and especially expeditions devoted to research in the Antarctic regions, where there is so large and important an area which must exercise a potent influence on the weather of the world, but of which our knowledge is slight.

PETROLOGICAL LABORATORY.

The services of the Petrological Laboratory have been in large demand during the year. The increasing need for wide use of stone materials for building purposes necessitates the acquisition of further knowledge of the rock resources of the Dominion, and investigations have been continued to this end. Similar knowledge is also required of the suitability of the shingle and rock supplies for highway construction and maintenance, these materials entering very largely into the manufacture of concrete and bitumen preparations. Harbour-construction and protective work dealing with shingle and sand movements along coastlines represents one of the large problems affecting harbour authorities. Valuable fundamental work on sand formation and drift has been in progress at Napier and Otago, giving results of much practical and scientific significance.

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 are also 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 undertake only those researches which the position of the Observatory, having regard to both latitude and longitude, warrants. Many astronomical observations, such as the study of variable stars, meteors, occulations, and planets, are carried out by members of the New Zealand Astronomical Society, and the results are forwarded to the Observatory.

In seismology the standard equipment has consisted of two Milne-Shaw and one Milne horizontal-component seismographs. As a result of the destructive earthquake which occurred on the 17th June, 1929, in the Murchison area, and the large number of after shocks, 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 Galitzen vertical-component instrument, a Wood-Anderson horizontal component, and an Imamura strong-motion horizontal-component instrument. In addition, an Ishimoto clinograph has been ordered. At Suva, Fiji, there is a twin-boom Milne seismograph, the records of which are sent to the Dominion Observatory.

The records from New Zealand are forwarded to many seismological observatories, and appear in the International Seismological Summary.

APIA OBSERVATORY.

The work of the Apia Observatory, dealing with terrestrial magnetism, seismology, meteorology, and upper-air observations, has been actively continued during the year. The Director, Mr. A. Thomson, was transferred in order to undertake special observations in connection with upper-air work in New Zealand, and his place as Director has been filled by the appointment of Mr. John Wadsworth.

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

DAIRY RESEARCH.

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

The Dairy Research Institute (N.Z.) is situated in temporary laboratory buildings adjacent to Massey Agricultural College at Palmerston North. The dairy factory, herds, and buildings belonging to the College are available for research purposes. Provision is now being made in the new Massey College buildings, in course of erection, for the permanent housing of the Dairy Research Institute. The staff and the facilities of the Institute are availed of during the short instructional courses conducted during the winter months, and thereby direct contact with the industry is regularly maintained.

The New Zealand Co-operative Dairy Co.'s laboratory at Hamilton, and the South Taranaki Federation of Dairy Companies' laboratory at Hawera have undertaken definite lines of investigation in co-operation with the Dairy Research Institute.

Director's Report.

This report reviews the first complete twelve months' investigation of problems affecting the manufacture of dairy-produce by the Dairy Research Institute (N.Z.). At the close of the previous year the Massey Agricultural College dairy factory had just been recently completed, and the manufacturing experiments then in progress had not reached a stage for being reported upon. When the results of these first trials become available during the present year, experiments were considerably extended on the manufacture of cheese, and additional research work relating to the manufacture of butter, transport of cheese, analysis of dairy-products, and the production of pure milk was undertaken.

In carrying out this programme of work the Institute has the hearty co-operation of the Massey Agricultural College, the Dairy Division, and the New Zealand Dairy-produce Board. The National Institute for Research in Dairying at Reading, England, has kindly co-operated in the examination of selected lots of produce in England. The laboratories attached to the Taranaki Federation of Co-operative Dairy Companies and the New Zealand Co-operative Dairy Co. have also collaborated with the Institute in certain sections of the work, and they have carried out independent investigations for which they have received financial assistance from the funds of the Institute.

Since practically all dairying problems are affected by the collective results of chemical, bacterial, and manufacturing conditions, the policy of investigating these three aspects simultaneously when working on any one problem has been continued. This has necessarily involved independent laboratory studies before they could be attempted on a manufacturing scale in some cases, and, in others, carefully controlled factory experiments before they could be followed up in the laboratory. But the main aim has been to elucidate facts from different angles concerning problems on which all three sections of the Institute have concentrated. In all questions affecting the quality of produce no attempt has been made to offer judgment till the promises of laboratory investigations have been confirmed by experiments carried out on a factory scale. The produce manufactured for this purpose has been carefully examined at regular intervals. Part of it has subsequently been exported under conditions similar to those which the Dominion export produce is exposed, and reports as to its suitability for the Home market have been received from Britain through the kind co-operation of the Dairy Division and the New Zealand Dairy-produce Board. Corresponding lots of produce have been held in the dairy-factory stores, so that the effects of conditions of transport could be measured.

One of the greatest difficulties in analysing the results of experiments on the production of milk and the manufacture of dairy-produce is the necessity for repeating the same experiment a number of times. In any process where living organisms are involved it is impossible to keep an absolute control of all the varying factors from day to day. In dairying one has to reckon with variations in the milk consequent upon variations in the cow, and in bacterial contamination at all stages. Furthermore, for every experimental procedure there must be some normal procedure which is taken as standard for purposes of comparison. Since uncontrollable variations have to be reckoned with, both in the normal and in the experimental procedure it is obvious that conclusions cannot be drawn from only one or a few experiments. In cheese-making, for example, milk and starter are two of the principal raw materials used. Milk, as is well known, varies from day to day, although it may exhibit no visual change. Starters may also vary in vitality without showing any apparent differences in acidity, flavour, or texture. Hence the results obtained on consecutive days of any one experiment do not necessarily show the same differences between "experimental" and "control." It is, then, only by carrying out trials over an extended period and comparing numbers of cheeses made under the same experimental conditions that reliable conclusions can be drawn. Thus experimental work must be slow unless it is carried out on a very large scale.

CHEESE PROBLEMS STUDIED.

In view of the disconcerting reports received from Home on the quality of New Zealand export cheese, special attention has been devoted to problems affecting the manufacture, curing, and transport of cheese. Openness in cheese has been the principal subject of the Institute's investigations. Conditions affecting the standardization of cheese milk, digressions necessary from normal practice in the manufacture of standardized milk-cheese, and the analysis of the standardized product have also been closely studied. Through the kind co-operation of the New Zealand Dairy-produce Board and the shipping companies, a careful record has been made of the variations in temperature to which export cheese is exposed aboard ship, and the results of these have been followed up by the examination of special lots of cheeses held at different points in the holds of the ships by the London officers of the Dairy Division and the National Institute for Research in Dairying at Reading. Experiments have also been carried out with a view to accelerating the rate of ripening of cheese.

Openness in Cheese.

All associated with the cheese industry realize the importance of this defect to New Zealand. It has been stated to mean an estimated annual loss of a million pounds sterling to the Dominion. This loss is possibly overestimated, because other factors have to be considered in comparing the published prices of New Zealand cheese with that of other countries. The defect, however, is undoubtedly serious, and it is essential that its cause or causes should be definitely known before it comes to be regarded as a characteristic blemish of New Zealand cheese. The problem is no simple one to overcome. Many remedies have been suggested, and, while these have been of assistance in some directions, they have not succeeded in eliminating the trouble.

Openness in cheese is by no means a new defect. It has been known since the earliest days of cheddar-cheese making in Great Britain, America, and New Zealand. It is referred to in the earliest dairy reports of the New Zealand Department of Agriculture by Messrs. Sawers and Laing, and in later reports by Messrs. Ruddick and Singleton, and the advice is there given to make good-bodied cheese with as much acid developed as possible at the time of salting the curd. It is interesting to observe that when Mr. Wright took up his duties in London in 1914 he called attention to the openness in texture present in a large proportion of New Zealand cheese. At this time the pasteurization of milk for cheesemaking was just coming into vogue, and he mentioned that, although pasteurization effected great improvements in cheese flavours, it did not improve texture. It would appear that within recent years an even greater proportion of New Zealand cheese shows openness in texture. Whatever the cause or causes may be—for there are possibly many factors at work—this comparatively recent development synchronizes with the period of most rapid increase in dairying. During this

time new dairying districts have been opened up, more intensive farming practices have been adopted, and modifications in standard manufacturing practice have been introduced. It is just possible that the correlation of these factors with the increase in the prevalence of openness may eventually throw some light on the cause of the trouble. It is conceivable, for instance, that there is something inherent in the milk of certain districts which renders the manufacture of close cheese a very difficult matter. It is surely more than a coincidence that experienced factory-managers, who always aim at quality, have encountered difficulties they cannot surmount. Many cases are known of factory-managers who have been able to manufacture finest-grade cheese in one district, yet they have been unable to get similar results in another, although they applied just as much skill and care in their work.

Types of Openness.—In the course of experimental work it has become plainly evident that there are three distinct types of openness; and to these a fourth may be added, if there is taken into consideration the texture of the cut surface of the cheese after it has been exposed for a few days. It is necessary to consider these types individually before proceeding to discuss them, because there is some evidence that one is not necessarily related to another. There are times when only one type is present in a cheese, and at other times two or even more types may be observed in any one cheese.

(*a*) Mechanical openness: This takes the form of holes of varied size and distribution. The holes may be confined mainly to one part of it. In all cases it is usually possible to discern the outline of the original curd-particles. This gives the impression that the curd-particles have never been pressed together. This is undoubtedly true, for such openness may be observed when a cheese is bored or cut immediately after being taken from the press. Fat may be present in some of the holes, but usually it does not fill up the whole of the cavity. There are at present no data to indicate whether the occurrence of the fat represents cause or effect of openness.

(*b*) Slit openness: This takes the form of slits in the body of the cheese, and often occurs in cheeses which are quite free of mechanical holes. The slits, again, are of varied size and distribution. Sometimes they may be only a mere fraction of an inch in length; at other times they may be 2 in. long, or even more. They occasionally appear to follow the line of junction of the original curd-particles, but they just as frequently arise in the centre of the curd-particles. They also occur close to mechanical holes where lines of weakness exist in the cheese. These holes are quite small at first and gradually enlarge, becoming usually irregular in shape. They are not present in the cheese when it comes from the press, but develop any time afterwards between the third and possibly the twentieth day after being taken from the press. A certain amount of this type of openness has possibly been attributed to fermentation. There is no direct evidence to show that fermentation is responsible. The reason for attributing it to fermentation is possibly the fact that these slits have been found in cheese with abnormal flavours. In this connection it has to be remembered that abnormal flavours may be observed in cheeses which are perfectly close, and, conversely, no abnormal flavour may be observed in cheeses with this defect. This type of openness is possibly the most difficult to deal with, because it can appear in cheeses which are very well made.

(*c*) Fermentation openness: The openings in this case have generally a more regular outline than in the other types, varying in size from mere pin-holes to holes the size of a grape. The shape may be round or somewhat slit-like. Yeasts have often been shown to be responsible for this condition; certain types of gas-producing germs have also been found to be a cause when no starter, or an inactive starter, was used in making the cheese. This type of openness has not been experienced in our experimental work, and there is no evidence to show that it is of widespread occurrence. It must, however, not be overlooked.

(*d*) Openings arising after cheese is cut: It occasionally happens that after a cheese-surface has been exposed for some time large openings will appear throughout the body of the cheese. This may happen to a cheese which at the time of cutting is perfectly close in texture. This condition is most disconcerting to the grocer, because its appearance is unattractive to the consumer and the cheese dries up quickly. Cheeses which are affected with slit openness are particularly liable to this fault.

Looseness: Closely akin to these distinct types of opening is the conditions of cheese known as "looseness." In this case fractures can be observed in the body of the cheese without any cavities being present. Slit openness often follows upon looseness.

Probable Causes of Openness.—At the outset of experimental work on the problem these distinct types of openness were not generally recognized, and therefore in the course of mapping out a scheme of work general impressions of any conditions that would possibly cause fractures in the cheese had to be used as a guide. The probable causes were grouped into four main classes:—

(1) Possible chemical and bacteriological peculiarities of the milk:
(2) Details in manufacture:
(3) Methods of pressing cheese:
(4) Methods of curing cheese.

In view of the impossibility of analysing all of the groups and their many complexities simultaneously, there had to be sought some outstanding difference between methods of manufacturing cheddar cheese in New Zealand on the one hand, and Canada and Britain on the other, since it is reported that Canadian and British cheeses are not so subject to openness as is the New Zealand product. The outstanding difference is that 90 per cent. of the Dominion product is made from pasteurized milk, while Canadian and Home cheese are made from raw milk. Since any manufacturing studies would need to be carried out with pasteurized milk to be in keeping with factory practice, it was decided to study closely the effects which pasteurization of milk has upon cheese-texture. In conjunction with this work it was decided to make a survey of the chemical and bacteriological condition of milk supplied to factories in the Manawatu district, so that a comparison could be made between factories badly affected with the trouble and those more fortunate.

Experiments on the Effect of Pasteurization of Milk on Cheese-texture.—The first series of experiments was carried out with whole milk supplied by the Massey Agricultural College herd during the period January–April, 1929. As explained in detail in the report of this Institute for the year ending 31st March, 1929, the mixed milk was divided into three equal portions daily. One cheese was made from raw milk, a second from milk pasteurized by the flash method at temperatures varying throughout the period from 145° F. to 175° F., and a third was made from milk pasteurized by the holding method at temperatures varying from 140° F. to 150° F. Careful control of the purity of the raw milk was exercised throughout the period, and it was submitted to regular bacteriological and chemical analysis. Analyses were also made of the cheese at regular intervals. All of these analyses were compared with those of mixed milks supplied to factories in the neighbourhood. The cheeses were examined at definite ages till they were ready for sale. The following results were obtained from these experiments in this preliminary investigation.

(1) Effect on texture: Pasteurization of milk had no influence upon the production of mechanical holes. These were experienced from time to time, but no great trouble was noticed at any one time, and it appeared as frequently in raw-milk cheese as in the pasteurized article. There was no apparent difference in slit openness. Even when the curds at the time of going to press were distinctly brittle and shotty, openness did not necessarily result. Fat-particles were noticed frequently in the raw-milk cheeses, especially in cases where the test of milk was high. These did not appear in the pasteurized-milk cheese. This fits in with accepted scientific ideas on the effect of heat on the dispersion of fat in milk: the clusters of fat-globules are broken up by heating, especially when accompanied by agitation, and are more evenly distributed throughout the cheese. There are always to be observed, floating on the whey of raw-milk-cheese vats, large blobs of butterfat which are never common on the whey from pasteurized milk.

(2) Flavour: Even when using very pure milk produced under the best sanitary conditions it was found that the flavour of cheese made from milk pasteurized at temperatures not exceeding 160° F. was superior to cheese made from raw milk. This superiority became more evident as the cheese matured: the pasteurized-milk cheeses held their flavour very much better. This evidence is in accord with results obtained by research workers elsewhere. When high pasteurizing temperatures were employed, however, a distinct influence upon flavour was noted. It was apparent that these cheeses did not mature in the ordinary way, and at four months old they had a bitter taste. This was especially so with the cheese used from milk pasteurized by the holding method.

(3) Yields: Pasteurization increased the yield of cheese per pound of fat and pound of milk. The holding method of pasteurization had more noticeable effect in this direction than the flash.

(4) Maturity: No distinct influence upon maturity was observed in the grading so long as low temperature of pasteurization (160° F. or below by the flash method) was adopted. At high temperatures normal ripening was interfered with.

(5) Behaviour of cut surfaces on exposure: No reliable information on this was collected, because of difficulties in examining the cheese after sale. A few cheeses, however, made from both raw milk and pasteurized milk, examined at four months old, opened on exposure, while two lots held till twelve months old did not open appreciably even after four months' exposure under ordinary atmospheric conditions.

These results were not accepted as final, for several reasons: (*a*) No bad openness was experienced in any of the makes; (*b*) there was no evidence to show that results obtained with milk derived from the one herd were applicable to milk produced in other districts; (*c*) there had not been adequate facilities for close examination of the cut surfaces of the mature cheese after they had been exposed for some time; and (*d*) the number of cheeses made was not considered large enough to warrant the formulation of definite conclusions.

During the past dairying season slit openness with occasional mechanical openness occurred in cheese made from College milk. Milk obtained from factories in the Manawatu district was also made into cheese in the College factory, and evidence was collected as to how this cheese compared with cheese made from College milk. In the past season, also, an improvement in the method of examination of the experimental cheese was developed. Photographs have been taken of the cut surfaces of the cheese when four months old, immediately after cutting, and again a few days later, the cut surfaces being exposed to the air in the interval. This has yielded some additional information on the relation of the cheese make to drying out after cutting under conditions which simulate those obtaining in the grocer's shop. Permanent records have thus been made available which will facilitate the final evaluation of the results. In these circumstances it was decided to extend the last year's work on pasteurization. Cheese was made from portions of the same milk in the raw state and after flash pasteurization to 160° F. and 175° F., both whole milk and standardized milk being employed. This procedure was followed in the College factory with milk obtained from two sources—(*a*) Massey Agricultural College herd; (*b*) a supplier of very good milk to a factory producing open cheese. These cheeses were made during the months of March and April and when they have been finally examined the results will be incorporated with those of last year's experiments. In addition, arrangements were made to have the experiments repeated during the late autumn in the Waikato district in one of the New Zealand co-operative dairy factories under the direction of Mr. W. H. Udy.

Relation of the Milk-supply to Mechanical and Slit Openness.—(*a*) Chemical composition of the milk: No constantly recurring difference in the amounts of various constituents in the milk supplied in the Manawatu district was revealed in analyses carried out by Dr. F. H. McDowall, between factories affected with openness and those free from the trouble. It is interesting to note, however, that New Zealand milk shows a distinct difference from that of other countries in possessing a lower ratio of casein to albumen. It is quite conceivable, also, that differences may occur in the nature rather than in the amount of the constituents. Any attempt to define such a qualitative difference would mean

an involved piece of work, and before embarking on such an investigation it seemed desirable to investigate in the College factory whether the ordinary factory milk-supplies from different localities, made into cheese under the same conditions, did actually give different results. It was found that cheese made from milk from all districts investigated developed slit openness. With regard to mechanical openness, on the other hand, the results were not conclusive. More difficulty was experienced in making cheese free from mechanical holes from the milk from certain districts. Definite results were upset by the difficulty of procuring milk of the same bacterial flora and numbers from day to day. There were indications in some experiments that the development of mechanical holes has a relation to the sanitary quality of the milk; but this does not preclude the possibility of chemical peculiarities also exerting an influence. Definite conclusions on the points can only be formed after further experiment.

(*b*) Bacterial content of the milk: As pointed out in the last annual report, no outstanding difference was revealed by Mr. H. R. Whitehead between factories little affected and badly affected with openness, in the bacteriological analyses of their raw milk and pasteurized milk. The milk-supplies in general were found to be unsatisfactory to enable the cheesemaker to exercise reasonable control over the process of manufacture. This state of affairs calls for national farm inspection, milk-grading as soon as it can be introduced, the proper care of milk on the farm, the careful cleaning and sterilization of milking-machines and milk-cans, and the cessation of the pernicious practice of carting whey back to farms where there are not adequate facilities for the sterilization of the cans used for this purpose.

In order to establish the effect on cheese-texture of certain gas-producing germs, commonly found in milk, Mr. H. R. Whitehead carried out a series of experiments in which these organisms were added to the milk just previous to the manufacture of cheese. The detailed experiments will be published at an early date. The principal finding from the point of view of the problem in hand was that so long as an active starter was used they did not exercise any influence upon texture, but they produced very offensive flavours in the mature product. The effect which these organisms have upon sustained action on the milk previous to pasteurization remains to be investigated. The necessity of precluding all bacterial contamination has led to studies concerning methods of pure-milk production under New Zealand conditions. This is being studied closely by Mr. H. R. Whitehead, and is reported upon under the heading "Pure-milk Production." In the course of experimental work with very pure milk, it has become apparent that such milk requires a much longer "ripening" period than ordinary milk supplied to dairy factories and that the curd will not carry so much acid at salting. Further careful study is required in regard to the handling of very pure milk in its relation to what is popularly known as "desirable cheddar-cheese flavour."

(*c*) Slow milk and mechanical openness: It sometimes happens that the cheesemaking process is slowed up in one way or another either while the curd is in the whey or subsequent to drying. This abnormality has been attributed to contaminated milk and to impurity or lack of vitality of the starter, but definite evidence of any active cause in the milk itself has not yet, in any instance, been adduced. No one has been able to reproduce the non-acid condition in a cheese-vat by addition of supposedly causative germs to normal milk. There is, however, some evidence that certain germs growing for some time in a starter culture will reduce its vitality. Even pure starter cultures are known to lose their vitality for some unknown reason. In any case, an apparent non-acid condition does occur with milk of good sanitary quality as well as with milk of poor sanitary quality, so that it seems almost certain that the starter is responsible in some instances. Moreover, our experiments show that abnormal slowing-up on the cheesemaking process is conducive to mechanical holes in the cheese even though manufacture is prolonged to give the curd every chance of developing as much acid as possible before salting. Sometimes there may be an apparent slowing-up in acid-production between milling and salting, and even an apparent reduction in the amount of acid may occur. This has been experienced in our experimental makes, especially in slow vats. It is often associated with high fat content of any whey pressed out, and, since fat has no acidity, the acidity of the normal volume of whey used in testing is reduced. At this stage of manufacture the hot-iron test of a portion of curd taken from the centre of the mass is a better test. The feel of the curd to an experienced maker is even more reliable.

The Effect of Details in Manufacture on Slit and Mechanical Openness.—The art of cheddar-cheese manufacture lies in keeping acid-development and moisture-expulsion working in harmony, so that at the time of salting, the curd is well broken down, resilient to the feel, and free of excess moisture. This is effected in practice by adjusting from time to time, as the curd requires, the amounts of starter and rennet, ripening-period, cooking-temperature, and acidity at various stages in the process of manufacture. When salt is added to the curd, moisture is expelled and bacterial activity restrained, the effect upon each depending upon the amount of salt used. Acid-development is dependent on bacterial activity, which in turn depends upon the vitality of the acid-producing germs supplied largely by the starter, and upon the moisture content of the curd. This action continues after the salt is added, and it exercises a great influence on the quality of the cheese. Moisture is partly expelled by heat, and partly by acid-development. For these reasons, if a slow-working curd and a fast-working curd are salted at the same acidity and the same rate of salting, the texture, body, and flavour of the resulting cheeses are quite different. The chemical condition of the curd at the time of salting would appear to be the principal factor influencing the cheese later on. This is determined by the conditions referred to above. If the cheesemaker had an exact knowledge of the chemical state of his milk and curd at three critical stages—namely, setting, running the whey, and salting of the curd—he would be in a better position to control his manufacture. Unfortunately, this information is not yet available; indeed, there is not even a simple moisture test for curd that can be performed in a few minutes. Thus the cheesemaker has very largely to rely upon judgment, though he has some assistance from the acidity of the curd and the hot-iron test, if he is accustomed to the use of the latter. Experiments are in

progress with the object of obtaining a rapid method of estimating moisture at each stage of manufacture which can be related to acid-development. It is obvious that the flavour, body, and texture of cheese are dependent upon the moisture, acidity, and rate of acid-development at the time of salting the curd. It is possible to produce curds by differences in the process of manufacture that will have at the time of salting (*a*) differences in moisture and acidity; (*b*) the same moisture and acidity. These conditions have been studied in various ways.

Effect of moisture content of curd at pressing: As the result of experiments carried out in 1929–30 and again in 1930–31, it has been shown that cheeses made from very moist curd tend to develop more slit openness than cheeses made from curd of normal moisture and acidity at salting. They also deteriorate more in flavour. On the other hand, excessive dryness of curd, even when accompanied by fullness of acidity, does not prevent slits from arising. The cheese resulting from excessively dry curd, too, is very mealy and brittle, and takes longer to mature. If the same moisture and acidity at salting are developed by different methods of manufacture there is little difference in the texture of the resulting cheese, providing that the rate of acid-development in both cases is the same. The indications from these experiments, then, are that the incorporation of excessive moisture in cheese tends to increase slit openness. Lack of sufficient moisture would appear to be equally undesirable. Experimental records show no distinct relation between moisture content and mechanical openness. The number of cheeses made containing excessive moisture is, however, too small to state that excessive moisture may not have a bearing. There does seem, however, to be a distinct relation between the rate of acid-development and mechanical openness. Cheeses which have been made from slow-working vats are more subject to mechanical openness than normal or even relatively fast-working curds. It sometimes happens that a curd may appear to work normally, and the cheese on being graded at fourteen days old will be sweet. Such curds tend to show mechanical openness. It is a matter of doubt whether excessively slow development of acid will ever lead to close cheese, no matter how much time is devoted to the making process.

Effect of amount of salt added to curd: The effect of adding various amounts of salt to normal and soft curds has been carefully examined. Two series of cheeses have been made—one of which has been examined—and the following tentative conclusions can be drawn from the trial:—

(*a*) A moderate amount of salt, in the vicinity of 2 to 2¼ per cent. of the weight of the curd, produces the best type of body in the resulting cheese when the curd is normal.

(*b*) Increase in the rate of salting to 4¼ per cent. produces a very hard body, which does not break down properly, and gives the cheese a distinctly dry, crumbly body. It grades sweet when examined at fourteen days.

(*c*) The higher rate of salting tends to reduce slit openness, but this advantage is entirely offset by its bad effect on body.

(*d*) Increase in the rate of salting of soft-bodied curds firms these up and reduces slit openness, but it also has a bad effect upon the body of the mature cheese, which is dry, hard, and crumbly.

It should also be noted that excessive salting is uneconomic, because most of the salt passes into the whey. It remains to be seen whether the second series of trials will corroborate these tentative findings. Meanwhile these point to the necessity of cooking and cheddaring curd well, so that additional salt is not necessary to adjust previous errors in manufacture. It might also be pointed out that the standard rate of salting British cheddar cheese is 2 per cent., based upon the weight of curd.

Effect of physical condition of the curd: Experiments have been carried out to determine whether it is possible to alter the condition of the curd by mechanical means at the time of milling so that it will cohere more readily in the cheese-hoop. The same curd has been milled by two types of mills, which have distinct influences upon the nature of the curd—(1) the ordinary New Zealand mill, which cuts the curd; (2) the British peg mill, which tears the curd into shreds. The peg mill produced no improvement in texture—indeed, it resulted in white specks appearing throughout the body of the cheese—and it brought about increased fat-losses; yet from appearances of the curd at the time of milling one would have concluded that the shredded curd would more easily make a close-textured cheese.

Effect of hot-water treatment: The claim of certain Americans that immersion of the curd subsequent to milling in hot water produces close texture has also been investigated. Part of the curd from the same vat has been immersed in water and in whey at temperatures of 170° F. and 140° F., and the results show that the reverse is the case. The immersion of curd in hot water produces distinct mechanical openness in the mature cheese. Immersion in whey at these temperatures induces acid-development.

Effect of clarification of milk: The effect of clarifying milk for cheesemaking has been studied. It has been shown that the clarification of milk does not make closer cheese. When graded at fourteen days, clarified-milk cheeses showed lesser tendency to open; but these favourable results did not eventuate when the cheeses were examined at maturity. It is apparent that the beneficial effects of clarification in eye-formation, reported by American workers on Gruyere cheese, do not hold good with the close texture of cheddar cheese.

Effect of method of draining curd: Two methods of freeing curd of excessive moisture subsequent to running the whey are employed. In one case the curd is well stirred in the vat and subsequently allowed to mat there after a draining-channel has been made between the layers of curd, which is then piled along the side. In the other, the curd is transferred to a cloth placed on the top of racks, which allow free moisture to escape. The former method is universally applied in New Zealand; the latter is commonly used in the manufacture of cheddar cheese in other countries. Experiments carried out during the season show that rack draining possesses no advantages. No matter how curd is drained mechanically, the drying does not exert a material influence so long as care is taken to avoid the accumulation of free moisture. The rate of acid-development within the curd-mass would appear to be far more important than the means of draining the moisture exuded from the curd.

Effect of care in applying salt: It is known that salt exercises a preponderating influence upon cheese body and texture. The effect of lack of uniformity in salting and the time elapsing between salting the curd and hooping has been carefully investigated. These trials were carried out late in the season, and the mature cheese will not be ready for examination for some time.

The effect of Pressure on Texture.—This has been studied from three aspects—(*a*) The method of packing curd in hoops; (*b*) rate of applying pressure; and (*c*) examination of the cut surfaces of several cheeses from the same vat and press.

(*a*) Method of packing curd: It has been found in a trial carried out for a week that when a cheese-hoop is packed with curd added in small quantities at a time, followed by careful ramming, the cheese does not develop slit openness to such an extent as when the curd is added in large quantities, followed by less careful ramming. There appear to be no differences in mechanical openness.

(*b*) Rate of applying pressure: No distinct difference in texture has been observed when the rapid application of pressure has been compared with more gradual application.

These two experiments have been repeated later in the season in co-operative trials arranged with Messrs. Veale and Udy. The results of the latter trials have not yet come to hand.

(*c*) Examinations of cheese from the same vat and press: An examination of the uniformity in texture of cheeses from the same vat and press has been made by studying the cut surfaces of the several cheeses made from the same vats of curd and pressed in the one press on fifty-one different days. On the average, little difference in slit openness and less in mechanical openness was observed. Of the fifty-one days' make examined, all cheeses had the same texture on forty-two days, while there were differences observed in one or more cheese on the other nine days. It appears that texture is not governed only by pressure in the cheese-hoop. Pressure will not effectively bind together curd which has a tendency to produce openness, but it apparently may modify the degree of openness.

Arrangements have been made to study this question more closely by recording pressure on individual cheese and at different points in the same cheese in different types of presses during the forthcoming season.

The relation of Curing Conditions to Texture.—The curing of cheese is recognized to be as important as its manufacture. It affects flavour, body, and texture. There is no reason for believing that it has any bearing on mechanical openness, but there are grounds for considering that it affects slit openness and opening of cheese-surfaces after cutting.

In its freshly made state cheese is tough and indigestible. As it matures, moisture is lost and complex chemical changes take place which gradually make it somewhat plastic and very digestible. Most moisture is lost in the first few days, the rate of loss thereafter gradually diminishing. Similarly, chemical changes take place most rapidly in the first few days, and, although they continue till the cheese is ripe, their rate decreases. It is important to consider both of these conditions in a study of the effect of curing on texture.

Slit openness first became acute in all experimental produce made towards the middle of the season, and the following investigations were thereafter undertaken.

(*a*) Effect of rate of evaporation of moisture: On the theory that rapid evaporation of moisture might be more instrumental in producing slits than changes in condition of the cheese brought about by chemical influence, on seven days in early December four cheeses from one vat were subjected to the following conditions: One cheese of each day's make was placed in a casein-drier and air at atmospheric temperature blown over it for four hours daily for fourteen days; a second cheese was kept in a very damp room at ordinary atmospheric temperature; a third was held in cold storage at 50°-55° F.; and the fourth was held in the normal curing-room at approximately 60° F. Contrary to expectations, the cheese exposed to the driest conditions—viz., casein-drier—proved no more open than that in the moist room. The other two cheeses were better in texture, and, though much alike, a slight advantage lay on the average with the cheese cured at low temperature. The temperature of the casein-drier and the very damp room were slightly higher than that in the normal curing-room. Repetition of this experiment on a large scale is projected. This suggests that temperature and chemical changes are more important than evaporation.

(*b*) Effect of protecting cheese surfaces: With a view to controlling the rate of loss of moisture in another way, on twenty successive days four cheeses from one vat were waxed at different ages with the object of reducing evaporation—viz. (1) After drying the surface rapidly in a casein-drier for one day; (2) at seven days old; (3) at ten days old; (4) fourteen days old. A fifth cheese from the same vat was not waxed at all. All of these cheeses have yet to be examined.

(*c*) Study of changes in the dimensions of cheese during curing: The changes that take place in the dimensions of a cheese after it is taken from the press have been examined with a view to getting some idea of the stresses involved. Both export and medium cheeses have been measured daily for the first fourteen days and thereafter monthly. It appears that changes in dimensions take place rapidly in the first three days. Thereafter they continue at a reduced rate. The vertical height of the cheese diminishes. The horizontal diameter diminishes at the top and bottom edges, but increases over the remainder of the diameter of the cheese, the greatest swelling taking place at the centre. The vertical depth at the centre becomes greater than the vertical depth at the sides. Thus there are set up strains which may tend to cause ruptures throughout the cheese.

(*d*) Effect of change in temperature: It is well known that heat causes substances to expand and cold causes them to contract. Before applying this to the problem in hand it is necessary to know how quickly heat travels in a cheese. This was investigated, with the following results: there is a comparatively slow adjustment of the temperature of the body of a cheese to the changes in surrounding-air temperature. Such a change very rapidly induces a temperature gradient within the body of the cheese, which rises to a maximum in about nine hours and then gradually diminishes. The time required for development of a uniform temperature (within 1° F.) over the whole cheese varied to some

extent with the magnitude of the actual change in outside-air temperature, and possibly with other conditions, such as air-circulation. Periods varying from fifty-five hours to ninety hours were recorded in three experiments. In a room with temperature varying in accordance with night and day temperatures the oscillations in temperature at the centre of the cheese are very slight compared with the change near the outer surface. This has yet to be correlated with changes taking place in the curd.

Normal Loss in Weight of Cheese during Curing.—Since the beginning of experimental work the practice has been adopted of weighing the curd at milling, and the cheese as they come from the press, as well as at seven days, fourteen days, and when disposed of. These weights are all available but have not yet been correlated with texture.

It is apparent from the studies that slit openness is dependent on more than the mere loss of moisture. The condition of the curd and cheese must also be considered. The bearing of the chemical composition of New Zealand milk and of the starter used, and the chemical changes occurring in the curd are being investigated. It is quite conceivable that the abnormal casein albumen ratio of New Zealand milk and the type of starter employed may be factors.

These studies are very complex and they are not far enough advanced to report upon.

Cracking of Cheese subsequent to Cutting.—This is most objectionable to the consumer. It would appear to be closely associated with maturity of cheese. Maturity is hastened by three conditions in practice—(*a*) Increase of rennet; (*b*) increased incorporation of moisture; (*c*) increased curing temperature.

Marked increase in moisture is to be avoided in export cheese for the purpose of avoiding slit openness and bad flavours. Age also increases maturity, but other factors affecting this without reducing quality should be investigated in view of the high interest charges involved in holding cheeses. New Zealand cheese generally arrives in the export market by the time it is three or four months old. It is held at ordinary temperatures in factories for fourteen to twenty-one days, and thereafter held in cold storage at approximately 50° F. Home cheese is generally held in farm curing-rooms at ordinary temperatures till it is ripe, at from three to six or even more months old. It has been observed in the course of experimental work that cheese held at 50° F. from the time it is fourteen days old opens up badly at four months old when exposed to the air after cutting, while cheese held for a year at the same temperature scarcely opens up at all. Before considering the export of New Zealand cheese at higher temperatures it is necessary to know something of the temperatures in the holds of our transport ships. This has been investigated, and is reported on under the section dealing with the transportation of cheese.

To throw definite light on the probable effects of transporting cheese at higher temperatures, or of holding cheese at higher temperatures for some time previous to export, well-made corresponding cheeses from a selected factory are being held at the College dairy factory at 50° F. and 60° F. respectively. Further information is being sought by holding cheeses in London stores at different temperatures.

The effect of adding to cheese milk a culture of an organism isolated from ripe cheese was investigated by Mr. H. R. Whitehead with the object of ascertaining whether this organism, which was observed to be very common in ripe cheese, would accelerate the rate of ripening of cheese. The results proved disappointing. There was insufficient difference between the experimental and control cheeses to give promise that any advantage would be gained by addition of the organism to cheese milk. Small differences in flavour could be detected in the early stages of curing between the experimental and control cheeses, but these disappeared by the time both lots of cheese were ripe.

The pasteurization of milk for cheesemaking has been questioned on the ground that it induces openness in cheese subsequent to cutting. Further accurate information is needed. It is known that the flavour of raw-milk cheeses deteriorates on keeping, even when made from good milk. There is no definite evidence that raw-milk cheeses from very pure milk, which would need to be used to safeguard flavour, crack less on cutting at the same age. Since no definite facts supporting the contention have yet been brought forward, and in the light of the work outlined above on slit openness, it seems probable from the examination made so far of cheeses that pasteurization has not a serious effect on the opening of cheese after exposure to air. Further research work on this point has been undertaken by this Institute.

Summary of Openness Investigations.—(1) There are three distinct types of openness—(*a*) Mechanical; (*b*) slit; (*c*) fermentation. The cracking of cheese surfaces after cutting is another modification. The causes of these three conditions may be independent of one another.

(2) No distinct correlation has been found between high numbers of germs in milk nor between the *amount* of chemical constituents and openness of any kind. The *nature* of the organisms and of the milk constituents may, however, exert an influence. It is known that New Zealand milk differs from other milk in some respects.

(3) Good pure milk gives the cheesemaker the best chance of making close cheese, though there is no guarantee that it will produce cheese free from slit openness. Farm inspection and payment for milk on the basis of purity are thus highly desirable.

(4) Impure milk certainly deteriorates flavour, and may be conducive to mechanical openness.

(5) Slow vats tend to induce mechanical openness. The cause of slow vats is not clearly known.

(6) Milk from some districts is more difficult to make into close cheese then the milk of other districts.

(7) Pasteurization of milk does not appear in preliminary investigations to be responsible for openness of any type.

(8) Soft-bodied curds (curds excessively moist) are more conducive to slit openness in cheese than well-cooked curds carrying the necessary acidity.

(9) Excessive salting injures cheese-body and delays maturity, though it tends to bring about closer texture.

(10) The careless packing of hoops favours slit openness.

(11) Pressure may be a factor in accentuating openness, but faults in ordinary methods of pressing are not the prime cause.

(12) The careful control of cheese whilst in the curing-room is important. High temperatures of curing-rooms should be avoided.

(13) The cracking of the cut surface of cheese on exposure to air depends to a certain extent on maturity.

(14) Further research is required on factors affecting the curing of cheese, methods of pressing, chemical constituents of milk and curd in relation to cheesemaking, the cause of slow vats, the influence of starters, the influence of the test of the milk, and certain modifications in manufacture.

(15) It is apparent that the cause or causes of open texture in cheese is far more complex than is commonly presumed, and that no cure is likely to be ascertained without possibly long and unrestricted effort.

Standardization of Milk for Cheesemaking.

During the past dairying season most of the experimental cheese has been made from standardized milk, in order to eliminate as far as possible differences in the cheese arising from differences in the fat-casein ratio of the milk. Much valuable information on the practice of standardizing milk has thus been obtained in the course of the year. This should be a very useful guide to cheese-factories adopting the standardization of milk, which has now become a very common practice in the North Island.

A fat-casein ratio of 0·70 was adopted for the manufacture of cheese to comply with the regulations requiring 50 per cent. fat in water-free substance. The fat in the milk was estimated in the factory by the Gerber method, and the casein was estimated by the Walker method. The accuracy of the factory testing was checked by laboratory analyses. During March and April the casein-fat ratio was reduced to 0·65 for the manufacture of a cheese containing 52 per cent. fat in the water-free solids. A detailed analysis of the figures is in course of preparation and will be published in the near future. It may be stated, however, that the Walker test has proved itself almost indispensible for a proper standardization of the milk received at the experimental factory. Although wide differences in fat content, in casein content, and the casein-fat ratio were experienced from day to day, the range of figures for fat in the water-free substance showed a maximum variation of 50 to 54·5, while 88 per cent. of the figures ranged from 51 to 53·5. The testing of the cheese was carried out for the most part in the College factory. Where analytical methods of testing cheese were used the maximum range of variation was somewhat smaller. Calculations of possible errors due to variations in the losses in manufacture, variations in quantity of salt incorporated in the cheese, errors in the Gerber fat test and the Walker casein test, and possible errors in the testing of cheese, indicate that it is not safe to aim at a figure for fat in the water-free solids too close to the standard required.

The standardization results indicate that a casein-fat ratio of 0·725 would be safe under the conditions of cheese-manufacture at the Institute. This should yield a mean result of 51·8 per cent. of fat in the water-free substance, provided that conditions of manufacture remain reasonably constant.

Through the kindness of the manager, the standardization figures of a factory near Palmerston North where the Walker test has been regularly used were examined, and were found to agree fairly closely with those at the Institute. As was to be expected in view of the greater difficulties in measuring volumes of milk and in sampling, the range of figures for fat in the water-free substance is rather large—namely, 49·5 to 55·5 per cent. The majority of the results (93 per cent. of a series of 441 figures), however, fell within the range of 50·5 to 54, the mean being 52·2.

The standardization records show further that a casein-fat ratio of 0·65 is suitable where cheese containing 52 per cent. fat in the water-free substance is desired.

The Manufacture of Standardized Cheese.

It has become apparent in the course of the past year's work that standardized cheese must be allowed to develop more acidity previous to salting than whole-milk cheese made from milk of the same fat percentage. Great attention needs to be paid to cooking temperatures.

Since standardization of milk for cheesemaking results in the reduction of cheese-output in proportion to the amount of fat and other cheese solids removed with the cream, an attempt has been made to study on a small scale (*a*) the extent of reduction in yield, (*b*) the effect on the quality of the produce, and (*c*) the possibility of adding skim-milk powder to high-testing milk in place of removing fat in order to obtain the desirable fat-casein ratio. All of the cheeses comprising this series of experiments have not yet been examined. It may be stated, however, from the examinations already made that the addition of skim-milk powder to high-testing milk produces a cheese-milk with a very firm and gritty body. It is also inferior in flavour to the corresponding whole-milk cheese. Milk standardized by the addition of liquid skim-milk produced cheese which scored slightly less in flavour, without any reduction in body and texture, than the corresponding whole-milk cheese. No comparison was made with low-testing whole milk of the same composition as the standardized high-testing milk. A detailed report of this experiment will be published when all the data has been collected.

Analysis of Standardized Cheese.

The analysis of cheese plays a most important part in fulfilling the regulations pertaining to the export and sale of standardized cheese. Dr. F. H. McDowall made a careful study of the unavoidable errors that arise in testing cheese under factory conditions, and of the extent of variation of solids in different parts of a cheese. The details of this work were published in a bulletin entitled "Standardized Cheese and Cheese-analysis." Briefly stated, the investigation showed that the theoretical error of

determining fat in the water-free substance of cheese by factory methods as compared with analytical methods is 1·5 per cent. These theoretical errors were shown to occur in practice. Variations of 1·5 per cent. in the water-free substance figures from place to place in a single cheese, and variations of 1 per cent. in the fat water-free substance in single samples drawn by an ordinary cheese-trier from different cheeses from one vat, were found. Thus in extreme cases two estimations on different samples of the same cheese from one vat could show a total divergence of 4·5 per cent. fat in the water-free substance. Whilst such extreme variations are seldom likely to occur, the analyses of duplicate cheeses made in the experimental factory during the past year confirmed those conclusions with regard to the range of possible error that may arise in practice.

Conditions affecting the Transport of Cheese.

It is generally recognized that export cheese is still in an immature state when it leaves the dairy factory and that it matures while on the way to the Home market. It is equally well known that the conditions to which cheese is exposed during curing are just as important as the actual manufacture of it. With a view to measuring the variations in temperature in the holds of ships during the voyage to England and the effects which these have upon cheese quality, the Institute conducted a series of trials during the past season. This work was made possible by the shipping companies concerned granting permission to place thermographs at various points in the hold, and to adopt other measures of recording temperature and humidity. The Institute had the enthusiastic co-operation of the New Zealand Dairy-produce Board, the Dairy Division, the Department of Scientific and Industrial Research, and the National Institute for Research in Dairying in carrying out the experiments. In spring and midsummer, several days' make of cheeses were manufactured in the experimental dairy factory from milk of known sanitary and chemical quality. Milks classed as good and bad respectively from a sanitary viewpoint were used. The cheeses were subjected to chemical and bacteriological examination fourteen days after manufacture, and they were individually graded in the ordinary way. One cheese from each vat was thereafter transferred to the factory cold stores to act as a control on those exported, and the remainder were exported. In loading the cheeses aboard ship four points in the ship's hold were selected and corresponding cheeses were stored at these points, at each of which was placed a carefully calibrated thermograph. On arrival at London the cheeses made in the spring months were graded by officers of the Dairy Division and transferred to the National Institute for Research in Dairying. Chemical and bacteriological analyses of the cheeses were made there, accompanied by grading at regular intervals till they were ripe, when they were cut and photographed. The corresponding cheeses held in the factory cold stores were subjected to similar examinations. From these two trials it is hoped to get some information on the effect of sea transport, but the information can only be used as a guide to more comprehensive research work in cheese ripening and storage, because the number of cheeses examined is too small to formulate reliable conclusions.

In a second series of experiments the effect of possible variations in temperature at different points in the hold of ships on the loss of weight of waxed and unwaxed cheese was studied along with the effect in quality. This was extended to inquire into the effect of holding cheeses in London stores at different temperatures. Batches of export cheese were stored in the holds of ships in the way described above. Observations of temperature and humidity were made daily at the different points in the holds on the voyage to England. After inspection and weighing at London, they were transferred to cold stores, to be held at definite and different temperatures till they are mature. The results of these experiments have not yet been received.

BUTTERMAKING EXPERIMENTS.

In the development of the New Zealand butter industry the practice of manufacturing butter from fresh and neutralized cream has entirely displaced the practice of other countries, of using cream that is ripened to a varying degree of acidity. Recently some factories have revived the practice of adding starter to cream in very moderate amounts with the object of improving the flavour of their butter. The evil effects of excessive acidity of cream at the time of churning on the keeping-quality of butter are well known, but there is no definite information of the minimum degree of acidity which would impart a decided full flavour to the butter without influencing its keeping-quality. During the past season the Institute has carried out a trial with this object in view. Butter has been made from lines of fresh and neutralized cream; each line has been divided into two portions, one of which has been treated in the natural way, and to the other starter has been added. One half of each day's manufacture has been exported, and is being examined on arrival in London. The corresponding half is being held for six months in cold storage in the Dominion to observe the effect of storage on keeping-quality.

In the course of the above experimental work on buttermaking it was shown that cream could be very easily contaminated subsequent to pasteurization and while passing from the coolers to the holding-vats. This was avoided by paying particular attention to the careful sterilization of the cream-pumps and cream-holding vats before using these daily.

PURE-MILK PRODUCTION PROBLEMS.

Experiments are in progress to determine the most common sources of contamination of milk in the ordinary type of New Zealand milking-shed. Special attention is being devoted to the effect of contamination from milking-machines, and to simple practical methods of keeping milking-machines clean and free from contamination. These experiments must necessarily be carried out over a long period of time, on account of uncontrollable variations that occur from day to day, and seasonal

variations in atmospheric temperature. Consequently they have not yet reached a stage to be reported on. Although it takes a long time to arrive at definite conclusions in this class of research work, this work in itself is extremely important, as no subsequent treatment of milk will restore the good lost by lack of sufficient care at the time of production.

Throughout the whole season milk delivered to the dairy factory has been carefully graded in the Bacteriological Laboratory by several methods, and much information has been collected concerning the value of these for ordinary dairy-factory use. Both the direct microscopic count (Breed method) and the reductase methylene blue test have been found to be sufficiently reliable for the grading of cheese milk to be paid for at differential rates. In the present state of development of the New Zealand dairy industry the reductase test is possibly more applicable than the direct count. The choice of one of these two tests is less important than the immediate need for the introduction of payment for cheese milk on grade. Experience with milk produced in the Massey Agricultural College milking-shed, which is no more elaborately equipped than others on well-managed farms, shows that pure milk can be produced without additional labour and expensive equipment, if proper care is taken. Examination of milks supplied to factories also shows that some farmers provide good milk, while the poor standard of others reduces the average quality of the factory supply below a satisfactory standard. A penalty imposed on the suppliers of poor-quality milk, and regular farm instructions, would considerably assist in raising the average quality of factory raw supplies.

A very interesting and important observation was made by Mr. H. R. Whitehead in regard to the carrying-out of the reductase test. He showed that exposure of the coloured samples of milk to light while the test is being carried out hastens the rate of discolorization. Accordingly, equipment provided with an inspection-glass to observe when samples are decolorized should not be used. He has also shown that, under certain conditions, organisms may not stain properly when smears of milk are prepared for examination by the direct-count method.

OTHER WORK CARRIED OUT BY THE INSTITUTE.

Further studies in progress include (*a*) the effect of certain organisms on the vitality of starter organisms; (*b*) the bio-chemical characters of pure cultures of starter organisms; (*c*) the daily variation in the fat-casein ratio of milk of the Massey Agricultural College herd; (*d*) the resistance of certain cements, coating-materials, and flooring-materials to the action of milk, buttermilk, and whey; (*e*) improved methods of daily analysis; (*f*) the collection of information regarding the disposal of dairy-factory sewage; and (*g*) changes in temperature of butter with changes in temperature of the surrounding atmosphere.

Throughout the dairying season, starter cultures were supplied to factories in all parts of the Dominion at a very moderate cost.

Samples of milk, butter, and cheese of known history were supplied to Professor Malcolm, of Otago University, for research work on the nutritive value of these products.

WORK CARRIED OUT BY THE LABORATORY OF THE TARANAKI CO-OPERATIVE DAIRY FACTORIES.

Mr. P. O. Veale, research chemist to the Taranaki Co-operative Dairy Factory, collaborated with the Institute in trials affecting the pressing of cheese and methods of packing cheese-hoops. In independent studies he compared the usefulness of the reductase test, direct count, coliform test, and fermentation test for the grading of milk for cheesemaking. He has also made, during the past season, a study of the economics of standardizing milk under ordinary factory conditions and devised a method of standardizing milk, based on the total ratios of the milk and fat test.

WORK OF THE NEW ZEALAND CO-OPERATIVE DAIRY COMPANY LABORATORY.

Mr. W. H. Udy, chemist in charge of this laboratory, has also collaborated with the Institute in trials on methods of packing cheese-hoops, and on the effect of pasteurization of milk on the texture of cheddar cheese. In independent studies he has examined the extent of losses of butterfat in buttermilk, and is making a close investigation of the unavoidable losses. He has shown that some factories are experiencing a loss of £1 per ton of butter manufactured more than other factories.

FORMATION OF A NEW ZEALAND DAIRY SCIENCE ASSOCIATION.

At the instigation of members of the staff of the Dairy Research Institute, a New Zealand Dairy Science Association was formed in August, 1929, and the first meeting of the association was held at the Massey Agricultural College. The members include all those engaged in dairy science in the Dominion, and its formation promises to bring into closer touch, with a view to assisting all branches of dairy manufactures, all those with that common interest.

PUBLICATIONS.

The following publications were issued during the year:—

"Standardized Cheese and Cheese-analysis," by Dr. F. H. McDowall.
"Metals for Dairy Machinery," by Dr. F. H. McDowall.
"Flooring-materials for Dairy Factories," by Dr. F. H. McDowall.
"Packages for Dried Skim-milk and Dried Buttermilk," by Dr. F. H. McDowall.
"Pasteurization of Milk by Electricity," by Dr. F. H. McDowall.
"Production of Graded Milk in England," by H. R. Whitehead, M.Sc.

Others are ready for publication.

Finally, I would like to place on record the hearty co-operation of, and great assistance received from, the staff of the Research Institute. Amongst these are Dr. F. H. McDowall (Research Chemist), Mr. H. R. Whitehead (Research Bacteriologist), Mr. G. M. Valentine (Dairy-factory Superintendent), Mr. Sawers (Cheesemaker), and Mr. Stevenson (Buttermaker), who, with their assistants, have spared neither time nor effort in their work which has made available the information set out above. I would also like to record my appreciation of the hearty co-operation of Messrs. P. O. Veale and W. H. Udy.

The Massey Agricultural College has at all times given the greatest assistance in carrying out the work of the Institute by providing gratis the services of some members of its staff, the use of the College dairy factory and equipment, its milking herd and shed for experimental purposes, whatever facilities that were feasible, and taking the keenest of interest in the work at all times.

I would also like to record the invaluable assistance received from the Dairy Division in the grading of the experimental produce both in New Zealand and London, and for their friendly criticism of the work at various stages. To the Dairy Board and its officers I would like to pay a personal tribute for assistance received at many times.

RESULTS OF INVESTIGATIONS WHICH HAVE AN IMMEDIATE APPLICATION IN DAIRY PRACTICE.

From the investigations conducted at the Institute during the year it is now very apparent that "slow vats" are very conducive to openness. Every attempt should be made to overcome the slow development of curd by ensuring the purity of the milk-supply, and by the use of an active and pure starter. It is possible that other and as yet undetermined factors are involved in the production of slowness in acid development.

Excessive mealiness in the body of the cheese has been traced to the use of excessive salt in the curd. Firm-bodied curds with the proper degree of acidity should invariably be aimed at, and this is secured only by the use of a moderate amount of salt. Excessive moisture in cheese-curd at salting leads to increased slit openness, and therefore should be avoided.

It has been shown that great care should be taken in packing cheese-hoops in order to minimize slit openness.

To minimize cracking subsequent to cutting cheese should be well matured before being offered for sale.

PLANT RESEARCH STATION.

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

Report of Director.

It is desired to give a general account of the work of the Station, and particularly the underlying features of the objectives of the research work it is undertaking, then to deal with some of the essential requirements for the furtherance of its work, and particularly deal with certain factors that are tending to retard seriously its usefulness.

The research work carried out has as its ultimate objective the formulation and adoption of farm practice that will tend to raising of the level of crop-production, both grass and annual farm crops, by reducing the losses that take place by inferior plants, by inferior management, and by the incidence of disease. Research leading to these ends is only of practical value provided the results can be applied, and in all the work being carried out it is this application that is foremost in one's mind. For that reason the close co-operation and mutual inter-relation of the Plant Research Station with the Fields Division is of the very greatest significance, application of results being made possible in any stage in research being developed by the Station. I want also, before dealing in general terms with some of the outstanding work of the Station, to bring before you the fact of the many-sided aspects of research in relationship to its application, and for this purpose desire to quote three examples.

It has been definitely shown by carefully conducted experiments extending over five years that 1 cwt. of super increases the yield of wheat by 5 bushels, and is highly payable. It has also been shown that by top-dressing phosphated wheat with nitrogen in the spring a further 5-bushel increase can be realized, and both these methods of increasing the wheat-yield should be adopted by every wheat-grower in New Zealand. When the farmer is told that he should adopt such practices there is nothing to prevent him following the advice. In other words, the research has led immediately to the formulation of a farm practice which is within the power of the farmer to adopt. Some years ago less than 30 per cent. of the wheat grown in New Zealand was fertilized with super. Last season over 80 per cent. was so treated, increasing the wheat-yield by something like 950,000 bushels. So far as nitrogen is concerned we are now in a definite position to say that top-dressing wheat with a nitrogenous fertilizer is payable and, on the present acreage, is capable of increasing our wheat-yield by an additional million bushels. All that the farmer has to do is to adopt the practice. A great deal of work, of course, still remains to be done in finding out the factors that will still further increase the efficiency of phosphatic and nitrogenous fertilizers for wheat, and, when discovered, the information can be passed on to farmers for adoption. This wheat work may be quoted as an example of an investigation which, when completed, or even partly completed, can be straight away put into practice by the farming community without any further direct control by the Station.

With reference to the research work that has been conducted with regard to virus disease in potatoes, it has been shown that virus diseases are the main limiting factor in potato-yield. The obvious practice of the potato-grower should be to use seed that is free from virus. To advise him to do so, however, can be of no value unless he is able to secure such material, and the only way that this can be done is for the Plant Research Station to provide the initial supplies of such material. In doing this a vast amount of preliminary research work on potato-virus disease work is necessary, leading to the station itself being able to adopt methods whereby virus-free material can be produced.

The initial research work in this case is for the purpose of furthering the actual work of the Station, and is of no immediate significance to the farmer other than that it will enable the advice to be given him, "Use virus-free seed," to be finally carried out. But here again there is an intermediate step that can, and is, being taken to provide the farmer with a means to enable him to partially, at least, put the advice, "Use virus-free seed" into operation. It has been shown by a system of testing that certain potato crops of any variety have a far higher yielding-power than others, due in large part to a lessened virus-infection. Such crops are being certified to, and in this way the farmer is able to procure seed far superior to the average, which will enable him to greatly improve his potato returns until such time as the Station is able to put under a certification scheme absolutely virus-free material. This work is rather a good example of where research leads to the formulation of a farm practice that can only be put into practical application provided the Station provides all the machinery necessary for its adoption. At the present time the advice is "Use certified potato-seed," and in order that this can be done a crop-certification scheme has been put into operation, the scheme itself entailing very considerable research and necessitating strict mycological and agronomical control.

Let me now quote a third example—namely, "dry-rot" in swedes. It has been definitely shown that this disease is seed-carried, and the reasonable advice to farmers should be "Use disease-free seed." But so far we do not know enough about the diseases concerned to determine just how disease-free seed may be secured, and a whole range of investigational work is necessary before this can be accomplished. So soon as this initial work is done methods enabling farmers to follow the advice, "Use disease-free seed," can be worked out, but until that time the research that is being carried out cannot in any way be applied to the farmer. The research work of the Station can, as exemplified by these three examples, be divided into three main groups—

(1) Where results from which can be immediately applied by the farmer himself. The wheat-manurial work is an example.
(2) Where results from which cannot be applied by the farmer himself unless the means for doing so are provided. The potato-certification work is an example.
(3) Where the results are necessary as a preliminary to putting into operation research that will lead to the formulation of a system enabling the farmer to adopt the practice. The dry-rot work is an example.

As far as the farmer is concerned, he is really interested in that which comes under the scope of Nos. (1) and (2), whereas the Station itself is more interested in that coming under No. (3), inasmuch as such work is fundamentally connected with the further development of the Station, and will provide a really scientific basis for the art of crop-production so far as New Zealand is concerned.

Grassland Research.

Perhaps the most significant scientific generalization with regard to the regular grasses and clovers that go to make up our sown grassland is that each vary amongst themselves just as widely, for instance, as one variety of wheat does from another, and in order to put grassland establishment on a proper basis it is essential that as much attention should be placed on strain in grasses and clovers as it is on live-stock that are to consume the herbage. It has been shown that with regard to our major grasses and clovers—rye, cocksfoot, white and red clover—there are strains that tend to be permanent and of high leaf-production on the one hand, and other strains that tend to be non-persistent and low in leaf-production on the other hand. It is clearly essential in a grazing country such as New Zealand that the main types of grasses and clovers used should be grazing ones, but, unfortunately, such is not by any means the case, and the main grassland work of the Station is being directed to remedy this weakness. The two underlying principles of grassland-management is that efficient animals should be provided to deal with the feed produced, and efficient plants should be used to provide such feed. Both with the plant and the animal the main objective of management is efficient feeding, and the better the animal and the plant the greater will be the returns from efficient feeding.

The enormous significance of grass and clover in the economical management of pastures is hardly yet realized, but the work on perennial rye-grass is showing this out very clearly. It has been shown that the perennial rye-grass, as used in New Zealand, consists of a number of distinct types—on the one hand, of high persistency, and admirably adapted for grazing, returning high returns for their feed expenditure, and, on the other hand, of low persistency, unsuitable for grazing, and returning low returns for their feed expenditure. The majority of the so-called perennial rye-grass sold in New Zealand represents bad strains, as has been clearly shown by the hundreds of lines that have been tested by the Station. Amongst these, however, are a number that represent true perennial, and it is obvious that such seed is what the farmer should use.

Following the work that has led to the defining of the types and the testing of them out, a system of perennial rye-grass certification has been devised whereby the true perennial rye-grass seed crops can be separated from the false perennial ones, and during the year 20,000 bushels were certified to. The definite advice to all farmers who use perennial rye-grass in their mixtures is that true perennial is far superior to the false perennial so frequently sold. However, there is not nearly enough true perennial harvested for New Zealand's requirements, and it is essential that this position should be

remedied as rapidly as possible. The system of certification that has been adopted should enable this to come about within a very few years, with immense benefit to New Zealand grassland-farming. In addition, as New Zealand is likely within a few years to be the only country producing appreciable quantities of true perennial, an extensive and lucrative export trade should be built up. It is recognized that the certification of the best crops in New Zealand is merely the first step in perennial rye-grass improvement. The next step, and one that is now well on the way, is the production of nucleus crops to later come under certification of culled true perennial rye, in which all the least valuable types have been eliminated; and behind this work again are the genetical studies that will lead to the production of actually pure strains. The first stage is the elimination of bad rye and its replacement by good rye; the next stage is the supplying of specially culled material for certification; and the final stage is the certification of genetically pure material. The method that is being adopted is somewhat dissimilar to that being carried out at many breeding-stations, the position being, to use an automobile phrase, that we have sufficiently good models to put on the market, and while this is being done the research necessary for their perfection can be carried out.

White clover has not, as yet, quite reached the same stage as rye-grass. A system of certification of white-clover crops that have been established for more than five years has been put into operation, it being viewed that such seed is more likely to be of a permanent type than seed from younger fields. Trials at the station have shown that this argument is moderately sound. It, however, has also been proved at the station that white-clover types exist in certain parts of New Zealand that are in themselves of outstanding merit, and when sown, irrespective of what white-clover seed may be in the ground, will become dominant. This is of first importance, and at the present time the various types are being defined as in the case of rye-grass, and the best crops in New Zealand are being located, so that a certification on all-fours with that of rye-grass can be put into operation. Behind this the culling method, followed by the genetical method to provide nucleus lines, as is being done with rye, is in operation.

Red clover, again, is being dealt with; but here the position is different to either rye or white clover. All New Zealand red is of the Board red, non-persistent type, and to secure good grazing reds recourse will have to be made to certain important types which it is hoped to certify to.

With regard to cocksfoot the position, again, is different from any of the others. It has been clearly shown that ordinary imported types are not to be compared with local ones, but whether or not outstanding crops can be defined, as has been the case in rye and white, has not yet been determined, largely owing to the fact that field methods for testing superiority or otherwise have not as yet been devised. The lessons from the grass and clover strain work of the station so far have been—

(1) That there are many outstanding pastures of perennial rye-grass in New Zealand the use of the seed from which would revolutionize grassland-farming in many parts of New Zealand:
(2) There are many outstanding pastures of white clover in New Zealand:
(3) The quickest way to get supplies of grazing red clovers is to make use of imported strains which are at present available:
(4) Local cocksfoot is vastly superior to imported, but whether outstanding pastures of cocksfoot exist that can be put under a certification scheme such as is being adopted for rye-grass is not known.

The Feeding of Pastures.

Much valuable work is being done on the feeding of pastures with artificial manures, and the really important result that has come out is that fertilizer response and its payableness is very frequently linked with the strain of grass or clover that is being top-dressed. Where the strain is bad, top-dressing may not be at all payable, but on the same ground where the strain is good, highly payable yields will result. This question of strain in manurial trials has necessitated the laying-down at Marton of special pastures where the strain of the grass as well as the type of fertilizer is known. In this connection of strain to manurial response the value of nitrogen where the rye present is of a perennial type has been most marked.

Sodium Chlorate.

Extensive testing of sodium chlorate has been carried out by field officers of the Fields Division, and it has been shown that spraying with this material is a practical remedy against ragwort-invasion. It will probably have a very wide significance in grassland-management, and can be viewed as one of the outstanding features of grassland-development during the year.

Crop-certification of Annual Crops.

Potatoes.—The certification work with regard to potatoes has been outstanding. Certified seed has shown a 4 tons per acre greater cropping-power than uncertified seed, due primarily to a reduction in virus infection. In the potato-work exactly the same system is being adopted as with rye-grass. Tested crops that come up to a certain standard of excellence are being certified to, and selection work and virus-disease study are being prosecuted to enable better material to be produced to later come under certification.

Cereals.—The cereal-work of the Station in so far as wheat is concerned is closely linked up with the Wheat Research Institute. The main object of cereal-certification, apart from trueness to type, should be based on the absence of seed-borne disease; but with regard to these, with the exception of smuts, just how disease-free crops can be produced is not known, and much laboratory and greenhouse controlled work is necessary before any definite leads can be given.

Hot-water treatment with regard to smuts provides a means whereby smut-free crops may be produced, but the doing of this is beyond the ordinary farmer. Thanks to the Canterbury Seed Co., smut-free-barley seed in amounts sufficient for malting requirements is now able to be provided, the work having been done in co-operation with the Station. Loose smut of wheat could also be eliminated in exactly the same way the Canterbury Seed Co. is eliminating barley-smut, and some organization is necessary whereby the necessary nucleus disease-free seed is made available so that certification of loose smut-free wheat could be carried out, particularly with Solid-straw Tuscan.

Mycology.

Many of the diseases being dealt with by the Mycological Section are of those that are conveyed in seed, and, unfortunately, with many of them it is necessary to secure absolutely disease-free seed before any success in practice can be realized. In order to secure this, much painstaking research is necessary before any application of any results obtained can be put into practice. This work, again, requires the best of controlled conditions, and additional greenhouse accommodation is urgently required. Some noteworthy work, probably leading to rapid application, has, however, been done with regard to club-root. It has been shown that, provided the land is raised to a sufficiently high pH value, crop-infection on land previously affected is rare. This indicates the great value that lime must play in the final control of the disease. Again, with certain swedes, particularly the variety known as Herning, great resistance to club-root has been demonstrated. The fact, however, that on evenly affected ground some bulbs show far greater resistance than others indicates that selection within the variety may be valuable, and this work has been arranged for.

In this review certain phases of the Station's work have been dealt with, the full details being available in the sectional reports, but there are some other matters that must be dealt with.

AGRONOMY SECTION.

The work of this Section falls into three closely associated divisions—(1) The production, by selection, of pure and superior strains of farm seeds other than herbage-plant seeds; (2) the multiplication and distribution of these and of imported seeds by the Department or in co-operation with farmers; (3) the certification of the produce of farm crops conforming to certain standards of purity and freedom from disease.

(1) *Plant Selection Work.*

Wheat.—This work is undertaken in co-operation with the Wheat Research Institute, and so that there shall be no duplication of the activities of the Wheat Geneticist it embraces nothing but the production of pure and smut-free lines of the standard commercial varieties. The following varieties are under selection: Solid-straw Tuscan, Solid-straw Velvet, Major, Pearl, Marquis, Velvet, Dreadnought, Hunters, Sensation, White-straw Tuscan.

The area occupied was about 10 acres, consisting of—

(*a*) Three hundred single-ear selections:
(*b*) Twenty-eight preliminary yield trials of selections made during 1927–28. Replicated eight times these represent 336 plots.
(*c*) Fifty-one large-yield trials of selections made in 1926–27. Replicated eight times make a total of 600 plots.
(*d*) Seed is not reserved from the yield trials (*b*) and (*c*), therefore each selection is represented by an increase plot of pure seed.

The season's results have been considerably marred by excessive cross-pollination between varieties, and greater precautions will have to be taken in future years.

Seed of the following varieties is to be distributed for increase: Velvet, Solid-straw Velvet, Dreadnought, Major.

It has been decided that in future all lines of pedigree seed shall be the produce of crops which are of 99 per cent. varietal purity, altogether free of loose and stinking smut, and removed not more than six years from the single-plant stage.

Potato.—Potato-selection has as its objective varietal purity and freedom from disease, with particular reference to virus disease.

The work commenced in 1927–28 was largely hampered by the lack of material, and of the very large number of tuber units tested out only a few remain. This, however, has given material for distribution this coming season.

About 2,000 tuber units have been under trial and sixty-two increase blocks. These are being dug, and comprise mainly those varieties not obtainable outside New Zealand. The search for virus-free tubers became so difficult that during the season 1928–29 a number of varieties were imported from Scotland and Ireland. These proved so far superior to anything obtainable in this country that further supplies have again been imported this season.

Of the material imported during 1928–29 some 450 tuber units were planted, and thirty increase blocks in 1929–30. This work is likely to render available this season and next, lines of seed potatoes superior to anything that is available at the present time. Constant rogueing for disease and efficient isolation to prevent reinfection are the main difficulties that have to be overcome.

Barley.—As a result of work commenced in 1926–27 four smut-free selections are available of each of the standard malting varieties—Plumage, Archer-Spratt, Plumage-Archer, Chevalier, Goldthorpe-Spratt—and selections are being made of "Gisborne"—altogether twenty plots of $\frac{1}{10}$ acre each. These will go on to a yield trial next season, and thereafter distributed through the Canterbury Seed Co., with whom co-operation has been arranged.

Peas.—Three hundred and twenty selections of field-peas are under observation for further selection: 260 pure lines, comprising thirty varieties, of garden-peas are now in their third year of trial. The best of these will be put under yield trials next season, and multiplied as rapidly as possible for distribution through merchants who are growing on contract for export.

Linseed selection, in co-operation with the New Zealand Cattle-cake and Oil Co., is receiving attention, and certain work with onions, in co-operation with the Marshlands Onion-growers' Association.

(2) *Multiplication and Distribution of Selected and Imported Lines of Seed.*

The stage has now been reached when it becomes necessary to organize this most important aspect of the work. Several lines were distributed last year, and further lots of wheat and potatoes will be available again this season. It is a necessary step preparatory to certification.

Several areas have been sown with Montgomery red clover, and further supplies of this and also a quantity of Kentish wild white clover are being imported for next season's sowing. These areas will be under very close observation, the produce therefrom carefully tested, and, if satisfactory, distributed for seed-production under certification.

A similar step has been taken in connection with a variety of lupins suitable for stock-feed.

(3) *Certification.*

During the past season certification has been undertaken in connection with potatoes, wheat, perennial rye-grass, white clover, and brown-top.

Potato-certification.—This is the third year of operation, and there has been an increase from 180 crops last season to 420 for this season. The necessary field inspections and sample trials have entailed a great deal of work for the officers of the Fields Division.

It is very pleasing to report that both growers and merchants show a full appreciation of the benefits to be derived from the use of certified seed. There has been, however, a weakness in connection with the grading, and, while this may not be entirely overcome, new regulations now being enforced are likely to go a long way towards easing this difficulty. Before acceptance not only is the crop inspected at various stages, but a sample of the seed planted by the grower is collected. This seed is brought to one centre and grown under a comparative-yield trial, the result being that we are now, for the first time, in a position to indicate the relative cropping-power of each line entered for certification. This is likely to be a distinct advantage to everybody concerned. It is considered that cropping-power is a far more reliable guide in determining relative values at this stage than would be a statement as to the percentage of virus disease present.

Wheat-certification.—Wheat-certification is undertaken in close co-operation with the Wheat Research Institute. Last season 12,740 bushels of seed wheat were sold to merchants. The present season has not yet closed, and figures of actual delivery are not available, but orders received amount to over 14,000 bushels, and deliveries are likely to be proportionately higher than last season.

Perennial Rye-grass Certification.—This has been confined almost entirely to Hawke's Bay and Poverty Bay districts. A total area of 2,447 acres has been inspected and passed in the field, and practically the entire area harvested for seed. With very few exceptions, all this seed has been machine-dressed and sealed as certified permanent pasture, although most of it will ultimately be passed as "mother seed."

It is unfortunate that the price of certified seed has reached such a high figure as to hinder its wider distribution to growers in the South, who will, we hope, grow large areas for seed under certification and eventually bring down the price to something more reasonable. There is, however, no doubt that the economic value of the persistent strains of rye is of great importance, and certification affords a means of controlling with a considerable degree of accuracy the distribution and production of these strains. Moreover, the prospects of an export trade are very promising, provided constant supplies of high-class seed, efficiently machine-dressed, are available for export under a carefully supervised scheme of certification.

White Clover.—The certification of old-pasture white-clover seed has been extended considerably, and a very desirable feature has been the inclusion of a fair quantity of seed from Hawke's Bay. Seed is now about to be machine-dressed, and actual returns are not available.

The standard adopted so far has been one of age, and all certified seed is the produce of pastures five years old or over. A small amount of seed was accepted last season, and under trial has given sufficiently encouraging results to warrant continuation of this standard till a better technique has been evolved by the Agrostologist.

It is obvious from the trial that some certified lines are far superior to others, and it is hoped to arrange to have these superior strains distributed as widely as possible with a view to bringing certified seed up to this standard. When this has been attained the prospects of increasing our export trade are very promising. The strains may never attain the persistency of Kentish wild white, but they will be infinitely superior to the Dutch seed imported into Britain and used by the farmers for the want of something better at a reasonable price.

Brown-top.—Very extensive areas are being harvested under certification for export. Machine-dressing has hardly commenced, and no actual figures are available, but indications are that very little uncertified seed will be exported by merchants after this season.

Our certification amounts to a statement that the seed is free from red-top, which is an undesirable species for lawns and golf-courses. As in all other seed, a purity and germination certificate accompanies each line. There is in New Zealand very little red-top, and in a few years it is hoped to have mapped out large areas from which all the brown-top seed will be accepted without the expense of field inspections.

Staff.

Mr. Claridge is devoting all his time to potato-certification and Mr. Thomson to selection work. Both officers have rendered valuable and efficient service. The Fields Division officers have carried out their certification duties in a most efficient manner, and a great deal of credit is due to them for the accuracy of the large volume of work they have undertaken.

AGROSTOLOGY.

The year has been noteworthy for the evolution and consolidation of an organization that provides for research from its inception to ultimate extension by the Fields Extension Service of the Division. Roughly speaking, such an organization provides for—

(1) Critical study of the behaviour of the individual species or strains of these as single plants and in broadcast plots in pure sowings and in combinations under a management technique designed to test production, persistency, disease-resistance, establishment, effect of competition, &c.; the evolving by breeding and selection of elite strains and testing of these by an approved technique.

(2) After preliminary trial, and where differences in form and effect are shown to exist either in the commercial lines or in specially selected or bred-up lines, to provide for the testing of those types and practices throughout the country within differing habitat conditions (soil, climate, management.)

(3) Where constancy of behaviour characterizes a type and marks it superior to ordinary strains for a specific or general purpose, to provide for the reproduction and perpetuation of that type under certification scheme.

(4) To provide for co-ordinating and linking-up of all field research work with the Fields Extension Service, so that new ideas and facts automatically are absorbed and immediately become propaganda material.

Each of the above branches requires men specially trained for the service, and the agrostological unit is at the present moment in the happy position of being reasonably well served by an enthusiastic and competent staff.

The appointment of Mr. William Davies, M.Sc., as Plant Geneticist on loan from Aberystwyth enabled the preliminary critical trial work to be well started and efficiently carried out during the past year. The introduction of certification to rye-grass, brown-top, and white clover, with the possible extension in the coming year to include cocksfoot and red clover, working in close co-ordination with the Agrostologist and the Fields Extension Service, completes an organization that bids well to revolutionize the grassland swards of New Zealand and must ultimately have a big influence on the export seed trade of this country.

The research work of this section may be divided into two main branches: (1) Intensive critical research at the central Plant Research Station, (2) field research in co-ordination with the Fields Extension Service of the Division and other specialist officers of the Plant Research Station.

(1) *Work at the Central Research Station.*

This concerns itself largely up to the present with the strain trials in relation to grasses and clovers.

Perennial Rye-grass.—(*a*) Broadcast trials: Approximately 1,000 lines of rye-grass of commercial origin have been studied under broadcast conditions and under a triple system of utilization by mowing—(1) cutting by lawn-mower once a week, (2) cutting with a motor-mower at 6 in. to 10 in. stage, (3) cutting with motor-mower at flowering-stage. Persistency and recovery under these methods of cutting were carefully noted. Steps are now being taken to study further the lines that have shown high persistency and good recovery, and from these will be worked up forthwith elite strains. These, after definite field trials, will be handed over to the Agronomist for reproduction and perpetuation under certification scheme.

(*b*) Single-plant studies: From those broadcast plots showing eye-differences single plants were taken at random, 100 plants from each line. These were planted out at 2 ft. apart each way, and were critically examined from the following points of view: (1) Growth-form, (2) recovery after cutting, (3) persistency, (4) rust-resistance. Six thousand single plants in all were so studied. At the end of the first year's trial the first culling was made, and approximately 80 per cent. of the lot were rejected as not conforming to type. The 20 per cent. selected were nearly all drawn from the Hawke's Bay, Poverty Bay, and Sandon lines. These selected plants have been lifted and replanted, and single plants from the more persistent broadcast plots make the total of single plants now under study approximately 3,000.

(*c*) Nine hundred and eight additional broadcast plots were laid down this autumn. These are being subjected to the same triple-mowing scheme as outlined above.

(*d*) Rye-grass lots from various habitats and sources: Seed of 121 lots has been collected and sown in rows. From any outstanding lots of these single-plant studies will be made prior to working up sufficient seed for broadcast trials. Turfs of 140 lots have been collected and put out in rows for trial.

(*e*) Broadcast plots, sown spring, 1928: One hundred and four lines were sown. These have been regularly cut, and virtually all South Island and imported lines have practically disappeared. Hawke's Bay and Poverty Bay lines are now recovering well, with Sandon lines doing only fair. The rye-grass-strain work of 1929 can almost be regarded as ushering in a new epoch in the rye-grass-seed trade of New Zealand. The elimination of the poor types and perpetuation of the good types will have a far-reaching effect on the swards of the Dominion.

Cocksfoot.—(*a*) Broadcast trials: One hundred and seventeen lots laid down in the spring of 1928 have been regularly mown all the year and responses of the different types noted. Akaroa cocksfoot still maintains superiority over the Danish, both in total growth and persistency under weekly cutting.

(*b*) Row trials: One hundred and fifteen lots from various habitats and sources have been sown in rows. From these will be drawn material for single-plant study.

Brown-top.—(*a*) Broadcast trials: One hundred and four lots laid down in the spring of 1928 have been regularly mown all the year. The type from the poorer and drier soil-types of Canterbury still continues to make an excellent turf, and it would appear that there is little danger of this type proving undesirable from a lawn-seed export-trade point of view. For hill-country work, however, steps should be taken through certification to ensure that this form is not sold for secondary burns of hill country. Certainly, for this purpose, it is a less desirable type than the true *Agrostis tenuis* type. One hundred and sixty-eight lines were sown out in the spring of 1929, and reported on as to type. One line contained a trace of red-top; twenty-two lines were of the distinct pseudo-brown-top type from the poorer belts of Canterbury referred to above. By means of these plot trials it is hoped in a few years to map out definitely the various brown-top type regions. This will greatly assist certification.

(*b*) Row trials: Sixty-three lines from various habitats and sources have been sown out in rows. These will provide material for single-plant type study and for systematic botanical work by the Botanist.

Yorkshire Fog.—It has long been felt that this grass has a place for the grassing of second-quality lands, and a preliminary type study is being undertaken this coming year. Ninety-three lines from various habitats and sources have been sown in rows, and these will be used as material for preliminary single-plant-study work.

White Clover.—(*a*) Broadcast trials: One hundred and four lines sown in the spring of 1928 have been regularly mown throughout the year. Owing to volunteer white clover appearing everywhere throughout this area there was little difference to note for the first year of the trial. After January of this year, however, the volunteer type, together with many poor-recovery and low-persistent lines, failed badly, and at the time of writing there are marked contrasting types showing up. A small percentage of lines—many from Hawke's Bay—are outstanding. These showed good summer production and very rapid recovery after autumn rains. It would appear we are on the verge of important disclosures in regard to white-clover types from varying sources of origin.

(*b*) Row trials: In order to control volunteer white clover in further trials of this species, the double row, 2 ft. apart, was adopted rather than the broadcast plot. To ensure further freedom from volunteer white clover, some 400 lines were sown in sterilized soil. Ultimately the double row will join up as one broadcast plot, when both crown and tiller persistency can be studied. Eight hundred commercial lines from all over New Zealand are sown out in this trial with Kentish wild white clover and imported Dutch types as opposing control.

(*c*) Row trials from various sources and habitats: One hundred and thirty-three lines additional to the above were sown out this autumn. Many of these are hand gathered and will be used for single-plant studies in comparison with commercial lots.

(*d*) Single-plant studies: Approximately 4,000 plants are out for single-plant study as to type and crown persistency. These lines were sown in boxes in sterilized soil and were transplanted into their permanent positions 2 ft. apart each way. Kentish wild white and imported Dutch white clover are again used as opposing controls.

Red Clover.—(*a*) Broadcast lots: One hundred and four lots sown in the spring of 1928 have been regularly cut. The weekly cut has eliminated virtually all the broad red and other non-persistent types, and the outstanding success of the Montgomery red-clover type in persisting under this treatment offers great hope in the possibility of ultimately working up a good persistent grazing type of red clover.

(*b*) Single-plant study: Approximately 1,000 single plants of the three main red-clover types are under trial, and some 2,000 additional plants are pricked out in boxes ready for transplanting.

(*c*) Row lots: One hundred and four lines from various habitats and sources were sown out this autumn. These will serve as additional material for single-plant study, the object of which will be to select up as rapidly as possible a uniform elite line of the Montgomery red-clover type.

Miscellaneous Species.—Two hundred and thirty broadcast plots or rows are sown out with the following species: Crested dogstail, Timothy, meadow fescue, tall fescue, Poa trivialis, Chewings fescue, Poa pratensis, Italian rye-grass, Western Wolths rye-grass, Wimmera rye-grass, Poa alpina, Poa serotina, Poa bulbosa, African veldt-grass, Phleum alpinum, Phleum Micheli, Phalaris arundinacea, Phalaris tuberosa, golden oat-grass, tall oat-grass, Aira caespitosa, Bromus inermis, prairie-grass, Plantago serpentina, Danthonia pilosa, Danthonia semiannularis, woolly finger-grass, Lotus major, Lotus hispidus, Lotus corniculatus, English trefoil, clustered clover, Trifolium cernuum, Trifolium stellatum, Egyptian clover, and alsike.

It is not hoped to do much with the foregoing species, but many of the lines are on trial on behalf of overseas research stations and farmers.

(2) *Field Research.*

The past year has been a busy one in the field and the enormous amount of work performed has been possible only through the close co-ordination and assistance of the Fields Extension Service and other specialists of the Plant Research Station.

Three thousand five hundred and ninety plots of perennial rye-grass, 216 cocksfoot, 393 white clover, 401 red clover, 200 connected with rates of seeding, and 1,220 of miscellaneous grasses and clovers are now sown down in the field outside the central research area at Palmerston North. These are sown on the main leading soil-types throughout New Zealand and extend from North Auckland to Southland. A special area at Gore, and one at Lincoln, in Canterbury, have been chosen for particular trials of rye-grass strains to study the particular behaviour of the different rye-grass types when grown in Southland and Canterbury respectively, and compare these with the same lines grown at the central research area at Palmerston North. As far as Southland is concerned, the evidence to date would indicate that the behaviour of Hawke's Bay type, for example, is identical in Southland with that in the North Island. The trials at Lincoln have not been sown sufficiently long to express an opinion.

Rates of Seeding and Establishment Trials.—One area of 200 plots has been laid down on sandy-plain country at Oroua Downs. This experiment is in conjunction with species and strain trial on the same soil-type. On any soil-type there are three outstanding questions: (1) What species or strains do best? (2) What quantity per acre of each in the mixture is required? (3) How can establishment of these species or strains best be effected, having in regard the need for the sowing of mixtures of species rather than pure sowing? The three experiments now laid down at Oroua Downs are designed to give information on these three points.

Ecological Studies under Differential Manuring.—(*a*) Nearly all species and strain trials are so designed as to permit a quadruple system of differential manuring across each series of plots, with and without lime. Each plot is divided into four sections: Section 1—No manure; or lime alone. Section 2—Super alone; or super and lime Section 3—Super and sulphate of ammonia; or super, sulphate of ammonia, and lime. Section 4—Super, sulphate of ammonia, and potash; or super, sulphate of ammonia, potash, and lime. The differential response of the species or strains in combination with the general base of other grasses and clovers is the theme for study.

(*b*) Control of the annual population in Hawke's Bay and Poverty Bay pastures: Twenty areas were laid down this autumn under differential manuring trial; fourteen in Hawke's Bay, and six in Poverty Bay. These experiments aim at stimulation of the rye-grass and white clover to the point of either preventing the establishment of the annuals or of suppressing them once establishment has been effected. The present dressing losses in seed-production would indicate that this work aims at the root of a major problem of the districts concerned.

Seed-mixtures for Co-operative Field Experiments.—Seed-mixtures have been devised and made up for regrassing, grazing, manurial, or seed-production trials at the following places: Pipiroa, Mackenzie County, Kapiro, Marton, Maruia, Pohe Island, Raupere (Hawke's Bay), Bushmere (Poverty Bay), Amberley, Irwell, Oxford, Katere, Feilding, Rongomai, and Tokaanu.

Certification Work in Grasses and Clovers.—(*a*) Field inspections of rye-grass crops in Hawke's Bay, Poverty Bay, and Sandon districts were carried out, together with technical advice and assistance in the matter of white clover, cocksfoot, red clover, and brown-top.

(*b*) Plot trials are being conducted of all certified lines of rye-grass, F/D and M/D lines being sown. Approximately 560 lines of these have been sown and are under critical study. One hundred and sixteen lines of brown-top were sown and reported on as to type.

Regrassing Experiments on Secondary-growth Country.—(*a*) The experiments on regrassing secondary-growth country have been continued and some additional 25 acres have been sown. Brown-top, crested dogstail, Lotus major, white clover, and Danthonia pilosa still show up clearly as the most suitable species for all classes of secondary-growth country.

(*b*) Hard-fern control by spraying has been continued, but the wet summer made extensive operations difficult. The originally sprayed areas (approximately 100 acres) are comparatively free of hard-fern. An additional 50 acres have been treated.

(*c*) Comparative manurial trials are being continued, and some 50 acres were dressed during the year.

Land for Central Grassland Research Work.—The small block of land (3 acres) acquired on a temporary lease was sold and we had to quit on the 14th February last, leaving much valuable work behind. By arrangement with the Massey College some 7 acres have been secured, again on a temporary and unsecured lease.

Annual Report of Field Crop Experimentalist for Year ending 31st March, 1930.

INTRODUCTION.

The programme of field experimental work is now very comprehensive and about 750 experiments of various kinds are under way in New Zealand. Although the majority of these on pastures (approximately 430) are of an observational nature, it will be seen later in the report (see Section B (4), "Observational Top-dressing of Pasture") that they are of considerable importance in advisory and demonstrational work of fields officers. Further, one of their main objects is to provide a survey of the pastures of New Zealand in the matter of response to various fertilizers. Each type of experimental work will be discussed in detail below.

RECORDS OF EXPERIMENTS.

A system of reporting and recording has been introduced and is working satisfactorily. The system enables each fields officer to keep a complete record of all work in his district, and provides for equally complete records being kept by the Crop Experimentalist at Palmerston North. The records of every experiment are reviewed from time to time and kept up to date, so that no experiment can be allowed to lapse for want of attention or interest. Transfers or resignations of officers will not interfere with the continuity of investigations, as the records will enable new officers to get full details of the previous history of each trial.

The following is a classification of experiments for purposes of this report:—

A. Research into fundamental grassland problems being carried out at—(1) Experimental Farm, Marton; (2) Farm of Instruction, Ruakura; (3) Experimental Farm, Winton; (4) Technical College, Christchurch (co-operation with).

B. Grassland investigations and demonstrations being carried out by fields officers of the Fields Division.

C. Annual crop experiments being carried out by fields officers.

DISCUSSION OF RESEARCH UNDER A.

(1) *Marton Experiment Farm.*

(*a*) *Measurement of Pasture-production throughout the Year by mowing with a Lawn-mower.*—This method is now being applied to six lines of investigation. The technique appears to be very satisfactory, with the exception of one or two minor defects which should be easily rectified. The main objective of this trial is to determine what kinds of manure, what methods, and what times of application are best suited for increasing grass-growth as much as possible during periods of low production. In other words, the object is to level the production curve as far as is possible by bringing up the low points.

(i) Trial of effect of applying super and slag in winter, spring, summer, and autumn applications respectively: This trial has been under way since August, 1928 (twenty months). The main features are: (1) That super shows a consistent superiority over slag, especially during low production periods; (2) that summer application of superphosphate has the greatest effect in increasing growth during low-production periods from February to August; (3) that fluctuation in production is enormous, ranging from about 10 lb. per acre per day to 300 lb. per acre per day of green material; (4) that the system of measurement adopted is not harming the production, but rather improving it, as any proper system of pasture management should.

(ii) Trial to determine effect of three distributed applications per annum of super + sulphate of ammonia, and super + sulphate of ammonia + potash, and to compare ammonium phosphate and Nitrophoska with the appropriate mixtures above: The trial was commenced in August, 1929. The general indications are—(1) That a 2 cwt. dressing of sulphate of ammonia applied in August increases production for a period of between two and three months; (2) that a 1 cwt. application in November increases production for about two months; (3) potash has had small but consistent effect in increasing production; (4) that the ammonium phosphate used (Leun aphos, 20 per cent. N and 20 per cent. P_2O_5) is equal to an equivalent amount of N and P_2O_5 in the mixture of super and sulphate of ammonia; (5) that Nitrophoska is not quite as effective as an equivalent amount of N, P_2O_5, and K_2O in mixture of super, sulphate of ammonia, and muriate of potash.

(iii) Trial to determine whether a heavy application of super at infrequent intervals is as effective as smaller applications at more frequent intervals: This trial was commenced in August, 1929. The treatments are arranged so as to supply 4 cwt. of super per acre per annum in the following ways: (1) 8 cwt. in two years; (2) 4 cwt. once a year; (3) 2 cwt. twice a year; (4) $1\frac{1}{3}$ cwt. three times a year; (5) initial 4 cwt. plus $1\frac{1}{3}$ cwt. three times a year. The general indications are—(1) The 8 cwt. application was slightly superior to the 4 cwt. until the middle of December; after that date its superiority became very marked and continued to be so until the present time; (2) the initial application of 4 cwt. plus $1\frac{1}{3}$ cwt. three times a year is next in order of superiority; (3) all treatments have yielded more or less into proportion to the amount of phosphate applied to date. (NOTE.—It would be inadvisable to draw conclusions from these results until after two years from the time of starting.)

(iv) Study of effect of applying sulphate of ammonia at intervals of two months on different plots: This trial was commenced in August, 1929. Two hundredweight of sulphate of ammonia per acre is used at each dressing, the ground having been treated with lime, phosphate, and potash in August. The general indications are—(1) That sulphate of ammonia applied in August continued to have effect for about two months; (2) that sulphate of ammonia applied in October and December increased production for a little more than a month in each case; (3) that summer applications "burn" badly and cause an initial falling-off in production, followed by an increase, which in turn is followed by falling-off in production relative to a "no nitrogen" plot; (4) all applications of nitrogen have increased production for a time, but the increase is followed by a depression of about 10 per cent. relative to a "no nitrogen" plot. This did not occur in trial (ii) above, where phosphate and nitrogen were applied together as super + sulphate of ammonia or as ammonium phosphate.

(v) Trial to determine the effect on production of utilizing herbage at 2 in.–3 in. stage and 4 in.–5 in. stage: Trial commenced November, 1929. The general indications are—(1) That where grass is utilized at the shorter stage its growth-production is lessened. (2) The cutting at 4 in.–5 in. stage resulted in 20 to 30 per cent. greater production than cutting at 2 in.–3 in. stage: this substantially confirms Woodman's results in England. (3) The practical significance is that in a system of rotational grazing the herbage should be left as long before grazing as is commensurate with proper utilization by the stock being used. It is quite practicable to allow pastures to grow to 4 in.–6 in. when cattle are being grazed, but a much shorter growth stage would have to be adopted when sheep are used, as they tend to foul long grass and suffer from foot troubles under wet conditions.

(vi) Trial to determine whether any loss of nitrogen occurs when sulphate of ammonia is mixed with carbonate of lime: Trial commenced in November, 1929. The investigation is important, in that continued use of sulphate of ammonia increases soil-acidity. It appears that $1\frac{1}{2}$ cwt. to 2 cwt. of carbonate of lime is required to neutralize the acidifying effect of 1 cwt. of sulphate of ammonia. If mixing of the two is safe, the mixture has a very good mechanical condition, and is easy to apply. Chemical determinations indicate practically no loss of nitrogen on mixing, providing mixture is reasonably dry. The field results to date indicate—(1) That sulphate of ammonia "burnt" clovers badly, but sulphate of ammonia + lime did not "burn" to any appreciable extent: this may be due to more friable condition of mixture and less adherence to leaves. (2) That sulphate of ammonia caused a depression in yield as result of burning, followed by an increase in production over sulphate of ammonia + lime; this was followed by a reduction in production relative to sulphate of ammonia + lime about two months after application, with a return to the same rate of production three months after application. (3) The comparison of the two methods should be better during autumn and spring, when the nitrogen effect will be more considerable.

Chemical analysis of herbage: No analyses have been made to date, on account of lack of equipment. A start is being made in April in the collection of material for chemical analysis.

Extension of work on mowing system: The method is so promising as a means of studying production at *all seasons of the year*, that it is necessary to investigate further a number of problems on which information is required. A meteorogical station should be established in conjunction with the work.

(*b*) *Sheep-grazing Trial.*—This trial was commenced in August, 1928. Eight fields, each about three-fifths of an acre, are used for measurement. Four fields are under phosphate treatment, and four are under phosphate plus nitrogen. In addition, there are two auxiliary areas on which the sheep run when there is no grazing on the plots. As far as possible, a permanent flock of sheep is run on each series of plots. This has been rendered difficult, because the stock are supplied by the owners of Marton and are taken away from time to time and supplemented by other sheep. Extra sheep are brought on to the plots when the permanent sheep cannot control the herbage. The permanent sheep have been weighed monthly since October, 1929.

A full analysis of the trial has not yet been made, but some outstanding features are as follows: (1) Full utilization of herbage has been achieved by careful attention to growth on fields and manipulation of stocks. (2) During the period September to January, inclusive, a system of about two days on and six days off each field provided the necessary rotation. (3) If growth is allowed to go for more than six days in the high-production period, there is loss through fouling by stock, and proper control cannot be effected. (4) Sheep which were kept continuously under the grazing-system from May until January, inclusive, have done exceedingly well, and increased in weight from an average of 79 lb. per head to 114 lb. per head live weight. The sheep were about nine months old when first put on plots. (5) The carrying-capacity has been greater during the second summer of the trial than during the first. This may be due in part to climatic conditions, but it is undoubtedly partly due to effect of system of management in the pastures. (6) There was practically no grazing during March, 1929. April and May gave sheep days equal to a carrying-capacity of about five sheep per acre. In June this rose to seven sheep per acre, and gradually increased to nine and eight in August and September respectively. During October, November, December, and January, twenty, twenty-three, twenty-three, and twenty-three sheep per acre were carried in the respective months.

These figures indicate the potentialities of grassland under a system of full utilization of herbage under intensive rotational grazing, and at the same time give some idea of the difficulties of adjusting the stock and hay-silage conservation factors. The trial points very strongly to the desirability of acquiring a farm on which a system of really intensive management of good pasture, with conservation of silage and hay, should be put into practice, and investigated from the economic and practicability aspects. Fat-lamb raising should be the objective. The pasture used in the trial cannot be regarded as a high-class one, and pastures with more true perennial rye-grass should do better in the autumn and winter months.

(*c*) *Trials to observe the Effect of different Forms of Nitrogen on Pasture.*—Two such trials commenced in 1928, and are being continued. Two different forms of nitrogen, three ammonium phosphates, and one Nitrophoska are under observation. The plots were botanically analysed in the spring. The chief features are: (1) There is not a big difference between different forms of nitrogen in their effect on growth. (2) Calcium cyanamide has a very undesirable effect of "yellowing" all herbage for two or three weeks after application. (3) Sulphate of ammonia causes a diminution in clover. The relationship of lime to this is being observed.

(2) *Ruakura Farm of Instruction, Auckland.*

Measurement of Pasture-production throughout the Year by Mowing with a Lawn-mower.—This trial was commenced in June, 1929, and is an extension of (1) (*a*) above. It aims at a determination of the effect of winter, spring, summer, and autumn applications of superphosphate. Applications of nitrogen in autumn and winter is also included. The responses to phosphate has been comparatively small, due probably to the fact that the whole area was dressed with 2½ cwt. of super in April, 1929. The winter application of nitrogen gave a very large increase, which continued to November, when the yield fell away to a little below that of a corresponding plot, which received no nitrogen.

(3) *Winton Experiment Farm.*

A similar trial to that at Ruakura—see (2) above—was commenced in June, 1929. The production on this area has been very slow, largely due to the fact that there is very little rye-grass in the sward. Nitrogen applied in the winter caused a big increase, which persisted until December, after which production fell slightly below that of a corresponding "no nitrogen" plot.

(4) *Christchurch Technical College.*

Co-operative trial. This is also a study of time of applying super. The field was sown in October, and the first dressing of plots took place in March. No weighings have yet been made.

DISCUSSION OF EXPERIMENTS UNDER B.

Grassland Investigation and Demonstrations being carried out by Fields Officer of the Fields Division.

(1) *Grazing Trials on Dairy-farms.*—Most of the eighty trials being conducted in the North Island were continued, and about fifteen were inaugurated in the South Island, principally in Southland. Each of these trials consists of the trial of one paddock receiving phosphate against another paddock receiving phosphate + nitrogen. Each paddock was originally half of the same field. The nitrogen has been supplied by Imperial Chemical Industries, which organization has again contributed about 70 tons of nitrogenous fertilizer for the coming season. The application of nitrogen has been confined

to winter and autumn dressings, as these gave most promise in last year's trials. A full report on these trials will be prepared during the coming winter. The winter dressing, about July in the North Island, has given varying results. These may be viewed as satisfactory in the majority of cases, especially where good rye-grass and cocksfoot are plentiful in the sward. In some cases the nitrogen-treated fields tend to dry up rather more than those without nitrogen during dry summer weather. The mowing trials at Marton confirm this, where nitrogen is applied without some phosphate at the same time. About half the trials will be continued in the coming season. It is difficult to interpret the results in terms of pounds, shillings, and pence, and it appears that this can be done only by running two similar farms under intensive rotational grazing. Both farms would have to be managed the same, mineral manures being used on one farm, and minerals + nitrogen on the other. Careful costing would be essential. The present system of trial does not give any measure of the indirect value on subsequent production of the production and feeding of grass at periods of normally low production.

(2) *Dairy-farm under Intensive System.*—A report on the intensive grass-farming of Mr. J. Ward's farm, Manawaru, was published by Mr. Woodcock in the *Journal of Agriculture* for October, 1929. The report showed the effect of properly controlled grazing in prolonging the peak of lactation. The production of butterfat reached a very satisfactory figure of 212½ lb. per acre in spite of adverse conditions during the early part of the season. A full examination will be made this winter of the difference in production between the phosphated fields and those treated with phosphate + nitrogen.

(3) *Grazing Trials to determine the Relative Merits of Hawke's Bay Perennial Rye-grass and so-called Canterbury Perennial Rye-grass in Canterbury.*—The work of the Agrostologist has demonstrated very clearly the advantages of true perennial rye-grass so far as persistence is concerned. It is of vital importance to get true perennial rye-grass sown throughout New Zealand, and in order to get some measure of its value relative to the strains normally sown in the South Island, arrangements have been made to carry out six grazing trials on various soil-types in Canterbury. The work is being done in collaboration with the Agrostologist. Two trials have already been laid down, and others will be sown in the spring. The fields will be managed under the intensive system, and records of stocking kept for several years.

(4) *Observational Top-dressing of Pasture.*—About 430 trials of this nature are under way. About 140 of these are in the North Island, and represent the trial and demonstration of the effect of manures according to district requirements. In Canterbury–Marlborough 240 trials and in Otago–Southland fifty trials are in progress. These are mainly experiments in which lime, phosphate, potash, and nitrogen are used. Most of the Canterbury series were laid down in the winter of 1928, and constitute a survey of the country to determine the chief limiting factors in pasture-production. These trials have been highly successful in indicating several important features, the chief of which are—

(*a*) Lime is of extreme importance in something like 90 per cent. of the areas under trial. There can be no doubt regarding its economic value even at the present unreasonable price on the majority of Canterbury lands. The light lands of low rainfall have responded to an unexpected extent. The efficient production of ground carbonate of lime, which would result in its being available to farmers at about 12s. per ton (as in Southland), is urgently needed in Canterbury.

(*b*) Superphosphate has given good results (except on some of the very light lands), especially on limed ground.

(*c*) Potash appears to be of little general value. In a few cases it has shown slight improvement of the pasture on limed ground. It has practically no effect on unlimed ground.

(*d*) Nitrogen is of extreme importance, and has generally improved the sole of grass where used in conjunction with lime and phosphate. Its economic value must be the object of further investigation in the near future.

The information obtained from these trials points clearly to the desirability of an experiment-plot survey of New Zealand. Experiments so far conducted outside Canterbury have demonstrated the fact that there are soils which are markedly deficient in potash, amongst other things, and it is necessary to get a manure-response map of New Zealand prepared as soon as possible. Arrangements have been made with the Director of the Fields Division for this work to be started. Unfortunately, staff-limitations prevent the scheme being fully launched at once, but a start is being made by getting about ten trials distributed over each Instructor's district. Further work in the South Island must be closely associated with the trial of manures on pastures sown with better and more perennial species than are being used at present. It is almost impossible to select a pasture which is reasonably good after its first year. This is particularly the case where so-called " perennial " rye-grass is the chief species sown.

(5) *Haying Trials.*—These are not being extended, and at present six are being carried out in the North Island, four in Canterbury, and fifty in Otago–Southland. The measurement of production in these trials occurs during the high-production period, and, as this is the time when production usually looks after itself, there seems no particular object in continuing this class of work, except where manuring is done specifically for the production of hay or silage.

DISCUSSION OF EXPERIMENTS UNDER C.

Experiments on Annual Crops being carried out by Fields Officers.

(1) *Wheat.*

(*a*) *Manuring.*—(i) A comprehensive series of manuring trials, consisting of twenty-five experiments in Canterbury and Marlborough and six in Otago, was laid down and carried to a successful conclusion. The trial of superphosphate, muriate of potash, and nitrate of soda was continued. In addition, a number of trials with 1 cwt. and 2 cwt. of super, with and without nitrate of soda, were sown. The general results are as for previous years so far as the first-mentioned manures are concerned. The

dry spring represented a condition under which nitrogen had not been tried previously. The results were quite satisfactory, and the Department is now in a position to recommend the spring application of soluble nitrogen to the wheat crops. On an average, a 5-bushel increase is to be expected from the use of 1 cwt. of nitrate of soda or sulphate of ammonia. This on top of an average 5-bushel increase from super means a 10-bushel increase over "no manure." Potash is of little use, and is likely to depress the yield. The increased rate of sowing of super to 2 cwt. per acre does not give very good promise in the main.

Propaganda: After last harvest a summary of six years' results, with recommendations to farmers, was printed, and 5,000 copies were distributed amongst wheat-growers.

(ii) Trial of five different forms of nitrogen at three different times of application: Until this year there was no information on the correct time to apply nitrogen to autumn- or winter-sown cereals. A detailed trial was made involving the use of nitrate of soda, sulphate of ammonia, urea, calcium cyanamide, and calnitro. The results indicate that nitrate of soda is the most efficient form of nitrogen, and the best time to apply is between the middle of September and the middle of October. Sulphate of ammonia was next in efficiency, but apparently should be applied about a month earlier than nitrate of soda. In view of its cheaper rate per unit of nitrogen, sulphate of ammonia is the bets form for farmers to use. This work must be continued for several years before definite conclusions can be drawn.

(*b*) *Rate of Seeding Trials.*—A knowledge of the effect of rate of seeding on yield is highly important in variety trials. Evidence obtainable indicated that a small increase in seeding in excess of the optimum for the particular season and soil would not affect the yield. If, however, the seeding happens to be a few pounds below the optimum the yields suffer. In variety trials it is necessary to eliminate such factors as rate of seeding. To test the accuracy of the evidence, two trials were laid down with two wheats differing markedly in habit of growth. The results of one trial confirms the theory on which the trials were based. With one variety 95 lb., 110 lb., and 120 lb. of seed per acre respectively did not differ in yield or size of grain produced, although all were better in yield, than a seeding of 80 lb. per acre. In the other trial the yield continued to rise with each increase in rate of seeding. Hence the optimum was not exceeded, so the working hypothesis could not be tested.

(*c*) *Variety Trials.*—Three of these were carried out in Canterbury, and indicate the necessity of the trial of varieties on different soil-types. In one trial Major was 6 bushels better than Tuscan, while on another soil-type it was several bushels poorer. A programme is arranged for the coming season in collaboration with the Wheat Research Institute.

(*d*) *Effect of Hot-water Treatment for Control of Disease on Yield* (trial conducted on behalf of Mycologist).—The trials of last season were continued, with very promising results. Three treated varieties were under test. Tuscan under hot-water treatment yielded about 4 bushels per acre better than untreated. Hunters under treatment was 2 bushels better than untreated. There was no effect with Pearl.

These trials and the rate of seeding ones were conducted at Lincoln College on paddock kindly lent by the College. The officers of the College rendered every assistance required.

(2) *Oats.*

(*a*) *Manuring.*—Three trials were conducted at the Gore Experimental Farm. The results of these were published in the *Journal of Agriculture* for January, 1930, page 45.

(*b*) *Hot-water Treatment.*—In the 1928–29 trial the treatment had no effect in yield. The 1930 trial was spoilt by a growth of weeds and was not threshed.

(3) *Barley.*

(*a*) *Manuring.*—Three manuring trials were conducted in Canterbury and Otago. The results are not yet available.

(*b*) *Hot-water Treatment.*—As for wheat. In 1928–29 the treatment had no effect, in 1929–30 the treatment gave a remarkable increase of about 7 bushels per acre. This trial was carried out on the Canterbury Seed Co.'s farm, by courtesy of Mr. Hewlett, manager of the Canterbury Seed Co.

(4) *Potatoes.*

(*a*) *Manuring.*—(i) Early potatoes, Pukekohe district (Auckland): Three experiments were conducted in early potato manuring. The salient features of the results were: (1) Potash at 2 cwt. per acre had no effect on yield when added to phosphate and nitrogen. When used at 4 cwt. per acre the yield was depressed. (2) Sulphate of ammonia gave paying results when used at 2, 4, and 6 cwt. per acre in addition to superphosphate. The greater quantity gave the best paying return. (3) Manure placed in a narrow band of about 3 in. wide along the line of the sets was significantly more effective than manure sown in a broad band about 9 in. wide. These trials are being repeated. A report on these experiments will be published in the *Journal of Agriculture* for April, 1930.

(ii) South Island experiments on main crop of potatoes: The 1928–29 experiments showed a fairly consistent response to superphosphate and also to sulphate of ammonia. As an addition to phosphate, potash had little effect, except in South Canterbury and Southland.

About 20 experiments were sown in 1929. These are not harvested yet. The indications are that phosphate + nitrogen is giving the best results. Newer fertilizers such as Ammophos and Diammonphos are under trial. The results of the experiments covering a period of three years will be summarized for publication this winter.

(*b*) *Certified* versus *Non-certified Seed Potatoes.*—Eight trials were laid down in the South Island to test the differences between a mixture of lines of certified potatoes and a mixture of lines of uncertified potatoes with each of four varieties. The work has been conducted on behalf of the Agronomist. The crops are not yet dug. The growth indicates a marked superiority of the certified lines over the uncertified.

(*c*) *Source of Origin of Seed Experiments.*—In collaboration with the Mycologist, Entomologist, and Agronomist, eight trials have been sown down with the same line of seeds. The trials are distributed over different soil and climatic types, and each year the seed will be brought to a central station to be tested against seed grown at the central station. The object of the trial is to determine what districts least favour the spread of virus disease and produce the most vigorous seed.

(*d*) *Effect of Control of Corticium-disease on Yield.*—A new line of potatoes was treated under direction of the Mycologist, and is being tested against untreated seed. The line selected was a good one except for a fairly bad Corticium infection. The crop is not yet dug.

(5) *Swede and Turnip Manuring.*

Twenty-four experiments were carried to a successful conclusion in the South Island. In Canterbury superphosphate caused its characteristic germination injury; in Southland it did not have a marked effect in this respect. Mixing equal parts of super and carbonate of lime eliminated the injury to germination, and this practice can be safely recommended to farmers. In the trial it usually gave a considerable increase in yield over super. Mixing can be done from several weeks to a day before sowing, and, providing weather conditions are suitable for growth, good germination is assured.

In 1929–30 trials, of which twenty-nine were sown, suffered badly on account of heavy rains after sowing, and a number will be useless as a result. The programme includes the trial of (1) super and super + lime in varying quantities; (2) super + a rock phosphate; (3) top-dressing with nitrogen.

(6) *Mangel-manuring.*

One experiment was conducted at Gore Experimental Farm. The effect of manures on germination as well as on yield was studied. It appears that mangel-seed is susceptible to injury, although to a lesser extent than cruciferous seeds. The same quantity of super applied in two different ways gave yields differing by $3\frac{1}{2}$ tons per acre.

(7) *Peas (Disease-control).*

One trial was sown on behalf of the Mycologist to test the effect of Ceresan on control of disease and yield. The trial is in process of being harvested.

(8) *Rape-manuring.*

Four experiments were conducted. As a result of adverse weather conditions the yield was poor. Germination of rape is affected by super but not to the same extent as turnips and swedes. Where manuring at more than 1 cwt. per acre is practised it is advantageous to use a mixture of super + lime or super + a slow acting phosphate. Nitrate of soda applied about 4–6 weeks after sowing will increase the yield by 15 cwt. to 1 ton.

Entomology.

Diamond-backed Moth (Plutella maculipennis).

A good deal of investigation has been carried out during the past year relating to this pest, and shortly it is hoped to publish a full account dealing with the moth in its various stages, its life-history and seasonal history, its habits and injury, its economic importance in New Zealand and in other parts of the world, the present biological control aspect in New Zealand, and a short annotated list of its parasites and predators occurring in other countries.

Owing to the small degree of control exercised by the parasite already here, it is proposed to introduce other parasites from abroad which in their country of origin exercise a far greater degree of control than the species we already have present. To this end £50 has been granted to the Imperial Bureau of Entomology for the collection and despatch of two specified parasites—namely, *Angitia plutellae* and *Angitia fenestralis*. The Imperial Bureau hope to commence sending shipments of these parasites during the coming spring.

Pear-midge (Perrisia pyri) *Parasite Work.*

The pear-midge parasite (*Mysocuclops marchali*) introduced from Europe for the control of the pear-midge has not come up to expectations, and it has been recommended that a further £150 be expended for the importation of further parasites of a different species.

Field-cricket (Gryllus servillei).

This insect has been the cause of occasional serious attacks on pastures on the Hauraki Plains and in parts of Northern Wairoa. During the past season, however, the crickets were not in sufficient abundance as to constitute a pest. A broad outline of their life-history has, nevertheless, been obtained. The very wet conditions during mid-season, coupled with the scarcity of the crickets, rendered it impossible to carry out the poisoning control methods as planned.

Potato-virus Diseases.

The research included—(*a*) A survey of potato crops to determine characteristic insects. This phase is now completed, and the following characteristic insects have been found: (1) *Macrosiphum gei;* (2) *Myzus persicae;* (3) *Myzus pseudosolani;* (4) *Melanophthalma gibbosa;* (5) *Thrips tabaci* (provisionally named); (6) *Erythroneura* sp. (specimens being sent to Imperial Bureau for identification); (7) *Collembola*—(*a*) Fam. *Sminthuridae,* (*b*) Fam. *Entomobryidae* (specimens in hand of Imperial Bureau for identification).

The dipteron *Lauxania bilineata* is also fairly common on the foliage. The aphid predators *Coccinella 11-punctatae* and *Melanostoma fasciatum* are present wherever the plant-lice are sufficiently abundant.

(*b*) Origin of seed trials, involving a survey of selected areas for potato-growing to determine relative abundance of characteristic insect fauna. The selected areas are situated in scattered localities in the South Island, and during the season it was necessary to visit these localities on three distinct occasions. The seed-potato trials will extend over a period of four years, and the results of the entomological survey are being forwarded to the Crop Experimentalist for proper recording along with other data.

(*c*) Under laboratory conditions rearing and determining which of the characteristic fauna is a virus vector. Everything is now in readiness for the prosecution of this work, and it will be commenced as soon as the mycologist section can supply us with the so-called virus-free potatoes. It is proposed to experiment with insects 1, 2, 3, 5, and 6, named under section (*a*).

Dry-rot in Swedes.

Laboratory experiments are in progress to determine whether the normal spread of dry-rot in a crop can be attributed to insects. Two insects are being used for this work: (1) A beetle of the family *Staphylindae.* These insects are present in comparatively large numbers on infested swedes. (2) A dipteron which breeds freely in the rotting bulbs. It is as yet too early to give any definite results.

Aphis (Brevicoryne brassicae) *on Swedes.*

Opportunity was taken during the "origin of seed trial" inspection to observe the incidence of the aphides on swede crops in the South. Distribution was general over all of the swede-growing areas. Several parasites of *Brevicoryne brassicae* and *Myzus persicae* on swedes have been found, and five or six species have been collected. Notes on the abundance of *B. brassicae* during the season have been made.

Ragwort.

The stem-boring moth *Homoeosoma farinaria* is being tested under laboratory conditions for its effect on ragwort.

MYCOLOGY.

(1) *Cereal Diseases.*

(*a*) *Smuts.*—Work during the year has been confined to bulk treatments by the hot-water process for elimination of loose and covered smuts of barley, wheat, and oats.

An investigation was carred out to determine whether loose smut was more prevalent in plants grown from apparently healthy seed taken from smutted plants than from those developed from seed taken from contiguous, non-smutted plants. Results showed no appreciable differences in percentages of infection between the two lines.

Several new seed disinfectants were tried out during the year, but none showed promise of being better than any of those in general use.

(*b*) *Wheat-scab.*—Twenty-two different seed-treatments were conducted during the year to determine whether this disease (which preliminary laboratory-work showed to be seed-carried) could be controlled. All failed owing to secondary infections occurring in the plots.

(*c*) *Stripe Disease.*—Forty-eight experiments on control of this disease were conducted on the farm. Although several of these treatments prevented seedling infection, all plots became infected subsequently from air-borne spores. Further studies in dissemination are therefore necessary before attempts at control on a field scale become possible.

(*d*) *Black End.*—Experiments to determine the cause of this condition—whether it was seed-carried—and a possible control by seed-treatment, were carried out at the farm and at Ashburton. The cause is still under investigation, pathogenicity studies being under way in the laboratory. The disease has been proved to be carried with seed; control experiments failed in that only partial success was met with, owing to only a few possible treatments being tried.

(*e*) *Take-all.*—Attempts to infect an area on the farm with the disease again failed. This is the third consecutive time that failure has resulted. Consequently a comprehensive laboratory study of the organism is considered necessary before further field-work can be undertaken.

(*f*) *Rusts.*—Preliminary field studies have been commenced with a view to determining whether any races of oats grown in the Dominion show promising indications of being resistant to physiologic forms of black-rust and crown-rust, thirty-two plots being sown on the farm. Certain of these show varying degrees of resistance, but little work can be carried out until the rusts have been studied from a physiological form viewpoint.

Summary.—The present position with regard to cereal-diseases is that smut-elimination on a field scale has proved practicable. With all other diseases under investigation, it has been found that a detailed study of each under laboratory conditions is necessary before field experiments on control can be undertaken with any degree of confidence.

Brassica Diseases.

(*a*) *Dry-rot.*—In the past four seasons seed-treatments have proved satisfactory in the laboratory, yet apparently failed when applied on a field scale. The reasons for this have been the subject of a considerable investigation during the past twelve months. It was thought that possibly the technique for testing the presence of the dry-rot organism in the seed was faulty. Consequently three different tests were utilized—the standard method, which consists of sowing seeds in lots of 100 on culture media in petri dishes; the "Copenhagen" germinator method, which consists of sowing seeds in lots of 25 on sterile blotting-paper covered by glass cloches and kept moist in this germinator; sowing seeds in lots of 100, in sterilized soil, kept in sterilized tins in the glasshouse. In testing the standard method, 500,000 seeds were tested; in the soil method, 60,000 seeds were tested; and in Copenhagen germinators, 20,000 seeds were tested. All were from one line of seed, known to carry the dry-rot organism. Results showed that the standard method was much more reliable than either of the other two.

A second point under investigation was the possible spread in the fields by insects. A fields survey showed that certain insects were invariably associated with infected roots. These have been isolated and are at present being tested with a view to determining whether any insect is a carrier, and, if so, the methods by which the disease is conveyed under field conditions.

A third point under investigation was to determine the manner in which seed became infected in the field. Swede roots were grown to seed under controlled conditions (in insect-proof cages) and inoculated at various times. As a result a quantity of heavily infected seed was obtained, the method demonstrating that if the seed-pods became infected, infected seed results.

Further work on seed-disinfection on a field scale has been undertaken. A modified form of the treatment previously recommended was developed and tested by all three methods outlined above. As all tests showed the seed to be dry-rot free, 420 lb. were treated and distributed to experimental areas throughout the Dominion. As this experimental series is not yet completed, results are not available. The modified treatment used was to soak seed for twelve hours in water, followed by a dip of five minutes in 0·25 per cent. semesan at 115° F.

Attempts at producing small lines of dry-rot-free seed are being undertaken on Hautu Prison Farm, Tokaanu. Seed of a few selected commercial lines have been treated and sown on land never before in swedes and miles away from other root crops in that locality.

(*b*) *Club-root.*—An intensive series of investigations covering this disease has been carried out during the year, one officer occupying his whole time with this work. Preliminary work of a technical nature was required to work out a method for testing the presence of the disease in the soil; effects of soil conditions, temperature, moisture, spore-load, time of infection, &c. Following this the following major points were investigated:—

Firstly, the possibility of there being definite biological strains had to be determined, to know whether one type of brassica (as rape) could or could not be grown on land previously under another type of brassica (as swede). No significant results were obtained, indicating that defined biological races do not exist in the New Zealand form of this disease.

Secondly, the host-range of the organism had to be ascertained in order to determine whether brassica weeds could carry the disease over in grassland for an indefinite period. Seeds of thirty-three species of weeds were collected and sown in specially prepared boxes of sterilized soil, to which viable spores of the club-root organism had been added. Infection was obtained on nine species, only one of which, *Capsella bursa-pastoris* (shepherd's purse), had any economic significance in that it is an abundant weed in cultivated areas. This work is being repeated on a larger scale.

Thirdly, an intensive series of investigations were conducted to determine whether the disease was carried with the seed. This work has as yet been negative; but this is to be expected, since preliminary investigations showed that infections were directly correlated with spore-load—in other words, that infection could be obtained artificially only when numerous spores were present in the inoculum.

Fourthly, a series of experiments has been conducted with a view to determining whether any varieties of swedes or turnips are markedly resistant to club-root. Of all those tried, Herning swede showed distinct promise, in several of the plots remaining quite free from the disease.

Work now in hand is concerned with determining how long the organism may remain in a viable condition in the soil, and whether any manurial culture practice or rotation will affect this period.

(3) *Heart-rot of Mangolds.*

An investigation into the cause and possible control of this disease is now being conducted.

(4) *Linseed-rust.*

A small nucleus line of "J.W.S." linseed has been produced free from rust (*Melampsora Lini*). This is now available for bulking.

(5) *Sclerotial Diseases.*

One of the most serious groups of parasitic fungi are those sclerotial diseases attacking tomatoes, lupins, potatoes, sunflowers, vegetables, flowers, artichokes, &c. Consequently, one of the major investigations now being undertaken covers these organisms.

(6) *Collar-rot of Peas.*

An intensive series of seed-disinfectant experiments has been undertaken wth a view to combating this serious disease, but with different results. It has been found that experiments in control along these lines have been deleteriously affected by secondary infections coming from outside sources. Consequently, until this disease has been more fully studied under laboratory conditions, control experiments have been discontinued.

(7) *Potato-disease.*

(*a*) *Virus Diseases.*—These, the most important diseases of potatoes in the Dominion, have been made the subject of a special investigation. Disease surveys of the potato areas have been made, to determine the extent of virus infection, and ascertain, if possible, areas free from this group of disease. Of all areas examined, Pukekohe alone shows comparative freedom from virus diseases. All types of virus have been studied in the field, and collections of typical material made. These have been planted at the farm, and have been under constant observation, with the result that we are now familiar with the field symptoms. Incidentally, all other diseases of the potato have been collected and are being studied on similar lines. Studies on pathogenicity are being conducted in the laboratory and glasshouse to determine certain points of the life-history, &c., with a view to working out methods of control. Commercial virus-free potatoes have been imported from Scotland, England, Ireland, and Canada, and grown under controlled conditions. Some of this material, especially Scottish seed, shows marked superiority to any lines grown commercially in New Zealand. Nucleus lines of completely virus-free tubers have been obtained from the Cambridge Virus Research Station during the past two years. Part of this material is being used in experimental work; the remainder is being bulked under controlled conditions for ultimate distribution. In this way it is hoped gradually to eliminate virus diseases from the potato crops of the Dominion.

(*b*) *Corticium-disease.*—Experiments on control of this disease have now reached a stage where we can obtain clean lines of seed. In the field, however, other factors, as soil-contamination, have made it difficult to apply this treatment on a commercial scale. It is believed that, in conjunction with the certification system now in use, more use will be made of this method for ridding crops of this disease. One point affecting the use of this treatment by the farmer was the possibility of damaging seed and thus reducing the yield. Experiments have shown that this is governed by time of treatment, for if tubers are treated some time prior to planting no damage results.

(*c*) *Black-leg, Mattery-eye, and Wilt.*—Potato-disease surveys during the past three years have shown that considerable losses are experienced through a group of diseases commonly termed "wilts." Consequently, investigations covering these diseases are being conducted this season. For this purpose material has been collected and grown on the farm. Incidentally one disease previously unrecorded has been collected by Mr. Chamberlain, who records it as being prevalent in Pukekohe district. This is black-rot disease, due to the fungus *Colletotrichum atramentarium*, recorded abroad as being the cause of a stem-wilt.

(8) *Lucerne Nodule Organism.*

Inoculation of lucerne with the nitrogen-forming organism has proved such a success that during the season material sufficient to inoculate 18,000 lb. of lucerne-seed has been sent out of the laboratory. Studies were made of different manurial practices as they affected the organism, and in these it was found that superphosphate exercised a detrimental effect, whereas basic superphosphate or basic slag were without harm.

In April the Mycologist left New Zealand for an extended tour through Canada, United States of America, Britain, and eight countries of the Continent of Europe. Studies of laboratory and glasshouse construction, laboratory technique, technique of seed-production, and the like, were made during this tour. On his return, in January, the laboratory has been undergoing a reorganization, modern methods being introduced wherever required. During his absence the laboratory work was carried on by Mr. J. C. Neill.

WHEAT RESEARCH INSTITUTE.

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

Director's Report.

The Institute was founded in February, 1928. It is financed by farmers, millers, and bakers, each of these paying 1½d. per ton of wheat or flour sold or bought. The levy is subsidized £1 for £1 by the Department of Scientific and Industrial Research.

The Institute attempts to improve wheat, flour, and bread by research into the problems of wheat growing, milling, and baking. It has a chemical laboratory, an experimental flour-mill, and bakeroom in Christchurch in close association with Canterbury College, and a Plant-breeding Station on ground and in buildings supplied by Lincoln College.

The activities of the Institute for the year were as follows:—

(1) *Wheat-breeding.*—(*a*) Variety trials were conducted at Lincoln, and at four other stations in Canterbury in conjunction with the Department of Agriculture. These were yield trials, with numerous replications of the plots to obtain reliable averages. In addition to them, the Department sowed in six localities single plots of several high-quality introduced wheats, to find what localities could grow these most successfully.

(*b*) In conjunction with the Department of Agriculture, the Institute carried on the work of maintaining pure seed wheat, and certified crops as fit for seed. About 15,000 bushels of such seed were bought through the Institute and distributed by merchants last season.

(*c*) Since the present New Zealand wheats have been introduced from foreign countries, and since good results have been achieved even by haphazard methods, it is thought that systematic introduction and trials may possibly disclose wheats still more valuable than those we now possess. Half-bushel lots of the best wheats from all countries whose conditions are similar to ours are therefore being imported for systematic trial.

(*d*) Cross-breeding is, however, the surest, though not the quickest, means of improving wheats, and a very large cross-breeding programme is in operation. Eleven hundred different kinds of wheats were grown last year, and studied during growth to see what characters possessed by any of them might make them suitable for crossing with our standard varieties. All varieties used or likely to be used for crossing are bred in pure lines, so as to secure reliable parents. Crosses are produced from few parents but in large numbers (1,228 F_1 grains in 1930), so as to increase the chances of finding favourable combinations. The crosses made in previous years were tried by the rod-row method in ten replicates. A chess-board with eight replicates was used for ten varieties, and an elaborate spacing trial was sown. In all, 4,992 plots were sown and harvested, 4,590 of these being hand sown. The area covered was 25 acres, most of this being trials of varieties of older crosses, tested by the half-drill-strip method. The further trials of an old cross, Hunters × Tuscan, were disappointing, for, although the quality was high, the yield was not equal to that of either of the parents. Of 176 families at the F_6 stage none proved a better yielder than our New Zealand standard varieties, and these failures have forced on us the procedure of more carefully analysing the yield of parents, and of attempting improvement by importation to fill up the time until useful crosses are available.

(2) *Chemical Tests of Wheat.*—At harvest-time samples of wheat of all varieties and from all localities were collected, and protein determinations were made, in the attempt to find if there were any localities that consistently gave high or low protein contents. It was hoped that 1,000 samples would be tested, but not more than 500 came to hand, and no conclusions could be drawn from the scanty material available. Such indications as there were pointed in the direction of greater variations in protein content from different fields in the same district than in the average fields of different districts. For the harvest of 1930, 2,500 sample packets were sent to growers through the courtesy of the *Wheat-grower*, and it is hoped that more material will be available for this year's work.

The use of header harvesters in Canterbury this year made the water content of wheat a matter of great interest, and a moisture-testing service was started by the Institute. Some 120 samples were tested for moisture during the harvest season.

(3) *Milling and Baking Tests of Wheats.*—During harvest wheat from fields of known history was collected in 6 lb. samples. These were selected to represent all the chief varieties, the chief wheat-growing localities, the commonest manurings, and the different methods of harvesting. In this trial nineteen wheats, cut green and cut ripe, each pair off the same field, were milled and baked, and eight wheats stook and stack threshed, each pair off the same field, were also milled and baked. Sixteen different varieties grown in the same field were similarly tested, and a total of 144 different millings and bakings were made to test the effect of manuring on the baking-quality of wheat. Altogether 325 wheats were milled and baked during the year, and a considerable amount of information was obtained on the effect of manuring, locality, and harvesting methods on the different varieties of wheat. Milling and baking tests were also made on samples of millers blends submitted for criticism.

(4) *Baking of Flours.*—Arrangements are made with millers by which the flours they are producing are periodically baked under uniform conditions, and a criticism of the resultant loaf is submitted. The baking-work started in earnest on the 3rd January, 1930, and during the three months following 1,500 loaves were baked under test conditions, judged, and recorded. Tests of flours submitted by bakers are also made.

(5) *Baking Methods.*—Many hundreds of tests have been carried out to find the baking method most likely to give a satisfactory loaf with normal New Zealand flour. Variations of temperature and fermentation periods are investigated, and, in particular, the effect of adding milk and malt. Different kinds of dried milk, condensed milk, &c., have been tested to guide the producers in preparing a product likely to benefit the baker and the consumer.

(6) *Subsidiary Activities.*—(*a*) A report on the possibilities of using the header harvester was prepared and issued to members of the committee before harvest. The report showed that the weather conditions during harvest in Canterbury are at least as favourable as in several American States in which harvesters are used, and made an attempt to estimate the costs of harvesting by the new and old methods. A committee was set up to investigate the work of harvesters in New Zealand during the harvest of 1930.

(*b*) An arrangement was made by which one of the staff at Lincoln College should pay special attention to the bacteria and moulds found in bread.

(*c*) The Chemist of the Institute visited many mills and bakehouses in Wellington and Auckland, and attended the meetings of the Master Bakers' Federation in Taranaki.

(*d*) A specialist committee, consisting of all the officers of the Department of Agriculture who are working with wheat, and the heads of departments of the Institute, was set up to discuss plans of work to secure complete co-ordination of effort.

NOXIOUS-WEEDS-CONTROL RESEARCH.

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

The funds for noxious-weeds-control research are provided by annual grants of £2,000 received from the Empire Marketing Board, supplemented by a similar sum from the Department, while the investigations are facilitated by the Cawthron Institute placing at the disposal of the Committee portion of its services.

Investigations by the Director.

It was decided during the year that Dr. Miller, Director of Research, should personally investigate matters concerning the work in North America, Europe, and South America. Details in connection with his tour, which was commenced in March, 1930, have been finalized.

Scope of Researches.

The researches during the year have been confined to the control of blackberry, ragwort, gorse, and piripiri.

Blackberry.

In connection with blackberry, *Coraebus rubi* has been concentrated upon. During the year four consignments of infested rose stocks have been received from the south of France. Emergences from the 1928 consignments were secured in January. A difficulty in connection with the mating of the beetles was encountered and overcome without loss of time. The 1929 consignments were held in cool storage for varying periods, and the first three planted out in the glasshouse; the fourth consignment, which was retained under low-temperature conditions for the longest period, was planted in an outdoor insectary. Beetle emergences from all consignments were secured, and the most striking result was obtained from the fourth consignment, emergences being secured under conditions closely approximating to those obtaining in the open. It has been ascertained that, by use of the glasshouse, emergences can be secured during the winter months, and that, as the continued subjection to low-temperature conditions does not appear to affect adversely the insect, emergences can be secured under practically natural conditions during the summer. At first some oviposition was secured upon rose-plants and the eggs transferred to blackberry. This method, however, was abandoned, and successful oviposition directly upon blackberry-plants in the glasshouse was secured.

Ragwort.

Work in connection with the control of this weed has been confined to *Tyria jacobaeae*, and highly encouraging results have been obtained. The insect was found to have over-wintered quite successfully in all the parts of the Dominion to which it was sent last year. Field surveys carried out during the spring in the North Island showed that abundant larvæ were present and the insect firmly established. Consignments of pupæ were secured from Farnham Royal during the year, and to these were added those obtained in Nelson. Emergences from these pupæ have not been quite as large as was expected, owing to high degree of parasitism occurring in the English material. This year 200,000 specimens have been distributed in the ragwort-infested areas of Taranaki, Waikato, Rotorua, King-country, Westland, Otago, and Southland, so that during the year supplies have been distributed to all provinces of the Dominion in which ragwort-infested areas occur.

Gorse.

One of the major difficulties encountered last year was the sterility of *Apion ulicis*. This problem was intensively investigated this year, and a new type of cage evolved. This cage, which allows of abundant light being obtained without any detrimental rise in temperature, has proved completely successful, and two generations of New-Zealand-bred weevils have already been secured.

During the year seven consignments of *Apion* were obtained from England, and the work of securing suitable quantities of locally-bred insects for the necessary tests prior to liberation is being concentrated upon.

Piripiri.

The necessary financial arrangements were made to enable Brother Claude Joseph to complete his studies upon *Antholcus varinervis*. This worker has made a detailed investigation into the biology of this insect, and the result of his work has been forwarded to New Zealand. A consignment of this insect, which will be shipped in what has been determined as the most suitable stage of its development, is arriving early next year.

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.

During the year investigations were concentrated upon phormium-breeding and cultural work, with which was associated research into yellow-leaf disease. No further chemical investigations affecting fibre-treatment have been undertaken, but the Committee has secured the part-time services of the late Dominion Analyst, Dr. J. S. Maclaurin, who will test out a number of bleaching and softening processes now under consideration. The Committee has also during the year inspected a number of methods designed to facilitate and improve fibre-processing, the reinstatement of the flax bonus giving rise to increased activity in this direction. Active inquiries have been continued abroad into phormium-fibre utilization, in the endeavour to widen the market for the New Zealand output by ascertaining new uses for this material.

The funds for this research are derived from levies imposed on fibre exported, such amounts as are received from this source being subsidized £1 for £1 by the Department. Almost the whole of the funds in this year have been devoted to the flax-cultural work done at Massey Agricultural College.

Report of Investigations at Massey Agricultural College.

By Dr. J. S. Yeates.

Selection, Breeding, and Testing.—The total number of strains now represented as fans in the planted area on the College farm is 250. Those planted at the beginning of the work have grown well, and will be ready to cut for testing purposes in another eighteen months. The varieties added to the collection this year include some twenty from the Pukekura Park, New Plymouth. They were part of a valuable collection of fine Maori varieties planted many years ago by Mr. W. W. Smith. Other varieties were secured from Maori plantations in the Waikato district and from scattered localities. An area of 1 acre planted in fans of a single good variety, is growing satisfactorily.

Seedlings.—The first seedlings grown are now almost two years old. Growth has been excellent, and these plants are now ready to plant out finally for testing purposes. The seedlings are from pod-by-pod planting of seed from fans in our collection, so that valuable information will be obtained as to the breeding-behaviour of these strains. Already it is possible to see with certainty how some important characters are inherited. One conclusion of considerable interest is that none of the twenty strains grown in the first year breeds true. We hope to select from these seedlings true-breeding strains of good quality. The seedlings now one year old include pod-by-pod sowings of more than one hundred of our strains. These are all planted out in seedling rows. Some most interesting facts are already shown in relation to the inheritance of bronze coloration in several strains.

Hybrid Seedlings.—The plants from crosses made in 1928 are growing very well. The object of this work was to combine disease-resistance and excellent fibre qualities of one strain with heavy cropping-powers of another. Further crosses have been made this year with the same object. Success was obtained in crossing several excellent varieties with the one (Seifert's Superior) which is resistant to yellow-leaf disease. It is expected that some thousands of seedlings will result from these crosses.

Manurial Trials.—Manurial trial plots have been set out on a total area of 5 acres, in three different localities. The object of these plots is largely to see whether the loss due to yellow-leaf disease can be reduced by suitable manures.

Yellow-leaf Disease.—Much of the above work, such as crossing and manuring, is aimed at solving the yellow-leaf problem in a practical manner. In addition, several strains of flax have been selected which appear to resist the disease, and these are being tested. Mr. Meadows has been concentrating on the isolation of fungi and bacteria from diseased plants in an attempt to find the cause of the disease. A number of pure cultures have been isolated and tests are being carried out to see if any of them is responsible for the disease. A number of other branches of this work have been started, but have not yet reached a stage where any progress can be reported. This refers to the possibility of yellow-leaf being a virus disease, or a disease due to soil deficiency.

General.—Visits have been paid to the main commercial flax-plantations for the purpose of observing progress and securing photographic records. The main phormium trial area at the College has now some 2½ acres under flax. A further area of about 3 acres is to be planted out during this autumn. This clay land is, of course, far from ideal for the purpose of flax-growing. It is hoped, however, that drainage now being undertaken will improve matters.

MINERAL CONTENT OF PASTURES RESEARCH.

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

Extracts from Report presented by B. C. Aston, Director.

Pasture-analysis.

At the beginning of the working-year a scheme of work was laid down for the year which would indicate roughly the effect of seasonal changes on the composition of typical pastures. The initial demand that the sampling of the pastures was a highly important work which required just as much skill lavished on it as on the analysis having been conceded, Mr. Grimmett, who has always been utilized as the officer in charge of the country work, was charged with the duty of supervising the collection of the pasture and soil samples.

The areas set down for intensive study in the North Island were: (1) the Te Kuiti district; (2) the Rotorua district.

Various troubles in stock occurring in these districts led to their being chosen for work in this investigation, among which were—

(1) Temporary sterility;
(2) Eclampsia;
(3) Waihi disease;
(4) Bush disease or similar trouble;
(5) "Dopiness," or Mairoa malnutrition;
(6) Iodine deficiency.

Under the close supervision of the local or other veterinary officer, in all cases, except Te Kuiti, farms were selected from which during this year periodic samples could be collected. It is not anticipated that work for one year would establish seasonal differences. The seasons in the North Island are notoriously fickle, the temperature and precipitation being extremely variable for the same season in different years. It was impressed on the samplers that they should exercise the greatest care in selecting the samples, and the Department obtained two assistants who were peculiarly fitted for this work.

Soil-analyses.

In the examination of the country in the Rotorua district the greatest value has been found from a consideration of the mechanical analysis of the soil. It was found possible to classify the country more easily on the basis of soil-texture rather than on either geological or chemical considerations, and the texture which can be expressed arithmetically will be the guiding principle in determining different classes of soil with regard to its incidence to this disease. Whether this will be found equally useful with malnutrition diseases other than bush sickness remains to be determined.

The examination of soils in the Laboratory has been continued under the supervision of Mr. F. J. Brogan, M.Sc., who has for some years specialized in this class of work.

Importance of Sampling.

In the first report for the quarter ending 30th June, 1928, to the Department of Scientific and Industrial Research, and in the annual report for 1929, page 22, on the result of the scheme of research under the Empire Marketing Board's grant, the importance of the work of sampling in the field the pastures to be analysed, and the necessity that this work should be supervised by a skilled assistant, was fully stressed. That the difficulty of obtaining an accurate sample of what the animal is eating is very great in the case of sheep was recognized early in this investigation.

It is doubtful whether a system of mown plots in which all stalky matter is eliminated, and certain species (*e.g.*, the high-lime-containing white clover) are encouraged, while others of lesser lime content are discouraged, although yielding interesting results, will provide representative samples. Artificial conditions are thus introduced and an artificial sample is gathered, and it is hardly possible that such a sample will represent the average herbage that is eaten by sheep on the average hilly sheep-run. Many samples of different types of herbage, either dead or living at the time of plucking, have been separately analysed, and analyses have shown a great disparity in the phosphoric-acid content of the dead compared with that of the living leaves.

In times of scarcity the sheep will eat the dead leaves, but in times of plenty will largely reject them in favour of the closely cropped sward. Sheep, moreover, undoubtedly balance their pasture diet by browsing certain leguminous shrubs, such as gorse and broom, and other plants of shrubby growth. The best method of sampling, therefore, is that recommended by Godden, of the Rowett Institute—viz., plucking the pasture showing signs of having been bitten by the sheep, and thus probably representing, when a large sample (2 lb. green matter) is collected over a large area, the material eaten at that particular time.

It is obvious that without experiments on animals in the field results of mere analyses are unconvincing. During the year, therefore, an endeavour has been made to push the animal experimental side of the investigation. Experiments with various licks, pellets, and other substances have been instituted with both sheep and cattle. Continued great and undoubted success has attended the use of the double citrate of iron and ammonium, so that the complete control of bush sickness in cattle at an early date may be confidently anticipated. The effective use of this compound with cattle has been recognized for several years by the Department of Agriculture and the settlers, but the idea of giving an additional food element is a novel practice and takes years to establish. A pleasing development of recent growth is the endeavour to use the remedy found so successful with cattle to accomplish the continuous grazing of sheep on bush-sick lands. An experiment at Mamaku Farm with a small flock of wethers was entirely successful in bringing the sheep back to health when they had started to become bush sick on unimproved paddocks heavily top-dressed with phosphates, and they were kept in good health for a year subsequently by the use of pellets containing iron. Finally the wethers were sold fat. The difficulties in connection with the automatic administration of the extra food iron to sheep are, the writer is convinced, not insuperable, although difficulties have been encountered in the past year, and losses sustained. Such are unavoidable in any original work where it is sought to impose an entirely new treatment of stock on the farmer.

In connection with this phase of the use of iron remedies, a recent report received states that "it is interesting to note that the five lambs and six ewes mentioned as having survived the hardships necessary to induce them to take the pellets are now in splendid condition and doing exceedingly well. These lambs are the first ever reared to the hogget stage on this farm. The future prospects of rearing one's own lambs to the breeding-ewe stage—which, incidentally, is the ideal aimed at in these experiments—is indeed bright, judging from the results of these few sheep under trial only three brief months."

Te Kuiti District.

The work in this area consisted chiefly of animal experiments in the field. These experiments were under the control of Mr. C. M. Wright, Country Analyst. In January Mr. Wright was transferred to the Native Department, and this rather upset the continuity of the field-work, as the results of a number of field experiments laid down and controlled entirely by him had yet to be adequately reported upon.

The laboratory-work in this district has consisted largely in the analysis of soils and some pastures. During the last few months the taking of samples from Mairoa, which offered, for various reasons, difficulty to the samplers, has been improved greatly. Regular and good samples have now been received, and are being as quickly analysed as circumstances permit.

Mairoa "Dopiness," or Calcium Deficiency.

The investigation of any deficiency disease in domestic stock is best studied in three different directions, with the object of ascertaining how (1) the soil, (2) the pasture, (3) the animal, differ from the normal, and each of these three factors should be studied separately to determine how far each departs from the normal.

In the case of the air-borne volcanic showers of fine material which form the typical soils of the Mairoa district and many other areas an initial study of the mechanical and chemical composition of the soil brings out certain abnormalities wherein the soil differs from that of average hillside upland sheep-pastures of the North Island. These are—

(1) The very high "lime requirement" by the Hutchison McLellan method—roughly, about 10 tons per acre.
(2) The very high organic matter content—20 to 30 per cent.;
(3) Exceptionally porous nature.

The soils belong to the class called "loams," which are recognized as fertile soils; hence it is probable that normal returns may again be expected under suitable treatment. In these three particulars the Mairoa soils, and probably all similar fine-grained volcanic scils with a similar history, are an exception to the ordinary poor upland sheep-runs, and it may be in the study of these divergencies that a clue will be found for the failure of the herbage to sustain normal growth in the animals thereon depastured. That the soil exhibits, in common with other soils put to a like purpcse, similar deficiencies (*e.g.*, phosphoric acid) does not help much, seeing that similar deficiences occur on all poor hilly country where disease does not develop.

(1) There can be no doubt of the excessively high lime requirement of the soils in this district.

(2) Regarding the high organic matter content, it is difficult to assess the effect, but such soils are usually responsive to lime dressings.

(3) The porous nature of the soil making this subject to excessive leaching, is further evidence that lime is highly necessary seeing that lime is a mineral substance lost from soils in very large amounts.

In experiments at Rotorua with a very coarse pumice soil treated with superphosphate, no phosphates could be detected in the drainage effluent. Joachim ("Peradenya Drainage and Leaching Trials," *Tropical Agriculturist*, Vol. 73, No. 5, 1929, p. 271) says, "No phosphoric acid appears to be lost in the drainage-waters of Ceylon soils."

Hendrick ("An Account of the Craibstone Drain Gauges," *Trans. Highland and Agricultural Society*, Vol. 33, p. 76, 1921) states: "Yet so well is the phosphate held by the soil, that practically none of it is washed away in the drainage."

It may therefore be taken that not only is there great deficiency of lime in the Mairoa soils, but that this deficiency is progressing both at Mairoa and on other soils more recently cleared and grassed; so that the experience gained at Mairoa may be expected to occur elsewhere in course of time. It must always be remembered that the initial history of Mairoa was highly favourable to the use of that type of country for sheep, but that after some years' stocking the country did not improve as does the typical bush-sick pumice country; on the contrary, progressive deterioration set in and its utilization as sheep-country became unprofitable. Something evidently was comparatively rapidly leached out of the soil, and that this something was lime, there is much circumstantial evidence to prove. It may therefore be taken as proved that the crying need of this country in order to make the soil more normal is lime carbonate or some other form of calcium. Experiments have been on limed and plastered paddocks—*i.e.*, paddocks treated with carbonate of lime and gypsum (sulphate of lime)—upon which culled hoggets from a near-by farm, but one much more sheltered and having a better pasture, were pastured for two years. The results showed a distinct improvement in the health and development of the stock, due to the use of both limestone and gypsum. It is to be hoped that arrangements for the continuance of these experiments may be effected during the coming months.

The analysis of the pasture provides the second class of criteria which must be examined in investigating the deficiency diseases; and this is a more difficult direction to explore, owing to the fact that one is dealing entirely with living matter which is changing in chemical composition all the time with the climate and season, with the stage of growth, and with the botanical composition. Nevertheless, the analyses of the Mairoa pastures do show an abnormally low calcium content at all seasons of the year, and when these pastures are top-dressed with calcium carbonate they do, if the samples are properly taken, show an appreciable increase in calcium content. The entire absence of leguminous constituents in the untreated pastures upon which the malnutrition develops is further evidence of calcium deficiency, since legumes are the characteristic lime-winning plants in a pasture normally containing from two to three times as much calcium as the grasses contain even on unmanured land.

Finally, the composition of the animal may be studied, or, what is more to the point, the physiological symptoms. This is a very special department, and the technique is as yet poorly developed and very difficult to carry out. That this is realized by the authorities is shown by the importance attributed to the analysis of pastures. Were it possible to determine from an analysis of blood, for instance, from what particular deficiency the animal is suffering, and any reliance could be placed on the result, the lengthy and laborious gathering and analyses of the pasture-samples could be largely discontinued.

Rotorua and Adjoining Counties.

The experiments in the coarse-pumice area involved the usual treatment of animals with pellet, lick, and drench, the collection of pasture-samples, the treatment of the soil by manuring and by top-dressing with fertilizers, and the collection and analysing of drainage-water. Mr. Taylor, a skilled Country Analyst's assistant, has been stationed at Rotorua in order to further these experiments. It is satisfactory to note that no evidence can be obtained of any leaching of phosphates from the soil when they are applied as superphosphates in the area of coarse soil and heavy rainfall (60–70 in.). Mr. Taylor also supervised experiments with various chemical compounds and mixtures on the eradication of ragwort by chemical means, and these provide evidence that ragwort, which is considered locally a great danger and cumulative with bush sickness in preventing the settlement of the pumice lands, need no longer be feared.

The writer of this report has previously remarked on the fact that soils formed from volcanic air-borne showers of material when coarse in texture give rise to malnutrition or deficiency diseases in ruminants, whereas adjacent or near-by sedimentary soils, even although principally derived from similar materials as the air-borne showers, are free from such diseases. There has been the inevitable tendency to confuse similar deficiency diseases, and the hypothesis has been advanced that the Mairoa "dopiness" in sheep is the same as "bush sickness" in spite of veterinary advice to the contrary. The exact definition of these two diseases is, of course, work for an animal pathologist; but it may be remarked that a typical bush-sick animal, even at death, has healthy well-developed bones, the repository of phosphate of lime in the animal, whereas Mairoa "dopiness" animals have light bones. It does not seem possible that a bush-sick animal should be suffering from a deficiency of phosphates and lime, when, at all stages of its growth, it is able to develop such good bones as do the animals on typical bush-sick country. Further, there is the experience acquired at the Mamaku Farm, and elsewhere, of several direct experiments that top-dressing the pasture with phosphates or with lime does not eliminate the disease. At Mairoa, on the contrary, there is gradually accumulating evidence that phosphates and lime, and even lime by itself, are curative when applied to the soil. Veterinary authorities assert, moreover, that the symptoms of these diseases are sufficiently distinct for them to be separated.

There seems to be still a desire in some quarters to attribute the sole cause of bush sickness to a possible poison, but the enthusiastic theorist in this search must face the initial difficulty of finding or even suggesting a possible mineral poison which will poison ruminants and not horses, which will remain healthy for twenty years on pasture which will kill a ruminant in nine months.

Mineral Contents of Pastures Investigation at the Cawthron Institute.—Second Annual Report, for the Year ended 31st March, 1930.

In the period under review the general survey of the mineral status of Nelson pastures, which formed a special feature of the programme during the first year, has been continued, and samples from the Rainy River, Sherry Valley, and Tui localities of the Waimea County have been analysed.

Much time has been devoted to an intensive study of the effect of season and fertilizer on the yield and composition of a typical dairying-pasture at Richmond, Nelson. On this pasture plots are available which have had specific but different fertilizer treatment during the last six years. It was anticipated that a careful study of the chemical composition of the pasture during the whole of the season would bring out many points of fundamental interest in pasture deficiency studies. Owing to the paucity of data in New Zealand bearing on the composition of pastures in different localities under different manurial programmes, it is extraordinarily difficult to interpret the analytical data of pasture-samples collected in mineral-deficient areas. The above investigation has revealed the great differences which occur in the mineral composition of pastures during the season and the importance of analysing samples from the same pasture at different periods before interpreting the results.

Investigations on the causes of xanthin-calculi formation in the kidneys of sheep have been continued. Samples of pasture from three typical farms located on the Moutere Hills soil-type associated with this trouble have been collected regularly throughout the season and analysed. The analytical data have revealed the great changes in composition which occur on these pastures during the season, and point clearly to great deficiencies in some constituents occurring at certain times. The field-work in connection with studies of xanthin-calculi formation has been extended, and considerable evidence has been obtained showing that lime and phosphatic treatment of the land greatly improves the pasture for stock and reduces greatly the incidence of calculi-formation.

Experiments have been continued concerning the value of bone-meal and other "licks" for stock on the poor Moutere Hills country, which is known to be deficient in both lime and phosphate. Cattle, particularly cows in milk and young stock, eat the bone-meal greedily, and great improvement in the health of stock has resulted. In the case of sheep considerable quantities of bone-meal have been eaten by ewes in the winter and early spring period, but more difficulty has been experienced in estimating the value of the "lick."

1. Mineral Content of Nelson Pastures.

In the last annual report data were presented showing the great variations in composition which occur in Nelson pastures in different localities. It was pointed out that, owing to the varied geology of the district, striking differences in soil-properties occurred, and that in a number of cases the composition of the pasture reflected the characteristic properties of the soils.

In a number of cases the chemical data showed conclusively that the pastures were deficient in one or more constituents. The data were in keeping with the known history of the pastures which had been found unsatisfactory for stock.

Several reputedly deficient pastures in localities not previously visited have been examined, and in several cases marked deficiencies in the composition of the pastures have been revealed. In the following table (Table 1) analytical data in connection with samples from Rainy River, Sherry Valley, and Tui localities are given. The analytical data show that deficiencies of phosphate occur in samples collected in both the Sherry Valley and Tui localities. The percentage of lime is rather low in all the samples, but at the present time there is not sufficient evidence available to make a definite statement in regard to the lime status of the pastures.

In the case of the samples from the Rainy River, stockmen state that cattle do not thrive and decline slowly in health. The analytical data for these samples show that the pastures are comparatively well supplied with phosphate; the percentage of iron is low. Further samples must be examined before any pronouncement can be made concerning the cause of stock ailment in this locality.

Table 1.—Chemical Composition of some Abnormal Nelson Pastures.

	Rainy River.		Sherry Valley.		Tui.	Average for Good Nelson Pastures.
	Alluvial Flats.		Heavy Loam (Granite Wash).	Alluvial Sandy Flats.	Moutere Gravels.	
Laboratory No.	133.	134.	165.	166.	168.	
Lime (CaO)	0·60	0·60	0·65	1·07	0·61	0·83
Phosphoric acid (P_2O_5) ..	0·98	0·94	0·31	0·49	0·45	1·06
Potash (K_2O)	3·31	3·28	2·26	3·04	2·58	3·96
Soda (Na_2O)	0·12	0·07	0·13	0·37	0·24	0·49
Chlorine (C_1)	0·81	0·74	0·51	0·66	0·60	1·45
Nitrogen (N)	4·12	3·68	2·17	2·99	2·40	5·34
Sulphur (S)	0·30	0·25	0·18	0·18	0·20	0·43
Iron (Fe)	0·012	0·014	0·025	0·032	0·012	0·033
Manganese (Mn)	0·021	0·032	0·028	0·021	0·035	0·017
Total ash	8·59	8·02	8·32	8·81	8·63	11·69
Soluble ash	6·27	6·08	4·44	6·70	5·11	9·10
Insoluble ash	2·32	1·94	3·88	2·11	3·52	2·59

NOTE.—All percentages are on dry matter. Samples represent young green growth collected spring, 1928.

II. Effect of Season and Fertilizer on the Yield and Composition of Nelson Pastures.

A very detailed study has been made of the various factors influencing the yield and chemical composition of a typical dairying-pasture at Richmond, Nelson. The investigation is still in progress, but much of the data obtained during the first year has been prepared for publication.

The more important conclusions resulting from this very detailed investigation are given below under the following headings: (*a*) "Effect of Season and Fertilizer on the Yield of Hay, Aftermath, and Pasture"; (*b*) "Effect of Season and Fertilizer on the Chemical Composition of Hay, Aftermath, and Pasture." A study of soil conditions on the pasture-plots has been included in the investigation, but the results have not yet been prepared for publication and on this account are not considered in this report.

(*a*) *Effect of Season and Fertilizer on the Yield of Hay, Aftermath, and Pasture (Mown Cuts).*—This section of the investigation deals with the relationships existing between climatic factors, such as temperature and rainfall, and yield of pasture. Production of dry matter in hay and aftermath crops is compared with the yield of dry matter from pasture frequently mown, so as to correspond with a rotational system of grazing under the same manurial treatment. The following summary covers the more important conclusions derived from this section of the investigation:—

(1) Nitrogenous and potassic manures have given greatly increased yields of hay over a period of six years. Superphosphate used alone has had little effect on the yield. A complete manure consisting of 2 cwt. superphosphate, ½ cwt. sulphate of potash, and 1 cwt. ammonium sulphate per acre has given an average annual increase in hay of 10·6 cwt. per acre over the untreated plots.

(2) In the Nelson District cold temperatures, accompanied by a great reduction in the hours of sunshine, are greatly responsible for low pasture-production during the period commencing 18th April and ending about 1st October. During the months of June and July it is very probable that no growth occurs in the case of a pasture which has been frequently mown the previous season. For the whole winter period, 6th May to 8th August, the production of dry matter from the untreated plots averaged only 1·4 lb. per acre daily. During the early spring period, 8th August to 5th September, production of dry matter rose to 5 lb. per acre daily. After this date a very rapid rise in rate of

production occurred, a maximum for the spring being attained during the period 9th to 16th October, with a yield of 23·5 lb. of dry matter per day. After this date until the 18th April the amount of rainfall was the deciding factor in maintaining pasture growth on the plots. During periods of drought yield on all the plots approached one another closely at a lower level. As might be expected, the yield of pasture was maintained for some time after the incidence of drought, and likewise did not rise to a new maximum for some weeks after the conclusion of the drought period.

(3) Fertilizer treatment greatly increased the yield of pasture in certain cases. On this pasture superphosphate used alone gave little benefit, a slight increase, mainly for the autumn period of pasture-production, being effected. Ammonium sulphate used alone or in combination with either superphosphate or superphosphate and potash gave a relatively great increase in yield of dry matter. For the period 20th September to 1st November, which probably covers the whole period of benefit resulting from the application of 1 cwt. ammonium sulphate per acre, the following increases in production of dry matter per acre over the untreated plots were noted: Superphosphate (2 cwt.), 63·1 lb.; ammonium sulphate (1 cwt.), 317·4 lb.; superphosphate (2 cwt.), ammonium sulphate (1 cwt), 350·6 lb.; superphosphate (2 cwt.), sulphate potash ($\frac{1}{2}$ cwt.), ammonium sulphate (1 cwt.), 401 lb.

The major effect from the use of ammonium sulphate occurred during the first three weeks after its application when applied on the 19th September under Nelson climatic conditions. At the commencement of the following season ammonium sulphate applied on the 8th August exerted a beneficial effect on yield for a period of nearly two months. Taking the figure of 22·5 lb. of dry matter to be the production requirement of a 7-cwt. dairy cow in milk, it would appear that the application of 1 cwt. of ammonium sulphate per acre provides on this pasture an increased stocking of approximately one-third cow per acre for a period of at least six weeks.

In the case of the plots receiving the complete treatment of superphosphate, potash, and ammonium sulphate the greatest increase in yield for the early spring period was effected. The yield of these plots was well maintained throughout the remainder of the season. Where ammonium sulphate was used either alone or in combination with superphosphate clovers were adversely affected and the yield for the midsummer and autumn periods was thereby reduced. The highest yield for the season was secured from the plots receiving the complete manure—5,274 lb. of dry matter per acre, against 4,241 lb. for the untreated plots. The inclusion of potash in the manurial programme resulted in a gain of 816 lb. dry matter per acre over the plot receiving super plus ammonium sulphate.

(4) The percentage of dry matter in the grass clippings varied considerably during the growing season. Rain or dew on the grass at time of cutting frequently reduced the percentage of dry matter to the low figure of 12–14 per cent. Excluding cases where the grass was known to be wet, the percentage of dry matter in the clippings varied from 16·0 to 21·4. The average percentage of dry matter for the whole season varied on different plots from 18·11 to 18·82.

(5) The yield of dry matter in the pasture clippings was much less than that in the hay crop grown during a corresponding period. The ratio of yield of dry matter in the pasture clippings to that in the hay crop was remarkably constant on different plots, varying only from 22·1 to 23·8 per cent. During the growth period of the aftermath crop the average daily production of dry matter from the pasture clippings was very similar to the daily average yield of dry matter in the aftermath crop, the percentage varying from 80 to 100.

For the full period represented by the hay and aftermath crops the yield of dry matter from the pasture clippings varied from 41·8 to 48·2 per cent. (on different plots) of the total dry matter in the combined hay and aftermath crops.

(*b*) *Effect of Season and Fertilizer on the Chemical Composition of Hay, Aftermath, and Pasture.*—This section of the investigation deals with the seasonal variations in the chemical composition of pasture and with the effect of fertilizer treatment on its composition. Chemical analyses of the hay and aftermath crops have also been made, so that a complete comparison is available of the composition of pasture regularly mown with that of the hay and aftermath crops.

The most striking features of the chemical work are as follows: Striking variations in the composition of both treated and untreated plots on the Richmond pasture occur during the season. In the case of the percentages of soluble ash, nitrogen, and potash, maximum percentages for the first half of the season are attained in the October period of growth. A great reduction in the percentages of these constituents occurs during November and December. The percentages of soluble ash and nitrogen then rise rapidly during January and February. In the March period the percentages of these two constituents remain stationary or drop a little. In the April period the percentage of nitrogen rises again, but the percentage of soluble ash remains at the previous level or tends to fall.

In view of the fact that the general tendency of curves plotted for the important chemical constituents in the pasture, both on untreated and treated plots, is the same, there can be no doubt that factors other than manurial treatment greatly influence the chemical composition of pasture during the growing season. The great drop in the percentages of soluble ash and nitrogen appears to be associated with droughty soil conditions during November and the greater part of December. Heavy rains were experienced towards the end of December, resulting in a plentiful supply of soil moisture during January. A great increase in the rate of growth in January might account for the increased percentages of several constituents which were obtained during this period. It does seem probable, however, that a progressive change in the flora of the plots also exerted a marked effect on the chemical composition of the pasture during the January and autumn periods of growth. The percentages of phosphoric acid and chlorine have a somewhat similar trend during the season on both treated and untreated plots. The highest percentages of these constituents occurs in the pasture during October, and then falls rapidly during the early summer. A minimum percentage occurs in the December period, after which a slight increase (more marked in the case of chlorine) takes place.

Marked variations in the lime content of the pasture during the season occurs on both treated and untreated plots. The curve for the lime content is essentially different from that of the other constituents.

The lowest percentages occur in the early spring, but a rapid rise then takes place during the summer. In the case of untreated pasture the percentage increases until the March period, when a fall in the lime content occurs. In the case of pasture receiving a complete treatment of lime, superphosphate, potash, and ammonium sulphate the variation in the lime content during the autumn is not so great, probably due to a more balanced flora.

The two sets of curves (see figs. 1 and 2) illustrating the variation in chemical composition of both treated and untreated pasture are of great interest in connection with mineral-deficiency studies. They show the differences which are likely to be found in a comparison of a rather poor pasture (untreated) with a fairly good pasture (treated). It will be seen that in the case of the untreated pasture two critical periods of high deficiency in the constituents occur. The first period is connected with early spring growth and the second with December growth. The untreated pasture

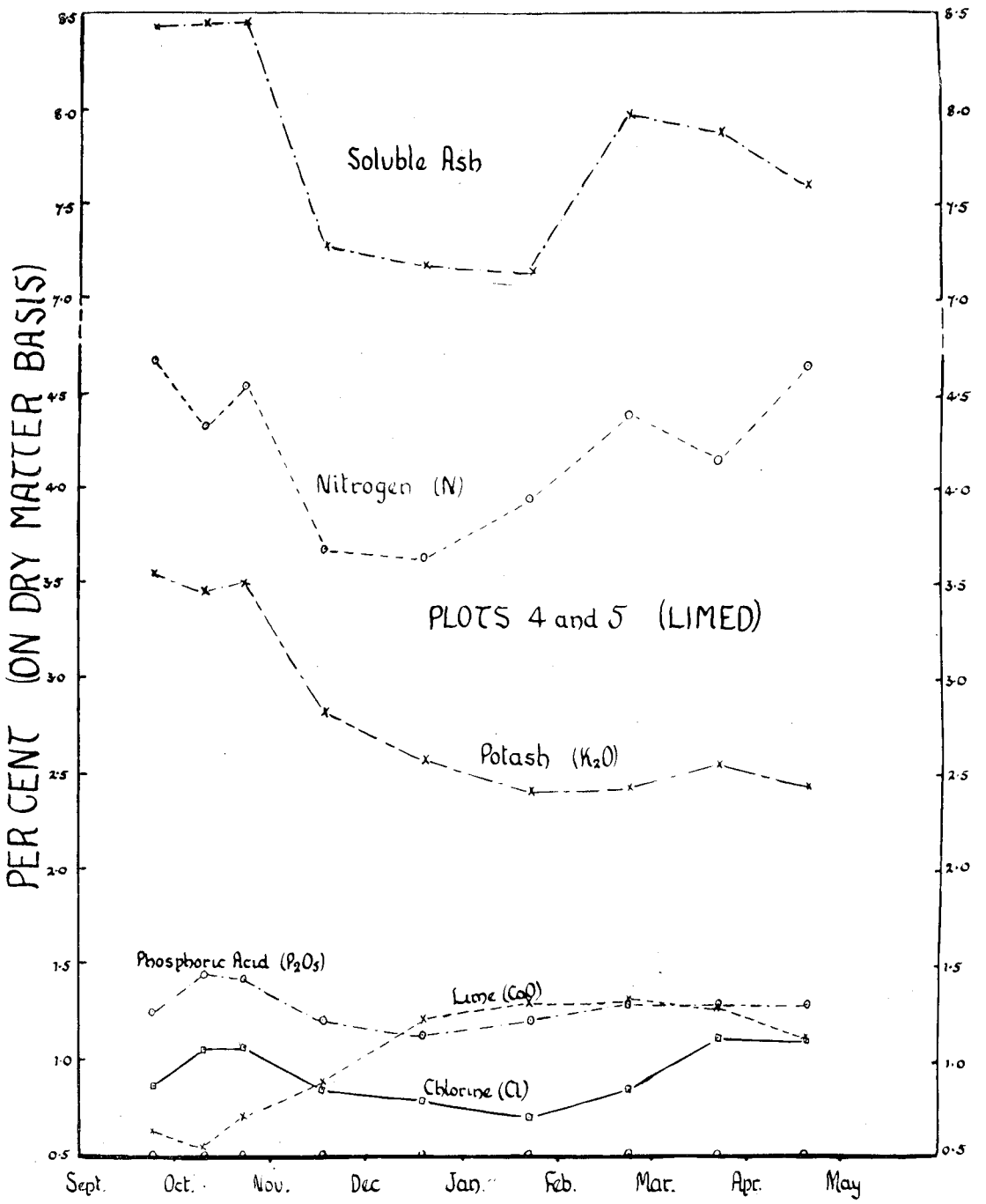

FIG. 1.—INFLUENCE OF MANURIAL TREATMENT ON CHEMICAL COMPOSITION OF A NELSON PASTURE (MOWN CUTS).

Treatment: 1 cwt. ammonium sulphate, 2 cwt. superphosphate, ½ cwt. sulphate of potash. Ground limestone at the rate of 1 ton per acre was applied in July, 1926.

NOTE.—The circles on the axis give the mean date of the growth period for which analyses are given.

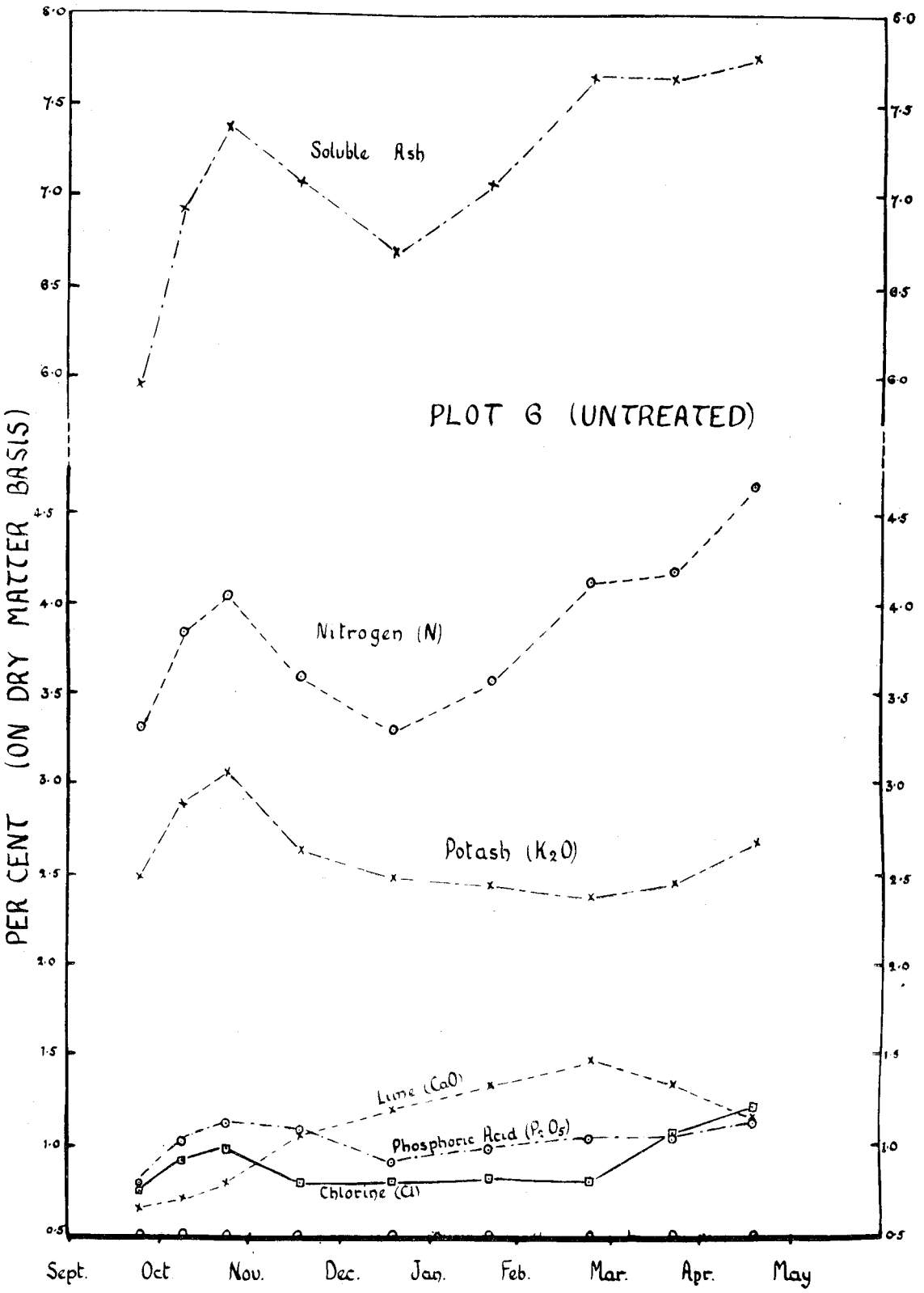

FIG. 2.—INFLUENCE OF MANURIAL TREATMENT ON CHEMICAL COMPOSITION OF A NELSON PASTURE (MOWN CUTS). Treatment: Untreated.

NOTE.—The circles on the axis give the mean date of the growth period for which analyses are given.

has the best composition during the late summer and autumn. In those cases where a somewhat low supply of phosphate is a probable cause of stock ailment it would appear that the December period—particularly when associated with droughty soil conditions—is likely to give the worst results with stock. At this time the curves for the untreated pasture show the minimum content of phosphoric acid associated with a relatively high percentage of lime. Such a ratio of high lime to low phosphoric acid would tend to aggravate a phosphate deficiency, as it is likely to prevent a full utilization by stock of the phosphate contained in the grass.

The effect of manurial treatment on the composition of the pasture is very marked for different constituents. This is particularly true of early spring growth, which on plots treated with superphosphate, potash, and ammonium sulphate contains relatively large amounts of all constituents, with the execution of lime. The percentages of constituents on treated pasture are maintained at a higher level throughout the season than is the case on the untreated pasture. Notable exceptions to this rule are, however, the curves for lime and chlorine, which run at the same level, or, indeed, drop below, the corresponding curves for untreated pasture.

Lime treatment of the pasture has given little benefit in raising the percentage of lime in the grass, but has had a marked influence in increasing the percentage of phosphate, potash, and nitrogen.

The use of ammonium sulphate has resulted in a great reduction in the percentage of lime in the pasture, particularly marked where ammonium sulphate has been used without phosphates and potash. The percentage of nitrogen in the pasture has been slightly increased where ammonium sulphate was applied.

III. Causes of Stock-ailment on the Moutere Hills Pastures.

In the last annual report attention was drawn to the serious mortality of stock associated with the sheep industry on the Moutere Hills type of soil in the Nelson District. One of the most striking features of stock-ailment on these pastures was the widespread occurrence of xanthin calculi in the kidneys of sheep. On certain farms mortality in sheep was high, and the presence of xanthin calculi was shown frequently to be a predisposing cause of death. Several preliminary analyses of pastures have been presented in earlier reports from the Cawthron Institute, but although the analytical data indicated deficiencies of lime, phosphate, and nitrogen, the figures were not outstandingly low, as might have been expected in the case of a pasture giving such poor results with stock.

In order to secure further information concerning the causes of stock-ailment, several field experiments were laid down to ascertain whether the pastures could be rendered healthy for stock by lime or fertilizer treatment. In addition, analyses of pasture-samples from three typical farms have been made at intervals throughout the season. The effect of lime and different fertilizers on the chemical composition of the pasture has also been studied. The analytical data obtained in this investigation show that the chemical composition of the untreated natural pasture varies greatly during the season. During the midsummer and early autumn period great deficiencies in phosphate, nitrogen, and soluble ash occur. The analytical data for this period show that the composition of Moutere pastures approaches closely that of other highly deficient pastures examined by investigators in other countries.

The whole of the chemical data obtained during this investigation has been published in a bulletin, entitled "Moutere Hills Pastures—Seasonal Variation in and Influence of Fertilizer on their Chemical Composition."

The more important conclusions resulting from the chemical investigation are as follows:—

(1) The farm associated with the highest mortality of sheep, and showing the greatest incidence of xanthin calculi, had the poorest pasture and soil. Pastures on this farm contained the lowest percentages of lime, phosphoric acid, nitrogen, and soluble ash.

(2) The chemical composition of Moutere pastures was best in the spring. The composition was worst in the dry summer and early autumn periods. An improvement in chemical composition occurred after rains in March.

The variations in chemical composition of the pasture follow closely the behaviour of sheep, which are known to increase rapidly in weight during the spring and early summer. During the midsummer period a reduction in live weight frequently occurs. A small increase in live weight is usually associated with the late autumn period of grazing.

(3) Applications of lime and phosphatic fertilizers increased the percentages of minerals in the pasture. Ammonium phosphate effected a great improvement in the percentage of phosphoric acid, but greatly reduced the percentage of lime.

(4) By suitable treatment with lime and phosphate a good mixed pasture of English grasses and clovers can be maintained on the Moutere Hills soil. Such a pasture maintains sheep in excellent condition, and its chemical composition compares favourably with that of other good pastures in the Waimea County.

General.

In the early part of the year covered by this report Mr. O. Barton, Assistant Agriculturist at the Cawthron Institute, replaced Mr. J. A. Bruce (resigned) as field officer for the mineral content of pastures investigation. Dr. Askew, assisted by Mr. L. Bishop and Mr. L. Hodgson, has been responsible for the chemical work which has figured so prominently in all the investigations. Mr. W. C. Davies, Curator of the Cawthron Institute, has assisted in botanical studies of pastures and in the photographic illustration of reports and papers.

The following papers and bulletins have been published since the commencement of the mineral content of pastures investigation.

(1) "The Mineral Contents of Typical Pastures in the Waimea County, Nelson," by T. Rigg and H. O. Askew.

(2) "The Value of Sulphur for the Fertilization of Lucerne," by B. W. Doak.

(3) "The Mineral Contents of Lucerne," by B. W. Doak.

(4) "A Widespread Occurrence of Xanthin Calculi," by T. H. Easterfield, T. Rigg, H. O. Askew, and J. A. Bruce.

(5) "The Occurrence of Xanthin Calculi in New Zealand Sheep," by T. H. Easterfield and J. A. Bruce.

(6) "Stock and Pasture Problems of the Waimea County," by H. O. Askew and T. Rigg.
(7) "Grassland Management," by T. Rigg.
(8) "Moutere Hills Pastures—Seasonal Variation in and Influence of Fertilizer on their Chemical Composition," by T. Rigg and H. O. Askew.

The following papers are in the press at the present time:—

(9) "The Influence of Ammonium Phosphate on the Yield and Composition of Meadow Hay," by H. O. Askew.
(10) "The Effect of Season and Fertilizer on the Yield of a Typical Dairying-pasture—Part I," by T. Rigg, and H. O. Askew.

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

SECOND ANNUAL REPORT OF THE PAKIHI INVESTIGATIONS CONDUCTED BY THE CAWTHRON INSTITUTE, 1930.

In the last annual report attention was drawn to the success which had been obtained on small-scale plots in the establishment of pasture at the Sergeant's Hill experimental area of the Cawthron Institute. The results obtained on these plots showed—(1) That lime treatment and phosphatic manuring were both essential in the establishment of grasses and clovers. (2) Successful establishment of pasture, provided lime treatment and phosphatic manuring were carried out, was obtained in certain cases with comparatively little preparation of the seed-bed. Disking of the surface without resort to ploughing or fallowing of the land, and, indeed, direct sowing of seed on to the burn, were attended with surprisingly good result.

During the second season the plots previously laid down have been continued, and experiments extended to ascertain whether the conclusions obtained from the small plots were practicable on the field scale. Further points in connection with the initial preparation of the seed-bed, and the use of lime and fertilizers, have been examined by extending the experimental plots. In addition, it has been possible to stock some of the experimental areas, thus obtaining information concerning the ability of the pasture to maintain stock and the effect of trampling by stock on the textural characteristics of the soil.

Pasture-establishment.

One of the outstanding features of the experiments during the first year was the success obtained in pasture-establishment by sowing a grass- and clover-seed mixture directly on the burn after treatment with lime and phosphatic manure. Several new plots, each measuring about a quarter of an acre, were laid down to test further the feasibility of this method of pasture-establishment. The plots selected were typical of pakihi land under somewhat dry and also rather wet conditions. In no case did failure result, and in the majority of cases an excellent stand of grasses and clovers was obtained. These plots gave a very fine cut of hay in the latter part of December, and were grazed during the remainder of the season. Little difference in the establishment of grasses and clovers was found in the case of sowings made on pakihi land burned over at different times prior to sowing. It was much easier, however, to obtain a seed-bed on those plots where burning had immediately preceded in the harrowing and treatment of the land.

As a result of the co-operation of Mr. L. G. Larsen, it was possible to lay down 6½ acres of pasture on the undulating pakihi land between Westport and Charleston. Over large areas of this country the pakihi land, owing to its sloping character, presents less difficulties in handling than the more low-lying land at Sergeant's Hill and Fairdown. With rather poor implements little difficulty was experienced by Mr. Larsen in obtaining a satisfactory seed-bed after four diskings and harrowings. The land was treated with 1½ tons of slaked lime and 5 cwt. of basic slag per acre. Seed was sown in the early part of April at the rate of 35 lb. per acre. Despite somewhat adverse conditions, owing to wet weather and lateness of the sowing, a very fair "take" of both grasses and clovers resulted. In the early summer a good cover was obtained over the whole of the 6½ acres.

Mr. Larsen's field and certain areas at Sergeant's Hill have been stocked with cattle ever since January. Very favourable weather was experienced, and the sward has improved greatly under stocking. At Sergeant's Hill the plots have maintained more than one cow to 2 acres until the end of April. There has been a great improvement in the texture of the soil as a result of pasture-growth and stocking. The land has lost its spongy feel, is firm to the tread, and comparatively dry on the surface. Owing to the absence of Mr. Larsen from Westport, it was not possible to arrange stocking on his field as early as desirable. A herd of thirteen to eighteen cows has, however, grazed the field at intervals from early February to the middle of May. Grazing has not been sufficiently heavy to secure the best results, but great improvement both in sward and in consolidation of the land has been effected.

Much valuable information has been obtained from other small plots which were laid down at Sergeant's Hill to test (1) the practicability of using smaller quantities of lime in the initial establishment of the pasture; (2) the value of ground limestone; (3) the value of top-dressing; (4) the value of different seed-mixtures.

As a result of these experiments the following conclusions can be drawn: Slaked lime appears to have a slight advantage over ground limestone in the initial stage of pasture-establishment. This is probably due to the more caustic action of slaked lime in releasing available nitrogen. In the later stages, however, little difference could be detected between plots treated with either slaked lime or ground limestone. In both cases, provided an application of basic slag or superphosphate had been made prior to sowing, a very satisfactory cover of grasses and clovers was secured by the

following summer. As far as the initial establishment of pasture is concerned, the use of 1 ton of ground limestone per acre has given as satisfactory results as the use of larger amounts—viz., 1½ tons and 2 tons per acre respectively. It is possible that in the second year plots with the larger dressing of lime will show to advantage over those with the smaller dressing.

Marked benefit has been obtained by top-dressing with basic slag or superphosphate the plots laid down in the previous year. Plots treated in this way have retained their freshness and have made excellent growth. Plots not receiving top-dressing are decidedly inferior. Even in those cases where top-dressing of superphosphate at the rate of 2 cwt. per acre was made in February, approximately a year from sowing, its effect on the pasture was immediately noticeable. Such plots were more closely grazed than corresponding plots which did not receive top-dressing. Ammonium sulphate at the rate of 1 cwt. per acre was used in February on several plots. Very marked improvement in growth of grass was obtained. A mixture of superphosphate and Nauru 1 : 1 at the rate of 5 cwt. per acre has proved equally satisfactory to either superphosphate or basic slag used at the same rate on plots where the lime treatment has not exceeded 1 ton of slaked lime or ground limestone per acre. In the early part of the season superphosphate gave greater benefit than the superphosphate-Nauru mixture. In the latter part of the season the reverse was the case.

The following seed-mixture has been used over a large number of plots and has given very satisfactory results:

	Per Acre. lb.		Per Acre. lb.
Perennial rye	14	*Paspalum dilatatum*	2
Western Wolths	6	White clover	4
Cocksfoot	4	Red clover	2
Brown-top	2	Alsyke	1
Yorkshire Fog	2	Timothy	2
Lotus major	1½	Crested dogstail	2
Lotus angustissimus	1½		44

A small plot was tried with a rye, paspalum, and subterranean clover mixture, but this so far has not proved successful. A good initial establishment of rye and subterranean clover was obtained, but by February little rye or subterranean clover was noticeable. It is possible that a great improvement in the subterranean clover will take place during the winter and coming spring, but in the meantime *Lotus* and inferior grasses have crept in, greatly reducing thereby the value of the sward.

Phormium tenax Experiments.

The flax plots continue to show the importance of both phosphates and flax-refuse in the establishment of flax on pakihi lands. Ammonium sulphate applied in the early part of March has greatly improved the growth of young plants which had previously received lime and phosphate treatment.

Further plots containing some 500 plants have been laid out with a view to securing further information concerning methods of land-treatment suitable for *Phormium tenax*. It is anticipated that in a few years these plots will give much valuable data concerning the nutrition of flax-plants and the effect of various plant-food deficiencies on disease and quality of fibre.

General.

In the early summer a demonstration on the plots at Sergeant's Hill was held by officers of the Cawthron Institute. It was attended by a representative gathering of business men and farmers from Westport and the surrounding districts. Representatives of the Department of Agriculture, Department of Lands, and local bodies were present, and many favourable opinions were expressed concerning the value of the work which had been accomplished.

As a result of representations made by officers of the Department of Agriculture and the Department of Lands, the Land Development Board has decided to test out on the farm scale the more important features of the experiments at Sergeant's Hill. An area of 120 acres has been taken up by the Board, and a commencement has been made with the sowing of a 10-acre block. Officers of the Cawthron Institute are co-operating with the Department of Agriculture in the experimental programme which is being developed in connection with the Board's project.

It is anticipated that the application of superphosphate at the rate of 2 cwt. per acre annually, together with an application of 1 ton of ground limestone per acre every four years, should suffice to maintain good grazing-pasture. At present prices for lime and fertilizer this represents a cost of £1 per acre annually for this treatment.

A paper entitled "Pakihi Lands of the Nelson Province," by T. H. Easterfield, T. Rigg, and J. A. Bruce, has been published in the *Journal of Science and Technology*. In this paper various aspects of the pakihi problem are considered, and a *résumé* is given of the field results during the first year.

PIG RECORDING.

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

This work was begun in 1928 as a result of a special grant of £1,775 made in order to facilitate investigations connected with the feeding and management of pigs. Three groups were in operation in 1928–29, and the information collected has been published in a special report in each centre and summarized in Bulletin No. 17 of this Department. The work has been continued in two centres in 1929–30.

The chief value of the work done so far is that actual facts are beginning to replace opinions. Whereas in the past the Dominion's pig population was thought good, bad, or indifferent, in accordance with different viewpoints, enough information has now been collected to say with certainty that the sow population is of a low-producing type, of which only 28 per cent. had satisfactory litters in the areas tested in 1928–29. Improvement is rapidly made under a system of recording, and this year just 50 per cent. of litters weighed reached the satisfactory standard. Pedigree breeders who are entirely responsible for the standard of excellence of purebred stock are mainly responsible for the quality of crossbred stock also. Their methods have resulted in stock of mediocre producing-capacity. By keeping records of production very marked and immediate progress can be made, and it must be very strongly urged upon stud breeders to incorporate performance in every pedigree, if pedigrees are to have any real value at all. The information that is the best indicator of producing-capacity is the weight of litter produced.

Although good pigs are an ultimate necessity, it is of little use having good pigs where management is poor. Few farmers could say whether their management was good or bad, and most would reasonably attribute non-success to high prices of bought feeds or low prices for pork. It is only by collecting and distributing the returns from different farms that it is possible to make comparisons between the returns of various farmers. If the methods of the best farmers could be universally adopted a marked increase in the profits of pig-raising would result. In the Waikato, in 1928, returns with pigs from skim-milk ranged from £2 up to £5 per cow. Finally, although it has long been recognized that grain is necessary in the milk districts, neither farmers nor grain-merchants have so far succeeded in providing a supply at sufficiently low prices to allow the use of grain profitably. Pig-meals are displayed at prices that make their use unprofitable. Information collected to date seems to definitely establish the fact that when pork is 6d. per pound farmers cannot afford to pay more than £12 per ton for peas or maize, £11 for barley, and £10 for pollard to feed to fattening pigs. For every 1d. reduction in the price of pork a reduction of £2 per ton is required in the price of feeds to allow of their profitable use. When used with sows and litters, grains can be fed profitably at present prices. No one who advocates the feeding of grain has been able to supply grain sufficiently cheaply to make its use economical, but as a result of a few feeding trials it would appear that meat and bone meals at present prices can be used profitably with porkers, and with sows and litters. With the latter, meat-meal has produced the most economical gains of all the concentrates used. If further trials support this point of view a very definite step in the solution of the feed question will have been made.

Definite information that must gradually displace opinions is being collected on these three main aspects of pig-production, and on others of lesser importance, such as the influence of breed of boar and sow on litter-weights, the influence of numbers per litter on litter-weights, the influence of feeding on litter-weights. Results this year so far show, by comparison with the previous year, a general marked improvement in litter-weights at eight weeks of age, due usually to better feeding and care on the part of the owner. Other aspects of pig-production that are being explored are the costs and returns that are obtained on different farms and the conditions under which high returns are obtained. A full report on 1929–30 season's work will be available when all the collected information is examined.

PORK AND BACON RESEARCH.

Since the interest in the adoption of new cures and processes, as used abroad, has to a large extent subsided owing to the non-enforcement of the regulations made by the Department of Health prohibiting the use of boric acid in bacon, the work of this section has been mainly connected with a lengthy investigation of "taint" in New Zealand pork.

The experiments, which are now nearly complete, were made on three series of pigs, given basic feeds of (1) buttermilk (Waikato), (2) barley (Canterbury), and (3) whey (Palmerston North). Each series has been divided into groups, and a foodstuff suspected of causing "fishy" (or "reasty") taint has been included in the diet for each experimental group. The curing-properties of a side from each pig, cured immediately after killing, have been carefully examined for the nature of the fat, and particularly for the presence of any signs of "taint." The other sides have been frozen for two to three months, examined, cured, and again examined.

The results are the subject of a detailed report, but, briefly stated, these show that the various oily and other meals derived from animal and fish offals would appear to predispose the carcass to taint when fed with buttermilk or whey, but probably not so when fed with a concentrate, such as barley.

Another series of experiments was made upon the freezing-properties of New Zealand milk-cured bacon. A side, roll, and ham were fairly successfully held for three months when given one week's initial sharp freezing at a temperature of 5° F. and then held at the usual meat-storage temperature of 12°–14° F. The results are fully reported in the *New Zealand Journal of Science and Technology*, Vol. 12, No. 1.

Occasional inquiries have been answered, the usual circular letters forwarded to bacon-curers, some analyses of hams for penetration of the cure, and advice given in reference to the nitrite cure, and hypochlorite disinfection of factories have been other small services given to members of the trade.

WOOL RESEARCH.

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

Wool investigatory work in New Zealand has been apportioned between Massey Agricultural College and Canterbury Agricultural College along the following lines:—

Massey:—

(1) Breeding experiments to ascertain the degree of wool-character inheritance occurring in the Romney Marsh breed.

(2) Detailed studies of fibre-development, particularly those relating to medullation, thickened tip, and hairiness.

(3) Chemical examination of wool grease and yolk, with especial reference to fibre-nutrition.

Canterbury :—

(1) Breeding experiments to ascertain relation between birth-coat of lambs and subsequent fleece-characters.

(2) Experimental feeding trials.

Details of the work and of the progress made to date are set forth in the extracts from reports prepared by the Directors of both Colleges.

Reviewing the situation as a whole, very satisfactory progress has been made. Continual contact with the breed on which we are working has given us a very fair appreciation of the existing state of affairs, the general practice in the matters of culling for wool and mating, the extent to which faulty wools occur, and more particularly the relative importance of the various faulty types. The systematic examination of Romney wool which has been in progress has already shown an even greater variation both in structure and yolk content than might have been expected, and a degree of complexity which it will take some considerable time to unravel. The progress already made, however, promises well. Dr. Dry is following very closely the development of the fleeces of a large number of stud lambs of parents whose wool has been critically examined as to type and faults. The close observation throughout their lives of the fleeces of these animals carrying sound wool, particularly if combined with differential treatment, should give valuable information of the extent to which wool may be influenced structurally, if at all, by factors other than heredity. The more immediate application of this particular work will be an indication of the extent to which lambs can be culled at an early age—for example, ram lambs at docking. The breeding experiments in hand, which are analytical rather than synthetical, in so far as wool-characters are concerned, though slow, will throw some light in the course of time on the inheritance of the individual characters chosen for study. With the completion of work on technique and methods which is also in hand, several other promising lines of attack can then be commenced.

The main problem which is being kept steadily in mind is, of course, an explanation of the appearance of wool of various degrees of medullation, and the various experiments of a biological nature all converge on this point.

The work of Messrs. Scrivener and Sutton has been confined very largely to the development of technique. The necessity for this will be apparent, since the problem of yolk is being tackled from an entirely new angle—its relationship to fibre-type and the management of the sheep. The work of Dr. Dry will fit in well with this investigation, since it would seem that at least the finer stages of this work must carefully take into account, when selecting animals for use, the wool-types which Dr. Dry is segregating. The results obtained so far are very interesting, and in some cases distinctly surprising. They indicate the importance of investigating this quite unknown field and of possessing a more complete knowledge of the fundamentals of wool-production.

Chemical investigations commenced into the nature of wool-yolk had, in the absence of references to previous work done elsewhere, to be along entirely new and original lines. Other investigations are reported to have given no indication as to the conditions under which the wool was grown. No record could be found in the literature on wool investigation as to whether yolk can influence type and quality of the fibre, or whether the amount and nature of yolk is merely incidental to the production on the animal of a certain type of fibre. The fact that a flock of sheep of a suitable nature was available at the College has rendered the inauguration of such an investigation obvious and possible. The question of proper sampling of wool, which is absolutely fundamental to any course of investigation, still needs further work before entirely reliable results can be assured. For the purposes of these investigations it was decided, after giving careful consideration to all information available, to take samples of wool from the middle of the side. There are two outstanding points which have real significance in this sampling—(1) the correspondence between producing sheep at the same time, and (2) the reliability of wool from the side as a sufficient indication of the condition of the whole fleece of the Romney.

Yolk or wool-grease consists of two main groups of substances—(*a*) the more complex organic compounds of the nature of wax, which are soluble in ether, and (*b*) the constituents of an inorganic nature, such as potash salts, which are insoluble in ether but soluble in hot water. This immediately suggested a means of detecting major differences in the composition of samples of yolk from different sources. This method had previously been used by Wilson (*Journal of Textile Science*, December, 1926), who divided raw wool into the following constituents: clean fibre, wool-fat, potash salts, soil, and moisture. On trial the apparatus described by Wilson was not found to be suitable for our purpose, but with slight modifications of the practical details this method of examination of wool has been used in all our experiments. In order to avoid confusion due to different definitions of such terms as "wool-fat," "suint," &c., we propose to use the following terms :—

Moisture: Loss in weight when wool is dried at 105° C.
Ether extract: That portion of the dried greasy wool soluble in dry ether.
Water extract: That portion of ether-treated wool soluble in hot water.
Insoluble matter: All impurities remaining after treatment with ether and water.
Clean fibre: Wool previously extracted with ether and water, from which all remaining impurities are removed by further scouring with hot water and hand picking.

On reaching this decision samples were accordingly taken from four Romney fleeces showing as wide differences as possible in yolk content, as determined by handling and visual observation. These were subjected to the above treatment, with the following results :—

Description of Sample.	Moisture.	Ether Extract.	Water Extract.	Insoluble Matter.	Clean Fibre.	Total "Yolk."	Total.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1. Harsh and dry ram's fleece, 40's	14·43	6·43	5·69	4·54	68·77	12·12	99·86
2. Dry, ewe's fleece, 46's ..	14·60	8·46	8·39	4·54	63·75	16·85	99·74
3. Heavy-condition ram's fleece, 40's	16·13	4·10	7·18	2·45	69·79	11·28	99·65
4. Heavy-condition ewe's fleece, 46's	16·74	8·11	13·80	5·17	54·54	21·91	98·36

Duplicate estimations were carried out, and it was apparent that the method was sufficiently accurate for the purpose, differences between individual sheep being much greater than any errors due to the method of analysis.

The most outstanding feature of these results is that the estimate of clean yield by handling and visual observation may be very misleading. It will be noticed that samples 1 and 2, selected for their light condition, actually gave a lower yield of clean fibre than sample 3, which was selected for its heavy condition. It is also apparent from these figures that the water extract is the most variable constituent.

Wool-buyers and others experienced in estimating the clean yield of raw wool expect to be within 1 or 2 per cent. and admit that they may be 3 per cent. out in their estimate, and we have evidence that this certainly does apply in some instances; but it would appear that in certain cases the appearance and handle of wool may be misleading even to men trained in estimating clean yield. For instance, a sample of wool free from sand and seeds estimated by a wool expert to yield 76 per cent. clean fibre (allowing standard regain) was on analysis found to yield 82 per cent. clean fibre.

The preliminary work described above confirmed our previous opinion that the causes for these important differences in amount and composition of yolk should be investigated. From information available at the time the following possible causes suggested themselves:—

(1) Effect of rain in washing out soluble constituents.
(2) Effect of temperature on yolk-production.
(3) Effect of feeding on yolk-production.
(4) Effect of season on yolk-production.
(5) Relationship of wool-type (character of staple and fibre) with yolk-production.
(6) Relationship of wool-type with yolk-retention.
(7) Individuality of animal, comprising all other factors, including health of the animal.

It is obvious that in farming practice several or all of the above operate together, but for the purpose of research work it is necessary to examine one factor at a time by eliminating as far as possible all other factors. With this end in view, and to make a preliminary investigation of several of the above factors, forty sheep from the Massey College flock of Romneys were selected in June, 1929. Since no special provision had then been made in stocking the farm for material for such work, the experiment had to be designed to make use of the flock as built up by ordinary farming practice. Owing to the impossibility of handling ewes during the lambing season, and since no wethers were available, we were forced to use ewe hoggets. Fortunately, some 300 were available for selection. A large number of individuals to choose from is essential in the Romney breed, since the variations in type are so wide and only a small proportion can be found to conform to any one type.

In biological work in general it is well known that as large a number of individuals as possible should be used, but we were limited by the assistance and apparatus required for the analysis of a large number of samples, without unduly precluding reasonably frequent samplings. Ultimately two even lines of ewe hoggets—twenty in each group—were selected, one group being strong-woolled (44–46's) and the other fine woolled (48–50's).

From the outset it was obviously necessary to find out to what extent sheep run under natural conditions would give reliable information and to what extent rain would wash out soluble constituents. For this reason ten of each of the above groups were provided with light waterproof covers and the remaining ten of each group left uncovered. These sheep were ultimately run together with the rest of the hoggets under normal conditions of management.

From this experiment it was hoped to show the effects of rain, season, and wool-type on the production and retention of yolk, in addition to providing fundamental information on the technique of experiments of this nature. At the same time it was hoped to ascertain the extent to which the number of animals taken would eliminate the individuality factor. This experiment in its original form is still being conducted and will not be concluded for several months, until the complete growth of wool has been examined. Meanwhile the following figures show the type of results being obtained:—

	Ether Extract.				Water Extract.			
	July.	August.	September.	October.	July.	August.	September.	October.
Strong uncovered	6·6	7·2	7·1	7·5	9·9	9·1	11·8	14·0
Strong covered	7·1	7·8	7·9	9·7	10·1	12·3	12·4	14·1
Fine uncovered	7·3	7·6	7·4	8·3	11·0	10·0	11·6	14·5
Fine covered	8·4	8·6	8·7	9·2	11·2	12·3	13·9	14·9

Season.—In the case of the covered animals there is a steady increase in percentage of yolk (both ether extract and water extract) from July to October. In the case of the uncovered sheep the increase, although of the same order over the whole period, is much less regular.

Wool-types.—The fine-woolled sheep have higher values than the strong-woolled sheep throughout when animals receiving similar treatment are compared. This is what one would expect.

Effect of Covering.—As may be expected, higher figures are obtained in all cases under covers than with uncovered sheep. At shearing-time the difference between the wool under cover and the uncovered wool seemed to lie more in the ether extract than in the water extract, in spite of wet weather prior to shearing, when it would have been reasonable to suppose that water-soluble constituents would be washed out of the fleeces of uncovered sheep.

Individuality.—It should be borne in mind that these figures are averages of widely divergent values. For instance, the figure 6·6 for strong-woolled uncovered sheep in the first column is the average of values ranging from 5·5 to 8·0, whereas the figure 7·1 for strong-woolled covered sheep is the average of values lying between 5·2 and 9·3. Similarly, the percentage of water extract for one

particular sheep was at the four successive samplings 8·5, 5·8, 11·1, 10·9. It is doubtful, therefore, if much reliance can be placed on the above general conclusions. This serves to emphasize the necessity for taking a large number of sheep over a long period of time in order to eliminate these individual variations.

The figures obtained are being subjected to statistical treatment as far as possible to determine to what extent they may be taken as being significant, but we are not yet in a position to present a critical report of the result.

Since commencing the above experiment eight further sheep have been included, bringing the total number up to forty-eight.

From the results of analysis of samples up to shearing-time it cannot be concluded that the only effect of covering is to prevent washing-out of yolk by rain. It may be argued that covering produces abnormal conditions of yolk or sweat production. In order to test this point, and since the best method of protecting the fleece from the weather without producing an abnormal flow of yolk must be determined before any further work can be undertaken, a second experiment was designed. Forty more sheep were selected from the same line of 300 two-tooths, conforming as closely as possible to a definite type. Samples of the wool were taken from each sheep in January. Twenty of these sheep were then covered, and the whole forty are being run together. All these animals are run into the wool-shed at nights, and also, in the event of rain, during the day. While in the shed they are provided with bedding, hay, turnips, and water, so that if it is necessary to keep them in for several days their condition should not suffer. In this way the uncovered sheep are as effectively protected from the weather as the covered sheep, the only variable factor being the temperature effect or other abnormality due to wearing a cover. This treatment will be continued until the end of April, when further samples will be taken and the effect thus measured.

By means of these two experiments, three methods of treatment can be compared, viz. :—

(*a*) Uncovered sheep exposed to weather.
(*b*) Uncovered sheep sheltered during rain.
(*c*) Covered sheep.

This experiment will also furnish valuable information on the type of distribution of figures within an even line of forty similar sheep.

Thus eighty-eight sheep are under close observation on the College farm. To date some 200 samples have been analysed, and 350 further samples will be dealt with before the experiments are concluded.

The main conclusion to be drawn from the work done so far, both here and in other centres, is that the most important need is for more accurate information of a fundamental character concerning the production and distribution of yolk in the fleece. To attempt to build up any schemes for more extended work without first clearing up these fundamental points would be waste of time.

The development of the biological side of wool research will provide knowledge of precise scientific methods of measuring the characters of the wool-fibre, and if at the same time definite knowledge concerning yolk (for which service we have splendid facilities) can be provided, the way would be paved for a great deal of work which would prove of the greatest assistance to the industry as a whole. Though from the nature of the work, including as it does so many uncontrollable biological factors, the results so far are not able to yield reliable conclusions, yet the gradual but definite progress made has convinced us that the field is a fertile one and capable of profitable development. Such development must be slow with painstaking attention to detail.

It is not easy to prophesy what turn the development of the work will take, but it is apparent that out of the present experiments will arise points for further trial and suggestive lines of attack on the major problem. There are, in addition, several investigations which have seemed of the first importance, involving the use of some of Dr. Dry's experimental breeding-flocks, for instance—

(1) Differences in yolk characteristics in the various well-defined types of Romney fleece.
(2) Correlation of yolk characteristics with presence of sweat and sebaceous glands.
(3) Seasonal changes in yolk content in different well-defined types.
(4) Distribution of yolk in different parts of the fleece.
(5) Lateral flow of yolk.

It is anticipated that future work will not necessitate such frequent samplings in all cases, and this will enable more animals to be kept under observation.

It will be realized that the practical difficulties associated with the continuous covering of sheep are not inconsiderable, especially as the animals in the original experiment are being kept under conditions of ordinary farming practice. From the experience gained considerable improvements have been made in the design of the covers and in the methods of securing the covers both before and after shearing. The covers were made of a light material in order to inconvenience the sheep as little as possible, and the material naturally suffers with continual exposure to the weather all the year round. Replacements and repairs have been frequently necessary, but it is anticipated that with the experience gained the cost of maintenance of the covers will be considerably reduced.

Biological Work.

The problems involved in the biological work on wool have been discussed at Wool Research Committee meetings and a scheme of work has been finalized. After a preliminary survey of the situation, certain lines of study were decided upon as foundation work upon which future advances in a number of directions could be based. The present report is a general statement of progress to date. The report deals largely in generalizations of a preliminary nature, for often the material—the wool, for instance, on the 1929 crop of lambs—has not reached a suitable stage for evaluation for certain

features. Often, too, the repetition of an experiment is necessary before any conclusion can be drawn with confidence. On the other hand, it is occasionally necessary to go into some detail in order to show the scope and purpose of an investigation, and the significance of the problems that have arisen.

Breeding Experiments.—In the 1929 breeding experiments 221 ewes, nearly all two-tooths, were mated and 199 lambs were tailed. In eight small flocks, representing different fleece-types, like was mated with like. The fleeces of the lambs are now about half-grown. The wool has been examined from time to time on the lambs and in samples, and tentative conclusions have been formed. The results are likely to be of the most interest from the point of view of thickened tip and of harshness, even in flocks selected primarily for some other purpose. It may be explained that the term "thickened tip" is used to include all cases where a thicker apical end is followed by a finer region. Frequently it is necessary to distinguish between hairy thickened tip, containing coarse medulla, and non-hairy thickened tip. In the fine-woolled flock the results prove to have bearing on thickened tip because the ram, while strikingly fine, shows tips that are thickened but not hairy.

The great majority of the offspring of parents both with thickened tip show thickened tip. Whether all these lambs have thickened tip cannot yet be stated. Whether thickened tip mated with thickened tip always produces lambs possessing this character is a fundamental question in genetic analysis. In matings between thickened-tip animals, both too fine to be called hairy, some offspring with coarser wool have been born, and these are being watched with interest; some of these lambs do show hairy tip. There is also further evidence that points to thickened tip being inherited as recessive to evenness, and the matter is being tested by further matings.

If it should be established that thickened tip breeds true, while at the same time of even-fibred animals some breed true and some throw some thickened-tip offspring, then simple practical conclusions would follow. The case would be parallel to that of the inheritance of black and red in cattle. Red breeds true; while some blacks can have red calves, some have only black calves. Should the two cases prove similar thickened tip could then be avoided by the choice of the right even-fibred ram, while thickened tip, though non-hairy, would be likely to lead to hairy thickened tip in stronger-woolled descendants.

With regard to harshness, attributed to small irregularities in individual fibres, the majority of the lambs from parents both harsh appear to be harsh, but a few not. After the receipt, some twelve months ago, of a memorandum by Dr. S. G. Barker upon the shape of cross-section of certain New Zealand wools, some attention was paid to small irregularities in wools of a wide range of breeds and crosses. The evidence suggested that the presence of small irregularities showed a considerable measure of dominance over the even cylindrical form of fibre, just as, taking examples again of well-known characters in cattle, black is dominant to red, polled to horn, and the white face of the Hereford to plain colour. While the conclusion is only tentative, the Romney breeding results also suggest the dominance of small irregularities. Should this be true, it would be important to choose both parents free from these irregularities; simply choosing for each generation a ram desirable in this regard would bring about improvement only slowly.

Breeding experiments on similar lines to those of last season are now in progress, being planned to have rather more direct bearing on thickened tip. The importance of this breeding-work lies in the possibility that the inheritance of major wool-characters—as distinct from fine distinctions—may turn out to be comparatively simple, just as it long ago proved possible to understand the main features in colour-inheritance in horses and cattle. At the outset Romney wool characters appeared a thorough jumble, and, while their inheritance is far from elucidated after only one season's work, genetic analysis of major features does seem a feasible project. It may be emphasized that the wool-character figuring in our experiments, like lustre and those dealt with more particularly in this report, can all be recognized on the sheep's back in the pen.

Numerical Measure of Thickened Tip and Hairiness.

During the long vacation Miss A. B. Hefford spent three months at the College in work on wool, and was mainly occupied in fibre counts and measurements designed to provide a basis for the numerical expression of the degree of thickened tip or hairiness of a sample. Such numerical expression is of obvious importance in order to measure accurately the results of any experiment on thickened tip or hairiness. We may wish, for example, to correlate parent and offspring, or to measure the influence of feed, weather conditions, or age. A system of judging by eye or hand leaves too much scope for error.

It proved convenient to sort fibres into groups by eye, count the numbers in each group, and then to measure the diameter at selected positions near both the coarse and the fine end where the fibre was appreciably coarser at one end. Brief mention may be made of two of the points that came out in this study.

(1) Thickened-tip fibres were divided into those with the apical end chalky in appearance because strongly medullated, and those sparkling in that region became relatively free from medulla. For each of those groups the ratio

$$\frac{\text{Average diameter of coarse end}}{\text{Average diameter of fine end}}$$

was calculated. This ratio was higher rather than lower in the "sparkling" group than in the "chalky" group. This serves to emphasize that it is difference of diameter in different parts of the fibre that constitutes the primary problem rather than the presence of coarse medulla.

(2) Frequency curves of fibre-diameters for the coarse ends of all the fibre groups combined were plotted. In general, those curves show two peaks—one peak in the region of the coarser thickened-tip fibres, the other peak in the region of the fine even fibres. The first-mentioned peak was well marked

in all the samples; the second one might or might not be so. The fleeces studied were all from four-tocths. For fibres growing throughout the year it is clear to the naked eye that fibre-length is greater or less according as a fibre is coarse or fine. It was, of course, known that there was a wide range of fibre-diameter in the wool samples studied, but a bi-modal curve had not been foreseen. If we were able to consider the weight of each fibre-group, instead of the number of fibres in that group, a curve plotted on that basis would be smoother, for the finer fibres would weigh less. The graphs revealed still another feature about the desirability of which for worsted-spinning one would feel doubts, though such fleeces may well afford excellent protection in harsh weather.

Differential Shearing.—Simple experiments with differential shearing have been reported before. Samples taken at shearing-time, nearly twelve months after the animals were partly shorn, are being examined, the earlier report being based on samples taken comparatively soon after the experimental shearing. This work provides a definite case of the influence of environmental conditions upon medullation. It is hoped to repeat and extend the work when knowledge of fibre-types and their development, and convenient technique of measurement, have provided a more definite basis for such experiments.

Fibre-types and their Development.—For three months during the long vacation Miss D. Spence-Sales, an assistant provided by the Council of Victoria University College, helped in this work.

Lambs from the experimental flocks are being utilized for detailed studies of the development of the fleece. This is a fundamental piece of research which ought, in any case, to be carried out, but in two ways it has particular bearing upon hairiness. It is sought—(1) to learn as early as possible whether the coat of a particular lamb will or will not lead to hairiness when the animal is older; (2) to ascertain whether hairy animals differ in kind as well as in degree.

With regard to (2), it may be explained that in some animals, for example, most of the fibres that are to be hairy have started their development just before birth, while it seems possible that in other animals the hairy fibres, which may be outstandingly hairy, may form only a small percentage of the total fibres, and may start their growth well after birth. Until such pertinent facts are known it will be recognized that the conclusions from breeding experiments must, by so much the more, be tentative. It does seem likely, however, on the one hand, that a big proportion of the animals with hairy tip may be deemed comparable, and, on the other hand, that there are special features about the hairiness of a few animals.

The story of development is a complicated one. The fibre-types of the first year's growth are classified provisionally in ten groups according to structure and developmental history. Several types of hairy fibres fall out. At least some of these shed fibres are succeeded by another fibre grown in the same follicle. This has been ascertained by dissecting out follicles from softened skin. In some follicles in which the original fibre has just completed its growth a new fibre has been found just beginning its development lower in the root. It is hoped that one method or another that is being employed for marking the position of a fibre, and preventing it from being lost on falling out, will prove satisfactory, for in the next crop of lambs this following-up of individual follicles, which can then be planned in the light of the first year's experience, must be done on a much bigger scale.

The shedding of hairy fibres present in the birthcoat raises intriguing questions. What is now said, it will be understood, has reference to the main area of the body. We are not now concerned with extremities, like the poll, or tail, or britch. The coarsest hairy fibres in the birthcoat—those to which the term "kemp" is often applied in the literature—fall out. Of the less coarse birthcoat hairy fibres—called "heterotypes" by Duerden—some fall out, while some remain in the fleece. Many of those which are retained show basal to a subapical thinning a hairy region of some 2 in. or 3 in. In the birthcoats of some fine-coated animals, apart from the definitely shed kemps, there are very few hairy fibres, if any, other than heterotypes, and it seems highly probable, if a birthcoat heterotype is not shed in the early months of life, that it will persist from year to year, and that each year a part of the fibre grown in the spring or summer will be hairy. What, therefore, determines the shedding of these fibres in the lamb's coat? Viewing the range of hairy fibres—the coarser shed, the finer retained—one wonders whether a fibre that once retains a certain rate of growth will fail to maintain itself in the skin. For this reason, apart from other reasons that exist, it is highly important that the growth-rates of individual fibres should be investigated.

Miller, at Edinburgh, is studying the effect of thyroxin upon the shedding of kemp. Our problem of the shedding of birthcoat heterotypes no doubt has much in common with Miller's problem. The age, or stage of development of the animal, at which birthcoat hairy fibres are shed is also likely to be important. Roberts some time ago was of the opinion that lambs shedding the hairy fibres of the birthcoat quickly had adult fleeces less hairy than lambs which retained those hairy fibres for a longer time. Assuredly, in the Romney breed, lambs vary greatly in the length which the birthcoat kemps attain before they are shed. It is already apparent that a lamb with many hairy fibres in the birthcoat that are shed may or may not have a completed first fleece that is hairy.

Summary.

(1) In breeding experiments a beginning has been made in the study of the inheritance of wool characters in the New Zealand Romney. These experiments have reference especially to thickened tip, including hairy tip, and to harshness.

(2) One convenient method has been found for obtaining a numerical measure of thickened tip and hairiness. In the course of this work various facts about the wool-samples studied were brought out that could hardly have been discovered without counts and measurements.

(3) Experiments with differential shearing have provided a definite case of medullation being influenced by environmental conditions.

(4) A detailed study is in progress of the fibre-types and their development. This is the most fundamental part of the biological work, and should provide the basis for many breeding and other experiments.

During the year, practical liaison was effected with the British Research Association for the Woollen and Worsted Industries, and results of all the investigations conducted by the staff of the association at Torridon and elsewhere will henceforth be available to the Committee. In view of the considerable extent and marked progress of the investigations conducted by this association this connection is one of much value to local research workers.

Advantage was taken of this arrangement to secure representative samples of Romney fleeces grown throughout New Zealand, and after selection and retention of duplicates these have been forwarded to Torridon for examination and report. The defects in the character of New Zealand Romney wool, as alleged by English manufacturers, have so far proved somewhat elusive and ill-defined, and this means of ascertaining the full nature of the defects, and possibly remedial measures is being resorted to.

It will be to the ultimate advantage of the New Zealand wool industry to supply material of the particular quality required by manufacturers. The facilities offered by the Research Association for the Woollen and Worsted Industries are therefore being availed of, to give indications as to possible improvements desirable in our wool in order to better fit it for spinning purposes.

In order that the investigations at Torridon may be followed closely and the maximum advantages derived from them, and in order to ascertain to what uses Romney wool is being put by English manufacturers, Mr. D. J. Sidey, B.Ag., of the staff of Canterbury Agricultural College, has been sent to England for this purpose.

The Committee, being fully aware of the complexity and of the importance of the wool problem as affecting the Dominion, has decided to follow a cautious policy and to acquire the fullest information on the whole subject before launching a comprehensive scheme of research. The work undertaken so far has therefore necessarily been largely of an exploratory nature.

FUEL RESEARCH.

Advisory Committee: Colonel W. D. Holgate (Chairman), Professor H. G. Denham, Mr. W. A. Flavell, Mr. A. H. Kimbell, Mr. Robert Lee, Dr. J. S. Maclaurin, Mr. H. Vickerman, 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. K. R. McDowell, M.Sc.

During the past year the chief work on hand has been the low-temperature-carbonization investigation of New Zealand coals. The carbonization of New Zealand sub-bituminous, or "brown," coals was first undertaken. These trials have now been completed, and the results obtained with Waikato coal have been published in bulletin form, whilst those with coals from the Kaitangata and the Ohai Coalfields are in the press.

The carbonization experiments have been carried out in a Fischer rotating retort taking a charge of 35 lb. of coal. The retort is fitted with suitable condensing and receiving apparatus, and an attempt has been made to make as complete a recovery as possible of the different products of carbonization. The yields of carbonized residue, tar-oil, aqueous liquor, light spirit, and gas have been determined for each coal.

Analyses have been made of the carbonized residue and the gas, whilst a preliminary examination of the tar-oil has been carried out. The results of this examination reveal the general nature of the tar-oil, which is very similar for each of the coals examined. Since these coals do not coke when carbonized, the carbonized residue would probably best be utilized in the form of briquettes. Briquettes made with such carbonized residue with the addition of an appropriate binding-material should prove an excellent fuel, free from smoke and of a fairly high calorific value. It should also be possible to make use of the residues, when pulverized, in dust-fired furnaces.

These low-temperature-carbonization investigations are now being extended to the bituminous coals of the west coast of the South Island. The problem in this case is somewhat different, since these are coking-coals, which in many cases yield a highly swollen carbonized residue. A number of the bituminous coals also contain comparatively high percentages of sulphur.

Millerton coal has been chosen for the initial experiments on this class of coal, and a number of laboratory assays and coking experiments have been made with a view to modifying the highly swollen nature of the coke. The effects of blending with non-coking coal or inert material, and the rate of heating, have also been studied.

The condensing and receiving apparatus used with the rotary retort is being modified in order to enable a determination to be made of the sulphur which comes off as sulphuretted hydrogen during carbonization.

One of the staff (Mr. W. G. Hughson) has assisted with trials carried out by the Railway Department on the use of New Zealand coals for locomotive purposes.

An experimental briquetting plant has been ordered from England, and is expected to arrive soon. It is proposed with the help of this plant to carry out some briquetting trials on blends of bituminous and sub-bituminous coals, carbonized residues, &c., and to experiment with various binders. The press will have a capacity of about 5 tons per day, so that a sufficient quantity of briquettes for actual firing trials can be readily produced.

Publications :—

(1) "Low-temperature Carbonization of Blended New Zealand Coals," by W. G. Hughson. Bulletin No. 10. N.Z. Department of Scientific and Industrial Research.

(2) "Low-temperature Carbonization of New Zealand Coals; 1—Waikato Coal," by W. A. Joiner. Bulletin No. 14. N.Z. Department of Scientific and Industrial Research.

In the press :—

(3) "Low-temperature Carbonization of New Zealand Coals: 2—Kaitangata and Linton Coals," by W. A. Joiner. Bulletin No. 20. N.Z. Department of Scientific and Industrial Research.

FRUIT RESEARCH.

A grant of £150 made to the New Zealand Institute of Horticulture for bud and stock selection work in connection with citrus fruits has been continued. Reports received from the Auckland branch of the New Zealand Institute of Horticulture have indicated that steady progress has been made with this work, but that it is too early to determine how far the stocks which have been imported from California and Australia are proving suitable for New Zealand conditions. The formation of a comprehensive scheme capable of providing for the Dominion's requirements in this direction, in view of the expanding fruit-export trade, has been the subject of a number of conferences with representatives of the industry, the Cawthron Institute, and the Department of Agriculture.

Arrangements have almost been finalized for the acquisition of a suitable experimental orchard property which will provide for field experiments and further investigatory work relating to the transport and storage of our main varieties of fruit. The Empire Marketing Board has in this instance made a generous offer of financial assistance towards the work proposed.

LEATHER RESEARCH ASSOCIATION.

Report for the Period 1st April, 1929, to 31st March, 1930.

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

During the year the Committee suffered the loss of one of its members owing to the death of Mr. A. M. Wright.

Report by the Research Chemist.

The aim of the association is to produce in New Zealand, from local supplies of raw materials, leather which will compare favourably with that produced in any other country both as regards appearance and wearing-qualities. With this object in view the tanneries have been visited periodically, and the processes used thoroughly investigated and discussed with those in charge. Where possible, factory experiments have been instituted to determine the direction along which improvements could be made.

One of the chief problems encountered was the determination of what course should be followed to improve the general appearance of the leather. This was necessary from the selling point of view. Other things being equal, the best-looking article is most easily sold. It is pleasing to record that progress has been made in this direction, and experiments are being carried out to bring about further improvement.

The economic aspects of the various processes have been investigated, with the result that better yields of leather have been obtained. As a result of this, tanners have been able to reduce the price of leather to an extent over and above that due to the general fall in the price-level of hides. By obtaining better yields the tanner not only has increased the efficiency of his factory, but also has been able to give greater satisfaction to his customers.

Throughout the year tanning-materials have been subjected to regular analysis, and by this means tanners have been supplied with knowledge which has served to assist and guide them in the control of their various processes. This phase of the work is both capable and worthy of considerable extension.

Endeavours have been made to eliminate waste products, both by reducing their actual quantity through adoption of improved processes, and by their conversion into useful by-products of the industry. In this direction there is still much scope for investigation.

It has been apparent that too wide a gap and too little contact exists between the manufacturer and the user of leather. In order to bring the tanner into closer touch with the defects of his leather, as far as possible visits have been made to the boot-factories. In this way it has been possible to determine the actual requirements of the large users of leather. Much information has been obtained, with the result that leather which otherwise would have been purchased abroad has been secured from New Zealand tanners. This work is capable of being developed to a greater extent, with advantage to the tanner and the boot-manufacturer.

Contact has been maintained with those Government Departments which purchase leather. These Departments have rendered valuable assistance in the direction of providing facilities for the conduct of practical tests on the wearing-qualities of New Zealand sole-leather. These tests are still in progress both in the North and South Islands. So far it has been shown that, on the whole, New Zealand sole-leather compares well with the best imported leather.

Imperfect flaying of hides has affected the quality of the raw material of the leather industry. Consequently, information has been circulated to all those concerned, stressing the importance of due care being given to this process. The annual loss due to the poor "take off" of hides and pelts is large, and could be avoided by the adoption of better methods in abattoirs and freezing-works.

Work is being carried out in conjunction with the British Leather Research Association on the curing of hides. Some damage, known as "red heat," "pinking," or "salt-burn," occurs in New

Zealand hides, and is due to bacteria present in the salt used for curing purposes. Experiments are being carried out to determine the best denaturant of salt to be used to prevent this damage.

Analysis of locally-grown varieties of bark suitable for tanning purposes has been continued. At present it seems that until some means has been found to combat the fungus which attacks the wattle-tree (*Acacia decurrens*) there is little likelihood of local production being increased. If this disease can be effectively dealt with, there is no reason why the amount of bark required by the tanners should not be grown entirely in New Zealand.

During the past year attention has been devoted to the chemical analyses both of New Zealand leather and of imported leather. These analyses have been associated with wear tests on the special testing-machine used.

Work is now in operation to correlate, if possible, microscopical examinations of leather-texture with its wearing-qualities.

Conditions affecting the water-absorbing qualities of leather have been under review, and a report thereon has been circulated to members of the association. Water-absorption by leather is very important from the boot-manufacturers' as well as from the wearing point of view. The bootmakers are faced with the difficulty of obtaining a bright clear finish on shoe-soles. If alterations in the processes now used in the boot-factories are to be avoided, attention must be given to reducing the water-absorbing qualities of the sole leather.

Further investigations are being made regarding the wearing-qualities of leather. Progress in this very important problem is slow, on account of the number of processes which have to be employed before the finished article is obtained. An alteration at any one stage not only affects the leather, but also the other processes. Thus it is extremely difficult to determine whether the altered wearing-value is due to the reaction on the leather or to the reaction on the succeeding processes.

An endeavour has been made in a very limited time to demonstrate that improvements can be effected in the fellmongering of sheep and lamb skins produced in some of the freezing-works. In this connection sample lines of skins have been processed by different methods for special trial. Shipments of these skins have been made to England and America for submission to manufacturers. It is expected that in this way it will be possible to ascertain with certainty the requirements of the actual users. At the same time endeavours are being made to expand the uses of New Zealand pickled pelts.

RADIO RESEARCH.

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

During the year arrangements have been completed for New Zealand's adhesion to the International Scientific Radio Union, which is one of the sections of the International Research Council. Membership of the Union will greatly facilitate the arrangement of experiments which may involve a certain amount of co-operation with foreign countries. An exchange of information has also been arranged with the British and the Australian Radio Research Boards respectively, so that there may be a proper co-ordination of the work and any overlapping may be avoided.

The Committee has decided to pursue, initially, a modest programme of research, involving work in connection with "atmospherics," measurements of field strength of local stations, and measurements of the diurnal variation in strength of certain Australian stations. It is also intended to carry out experiments in connection with the total solar eclipse which takes place in October, 1930.

In connection with "atmospherics," work is already in progress at Auckland University College, where a suitable direction-finder, utilizing a cathode-ray oscillograph is being developed, with the object of determining the direction of arrival of individual "atmospherics." If the preliminary work with this apparatus shows sufficient promise it is probable that a second set will be installed at Otago University, when, by utilizing land-line communication between the two stations, it should be possible to locate the position of the source of individual "atmospherics." As it is now fairly well established that "atmospherics" are intimately connected with particular meteorological conditions at the place of origin, it is hoped that the subsequent development of this work may play an important part in providing additional meteorological information from the Tasman Sea area.

Work is in progress at Victoria University College on the automatic recording of the signal-strength of certain Australian broadcasting stations. It is intended to analyse the records to determine whether there is any correlation between the signal variations and meteorological conditions over the Tasman Sea.

A detailed programme is being drawn up for work on measurements of the field strength round certain local broadcasting and Government wireless stations. The results of this research should be of direct benefit to the Broadcasting Company in enabling them to plan their services to the best advantage, and it is hoped, when the plans are finalized, that the Broadcasting Company and the Post and Telegraph Department will actively co-operate with this Department in the experiments.

The path of totality of the solar eclipse in October next passes across the Pacific Ocean, running between Fiji and Samoa. Arrangements will be made for measurements in New Zealand of signals originating in Honolulu and for measurements in Fiji of signals originating in Samoa, and *vice versa*.

The amateur wireless organizations in the Dominion will be given an opportunity of co-operating in this experiment.

STANDARDS AND STANDARDIZATION.

Proposed Standards Laboratory.—The report of the preliminary committee recommending the establishment of a laboratory for physical standards was placed before Cabinet, who approved the general scheme and the setting-up of a technical advisory committee, composed as follows: Professor J. E. L. Cull, representing University engineering interests; Professor C. C. Farr, representing the

New Zealand Institute; Professor D. C. H. Florance, representing Professors of Physics; Mr. F. J. Jones, representing the New Zealand Society of Civil Engineers; Mr. F. T. M. Kissel, representing the electrical-engineering interests of the New Zealand Society of Civil Engineers; Mr. W. L. Newnham, representing the Public Works Department; Mr. G. A. Pascoe, representing the New Zealand Manufacturers' Association; Mr. J. R. Smith, representing the Post and Telegraph Department; Mr. H. Vickerman, representing the Council of Scientific and Industrial Research; Mr. G. W. Wyles, representing the New Zealand Railways; Dr. E. Marsden (Secretary).

The committee has drawn up detailed recommendations and estimates as to immediate requirements in connection with the standards laboratory. It is proposed to provide standards and equipment for measurements of engineers' gauges and of electrical apparatus and measuring instruments of various kinds, also for the checking of thermometers and pyrometers, and for the measurement of the candle-power and efficiency of lamps, &c. At the present time there are no official electrical standards, or standards of temperature or of candle-power in the Dominion, and it is hoped that the new laboratory will fulfil what has now become an urgent demand.

Standardization.—With the development of New Zealand's secondary industries the question of standardization is becoming increasingly important. The need for adopting certain phases of standardization in the Dominion has been increasingly felt for some time, and during his recent visit Sir George Julius, Chairman of the Commonwealth Research Council, emphasized the importance of such measures and the benefits which had been derived from standardization in Australia. While it is necessary to have some executive body to carry the proposals into effect, it is fully appreciated that in the case of any particular product or material a request for standardization must first be made by the industry or industries concerned. It is not intended that standards should be forced on any industry, but that the necessary administrative machinery should be set up so that where the benefit of any particular standard is mutually recognized it can be given an official status.

An important conference of interested parties was held on the 4th July, when a scheme recommending, in general, the adoption of British standards was approved, and a local committee, established to act as a liaison body with overseas standardizing associations, was constituted. Modifications of British standards, such as will enable them to be made of greater application in New Zealand, will be brought to the notice of the British Engineering Standards Association.

FOREST BIOLOGICAL RESEARCH STATION.

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

First Annual Report.

By A. F. Clark, Forest Entomologist.

Buildings.—The erection of a suitable building in reinforced concrete has been undertaken by the Cawthron Trust Board. When completed, it will contain three small laboratories, one large general laboratory, and a library and committee-room. It is expected that possession of the building will be obtained in May; in the interim the staff is being housed by the Cawthron Institute.

Staff.—The staff consists of Dr. D. Miller, Director of Researches; Mr. A. F. Clark, Forest Entomologist, seconded from the State Forest Service; and Mr. L. J. Dumbleton, Assistant Forest Entomologist.

Equipment.—The equipment for the Forest Entomologist and Assistant Forest Entomologist was brought by Mr. Clark from the State Forest Service, and arrangements have been made to purchase further apparatus in Europe. Use has been made, where necessary, of the Cawthron Institute insectaries, pending the erection of those to be used solely for forestry investigations.

Researches.—The programme of researches during the past year has been a wide one. Good progress has been made, and the results secured have been most satisfactory. In view of the large afforestation schemes which are being developed by the State Forest Service and many private companies, the investigations have been mainly into the insect pests of exotic timber-trees. Minor routine studies of matters affecting the indigenous timbers, however, have been carried out during the year, and preparations made for further extending the programme to embrace the more outstanding of the problems connected with the growth and utilization of the native timbers.

Insect Survey.—The insect survey has as its object the collection of data upon the distribution and degree of infestation of insects affecting exotic timber-trees. Of necessity, as much matter concerning site factors, growth, and the silvical treatment of the various stands must be procured at the same time; in fact, while the prevalence and degree of damage caused by insect pests is measured, all the factors which enable the conditions so measured to obtain must be noted and weighed. The survey has been extended this year to the Auckland and Rotorua districts. The latter district contains the largest area under exotic trees in the Dominion. While much valuable data were obtained, the field-work undertaken in the Rotorua district is only considered to be a preliminary reconnaisance in preparation for more intensive work next year. To facilitate this further work the establishment of a permanent field station has been decided upon. The survey is considered to be a vitally important part of the researches, the results determining to a large extent the particular pests upon which investigations shall be carried out.

Sirex juvencus.—The control of *Sirex juvencus* by use of the ichneumonid parasite *Rhyssa persuasoria* has been undertaken. During the year consignments of this insect have been received from Farnham Royal, and from these adults have been successfully reared. No difficulty was

encountered with mating, and distribution of the parasite to infested stands at Hanmer Springs, Dumgree, and Blenheim, in the South Island, and at Palmerston North, in the North Island, has been made. It is too early to state definitely whether the insect has established, but observations made at the time of liberation are most encouraging, oviposition upon infested trees being observed. While the biology of *Sirex* is known generally, more intensive studies into the question are being prosecuted in view of the arrival in the near future of a further parasite from Europe. On all occasions the improvement of the silvicultural conditions of the infested stands has been urged.

Neomyzaphis abietina.—The spruce-aphis attacks members of the genus *Picea* in New Zealand, and is particularly severe in the case of *P. excelsa* and *P. sitchensis*. These two trees are subject to repeated defoliation and are ultimately killed. Studies have been carried out upon the biology of the insect, and one complete generation has been followed through. The occurrence of allate forms and the question of migration is receiving close attention: the possibility of the insect alternating with some plant outside the genus *Picea* is a most important one. Records of past fluctuations in the degree of infestation have been searched, and attempts to correlate ecological factors with these have been but partically successful, the paucity of reliable data proving a considerable handicap. A Hemerobid parasite of the spruce-aphis has been discovered in New Zealand, but its occurrence has been ascertained to be too slight to have any marked controlling influence upon the pest. The aphis does not attack the spring foliage of the spruce, but the advent of the conifer spinning-mite, which does attack this foliage, has made a complication in the investigation, which has consequently been extended to include the mite. Inquiries for suitable parasites of *N. abietina* have been made, and it is hoped that such an insect will reach New Zealand next year. The investigation into the insect enemies of spruce is one of the Station's most important activities, as it is well known that in spruce one has the most valuable tree for the production of paper-pulp.

Hylastes ater.—The initial outbreak of this insect, which occurred at Foxton, was recorded in July. The insect was quickly identified, and a survey made to ascertain the entent of the infestation with a view to putting into force measures for the total eradication of the pest. Unfortunately, the insect was found to be firmly established over an area too large in size for such measures to be attempted. The insect develops in the stumps and roots of pines, and in the adult stage attacks young conifers. The life-history of the insect has been worked out, and plans for its control by means of trap stems formulated. In co-operation with the State Forest Service, sample plots have been placed in the infested area and careful records are being kept of the actual loss which this insect is causing.

Eucalypt Pests.—The research into the pests of eucalypts concerned two insects.

(*a*) *Gonipterus scutellatus:* The control of this weevil by the introduction of a Mymarid parasite was attempted in 1927–28, when the parasite was reared and widely distributed throughout both Islands. Efforts to recover the parasite in the field not having been successful, it was decided to make a further introduction. Supplies of parasitized material were received from the Australian Bureau of Entomology, and from this material adult parasites were obtained. The breeding of New Zealand generations was completely successful, and adults from each generation, as well as parasitized material, were distributed in Nelson, Canterbury, and the Wairarapa. In January, however, Mymarids, the progeny of the original 1927–28 introduction were recorded in the field at Auckland and Cambridge, proving that the insect was already established in these localities at least. The work of rearing further supplies of the parasite was therefore discontinued and the whole of the parasitized material distributed.

(*b*) *Eriococcus coriaceus:* The collection and distribution of the ladybird *Rhizobius ventralis*, both in the adult and larval stages, has been continued. The ladybird is plentiful in the South Island, where it controls the scale insect, but is not so common in the North Island, the scale being a comparatively recent arrival in the North. Consignments of ladybirds are therefore sent from the South to the North at intervals. During the past year larvæ have been worked with upon most occasions, on account of the rather heavy mortality occurring amongst the hibernating adults.

Skin-infesting Insects.—Attention was drawn by the State Forest Service to insects infesting opossum-skins. Such damage was ascribed by the fur trade to the "weevil," but it was found that a number of insects were responsible for the damage. This work has been finalized, and a short account is given in the *Journal of Agriculture*, Vol. 39, No. 4, October, 1929.

Insects Infesting Forest-tree Seeds.—The infestation by foreign chalcids of the seeds of Douglas fir and wattle grown in New Zealand led to an extensive investigation of all imported tree-seeds. The results showed that not only were the seeds themselves infested at times, but that live insects in all stages were present in the accompanying debris. A cheap and effective method of fumigation was worked out and is now applied successfully by the State Forest Service to all tree-seeds, both imported and locally collected.

COOL STORAGE.

Cool-storage investigations during the year have been extended to deal with mutton and lamb, and cheese, while those concerned with fruit have been continued.

Meat.

Arrangements were made with the Food Investigation Board of the British Department of Scientific and Industrial Research for a survey to be undertaken of the freezing-works in New Zealand and of the conditions prevailing during overseas transport. The survey party, consisting of Drs. Griffiths and Vickery, and Messrs. Haddow and Holmes, arrived in New Zealand immediately prior

to the opening of the slaughtering season, and conducted a series of surveys of the conditions prevailing in the meat-freezing works and during transport to the ship. Selected lines of sheep and lambs of known pedigree, history, and in some cases fed on a known diet, were slaughtered and followed closely in regard to temperature, weight-changes, moisture-losses, &c., from the works onwards. Consignments of these selected sheep were maintained under continuous observation on the voyage to Great Britain, where the scientific examinations will be again resumed, and a report will be issued outlining the results and such amendments as may be suggested for the elimination of defects such as loss of bloom and weight, which are reported to occur in shipments of our mutton and lamb.

Pork and Bacon Investigations.

During the year a number of investigations on the effect of fluctuation in temperatures upon the keeping-quality of pork, and its subsequent influence upon bacon produced in this country, were conducted at a cool store in Wellington. The general result of these investigations indicate that fluctuations in temperature caused marked deterioration in the quality of the bacon produced, and where the variations have been extreme it was found impossible to make bacon from the pork which had deteriorated to such an extent in cool storage.

Cheese.

During the year investigations were inaugurated into the behaviour of cheese from the factory stage until its arrival on the London market. The Dairy Research Institute and the New Zealand Dairy-produce Board have co-operated in the provision of cheeses made under normal factory practice and under specified conditions. These cheeses have been maintained under known and measured conditions of temperature during storage and transport, and on arrival in London were again examined by the British Dairy Research Institute at Reading and by the Cambridge Low-temperature Research Station.

Fruit.

A series of experiments dealing with the behaviour of fruit in the holds of vessels while being transported overseas was completed in the previous season, and no further experimental consignments were despatched during this season. The complete report of the experiments is now being prepared, and will be shortly issued in London. Meantime the land store work of the Cawthron Institute has been continued, investigations dealing with the influence of soil, climate, storage, &c., on the six main export varieties being detailed below :—

The special feature of the year's work has been the study of maturity at picking-time and the temperature of storage in relation to the carriage of export fruit from New Zealand to England. The experiments have been designed to indicate the ideal treatment required by the more important varieties so as to ensure satisfactory condition on and after arrival of the fruit on the Home market. Conditions ruling in ordinary commercial practice have been simulated as far as possible in the experiments, so that the results of the work may have direct practical application. The varieties dealt with are Cox's Orange, Dunn's Favourite, Jonathan, Delicious, Statesman, and Sturmer, the principal varieties exported from New Zealand. Fruit was taken at two stages of maturity and stored at each of three temperatures 32° F., 35° F., and 38° F. After two month's storage, part of the fruit was examined immediately, and part was left at ordinary temperatures and examined at at the end of three weeks. Records were kept of the incidence of physiological and fungal diseases, and notes were made on the general appearance and quality of the fruit.

The association of internal breakdown with low temperature has been found to hold good for all varieties, but marked differences in resistance to the disease are shown by the individual varieties. Cox's Orange has been shown to be a particularly sensitive variety, Jonathan is fairly susceptible, Sturmer and Dunn's Favourite show a moderate degree of resistance, Statesman is still less markedly affected, while Delicious is practically unaffected by the disease. Storage temperatures have been suggested which will reduce the possibility of internal breakdown development to a minimum, having regard to the other factors which influence the condition of the fruit, and where a variety is tolerant of a range of temperature this has been indicated.

Cox's Orange is the only one of the six varieties that has shown any extensive development of bitter-pit. This disease is confined almost entirely to fruit of the early picking, and has been found more prevalent at high storage temperature. Low temperatures in store arrest the progress of the disease, but do not prevent its subsequent development when the fruit is taken out of store and kept at normal temperatures. In consideration of the risk of internal breakdown, low storage temperature is not recommended as a means of control of bitter-pit ; avoidance of early picking is suggested as the best method at present available.

Deep scald, a disease occurring chiefly in the Jonathan, has been shown to be associated with excessively low storage temperature. A temperature of 35° F. appears to be the lower limit beyond which a more or less extensive occurrence of scald may be expected. At 38° F., complete control of the disease was secured. Early-picked fruit is more susceptible than late-picked, and following a two-months' storage-period there is found a marked advance in the progress of the disease on removal of the fruit to outside temperatures.

Jonathan-spot is shown to occur only in late-picked fruit, and its development is favoured by storage at high temperature.

Where orchard operations have been carefully carried out, very little fungal trouble should be experienced in the overseas transport of any of the varieties under experiment. Practically the only serious losses due to rots occurred where the fruit was already damaged in some way or other by unsuitable storage conditions. Apples showing breakdown or deep-scald were found to be particularly

susceptible to fungal attack, and, as these diseases occur mainly at low temperature, the apparently anomalous result was obtained that fungal diseases were more prevalent at low temperature than at high. The practical interpretation of this result is that the lowering of storage temperature to minimize fungal development must not be carried to the point at which the physiological diseases mentioned above begin to occur. A bulletin covering details of experimental work and results has been published—Bulletin No. 23: "The Relation of Storage Temperature in the Overseas Carriage of Some Varieties of New Zealand Export Apples," by L. W. Tiller.

In addition to the above outlined experiments, further work has been carried out on the lines of that of previous seasons. Additional data have been obtained bearing on the effect of storage temperature and storage humidity on the incidence of internal breakdown. Other aspects of the storage problem which have continued to receive attention are the effects of soil conditions, orchard-manuring, and root-stock on the keeping-quality of the fruit. It is worthy of note that Jonathans grown on a seedling stock continue to show a very marked superiority in resistance to internal breakdown over those grown on Northern Spy and Double Vigour stocks.

A commencement has been made on this season's work, which includes a more detailed study of the Cox's Orange and Jonathan under export conditions; in addition to these two, Cleopatra and Rome Beauty will come under experiment. Storage arrangements have been made with the Nelson Freezing Co., Ltd., similar to those of last year.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

Plant-breeding.

A. Cereals.

(1) *Wheat.*—The work done by the College has been fully co-ordinated with that done by the Wheat Research Institute so that both efforts are directed towards the same ends and so that there is no overlapping. The College supplies laboratory accommodation and equipment, land, horses and implements, a great proportion of the labour, fields for extensive trials and multiplication, and organization for seed dressing and pickling, and distribution of the wheat to farmers. The Wheat Research Institute supplies the Geneticist (Dr. O. H. Frankel) and the expert labour needed for the sowing and harvesting the small plots, where greatest care is required, and for the subsequent examination of the wheats harvested, and the laboratory apparatus, as distinct from equipment. The Wheat Research Institute also makes milling and baking tests to secure selection of the best wheats. In this way what we consider the highest efficiency is obtained and the best value for the money expended. As a result the wheat-breeding work has been greatly increased in respect of both extent and thoroughness, so that the work has advanced with the advance of knowledge and of the requirements of the industry.

Last May 25 acres were sown in wheat-plots either with the drill or by hand. These were the usual half-drill strip trials of varieties, straws and crossbreds, which had reached the yield-trial stage, accounting for 381 plots. Selections from crosses approaching the yield-trial stage were sown in 2,010 plots; propagation of pure seed of hopeful crosses occupied 587 plots. Recent crosses being bred up from observation occupied 61 plots. There were small-scale yield trials largely for the purpose of comparing the accuracy of the rod-sow with the chess-board method to the number of 360 plots. A collection of varieties of wheat from all over the world, made with the object of studying their possibilities for crossing with New Zealand wheats, reached the number of 1,136. Single-head selections, rare New Zealand varieties, trials for susceptibility to loose smut, &c., ran to 457 plots, making a grand total of 4,992 plots, of which 4,590 were sown by hand. These were subjected to intensive study during the growing season, and after harvest to elaborate analysis of the qualities influencing yield. This work is still proceeding as the basis of selection for next season's sowing.

A heavy disappointment was experienced in the harvesting of crossbred 79/13, which had almost reached the stage of distribution to farmers, and of which great hopes had been entertained as an improvement both in quality and yield. For three years it had been equal to Tuscan in yield and was very much better in quality, but this year, although its high quality was maintained, its yield was 5 bushels less per acre than Tuscan. It has not been finally abandoned, but our hopes in it are considerably lessened.

The derivatives of 161 families of crossbreds also gave disappointing yields compared with Tuscan, thus demonstrating only too clearly the magnitude of the task set in attempting to improve our existing varieties. From these failures we have learned that a more careful study must be made of the wheats used as parents, and that very large numbers must be secured of the crosses finally decided upon. Organization to obtain these ends is now in hand.

In several varieties material was obtained for milling and baking trials in the laboratory of the Wheat Research Institute. Four wheats were sown side by side in winter and spring. Ten varieties were cut on the green side and completely ripe. Nine varieties were stook and stack threshed from the same plot.

(2) *Oats.*—A few crossbreds Garton × Algerian were put under a yield trial for further observation. The College pure strain of Algerian B 49 has now been distributed to farmers. No yield trial was made of it last season, as it had outyielded the original selection for five years. On a rather poor field last year it produced 78 bushels per acre, and a total of nearly 3,000 bushels were sold.

B. Herbage Plants.

(1) *Cocksfoot.*—Three hundred and fifty clones have been under observation during the past two years, notes being taken in the characters of each at frequent intervals, but especially at the critical

periods for grass-production. As all these clones came from an old pasture on Canterbury wheat land, an attempt was made to describe the cocksfoot-seed from such land by classifying the clones that came from it by the system of Stapledon. The analysis shows—Dense pasture types, 34·3 per cent.; spready pasture types, 19·4 per cent.; cup types, 9·7 per cent.; tussock types, 32·9 per cent.; dense hay types, 3·4 per cent.; lax hay types, 0·3 per cent. The high proportion of dense pasture types in this random selection shows the good quality of the plains cocksfoots.

Besides observations in rows, the best clones have been planted in plots and kept close mowed, but their product at critical times of the year and their proportion of stem to leaf are the bases of comparison. The best strains were also planted out where they can be grazed by sheep, to watch their reaction there. Specimens of all the types are also in this grazing trial, and about one hundred other strains are under continuous grazing for observation.

The production of seed from the cocksfoots selected involves technical difficulties owing to cross-fertilization by wind. The necessity is that the offspring be reasonably like their parents, and that presupposes that the parent was relatively pure bred. To test the purity of the parent, and the truth of the offspring to type, elaborate experiments have been made. These are not suitable for general description, but they involve thousands of sowings and plantings, and cuttings and weighings. Correlations of 0·84 and 0·90 have been obtained between parents and offspring in respect of length and breadth of leaves, this showing, as far as it goes, that the material used and the method of seed-production adopted are likely to give improved strains of practical utility.

The best strain so far isolated (C 23) was planted out on an acre of land. This produced about 100 lb. of dressed seed, which is being sown under field conditions for seed-production on a commercial scale. Small plots sown with this seed give promise of reasonable increase over the best bought seed.

The cocksfoot-plots that were growing on light land in Nelson and Marlborough, Mid-Canterbury, South Canterbury, and Mid-Otago have been closely selected, and the best of each lot are now growing in competition on similar land a few miles from the college. A selection of cocksfoot for light shingle country should soon be available.

(2) *Rye-grass.*—Observations were continued on 300 clones of plants obtained from permanent pasture on Canterbury wheat land. The thirteen best were planted out in wheatfields for shelter fertilization, and a fair amount of seed was obtained from certain of the strains. The seed has been sown, and observations are now starting in the young plants, as it is only the plants produced from seed that are of commercial interest. The best pasture-plants were interpollinated by hand to find parents the most valuable offspring. The number of crossbred seed obtained varied very greatly. In the twenty-eight crosses made the percentage of seed set varied from 0 to 72 per cent.

Some rye-grass strains of great promise are growing in Marlborough and in Central Otago. This will be selected during the coming winter.

(3) *Red Clover.*—Of 160 original selections thirty have been preserved. These have been planted out anew together with 200 more from old Canterbury pastures, and sixty from Cornish marl. Differences of 100 per cent. in yield are not uncommon, even among these permanent types, and difference in proportion of leaf to stem, productivity at critical times of year, and rapidity of recovery after grazing are equally striking. Here, again, the production of seed reproducing the parental excellencies is necessary for commercial purposes, and this forms the basis of our present work.

Seed raised in various ways from the seven best plants has been sown and thousands of cuttings and weighings have been made throughout the year. In case 1 the two very best plants we enclosed in the same cage and crossed by washed bumble-bees. In case 2 the five next best were all included in one cage and interfertilized similarly: In case 3 the same five were grown in the open and seed collected from them. Twenty plants from each lot were cut and weighed for the following yields: Case 1, best pair crossed, 457 grains of leaf; case 2, next best five interpollinated, 282 grains of leaf; case 3, the same five open interpollinated, 214 grains of leaf.

This result offers considerable promise of greatly increased clover-yield. The plants weighed from the cross of the best pair are of a very good type, and some thousands of cuttings of them are now growing in the greenhouse for transplanting to the field for shelter interfertilization and the production of seed to be sown in a field.

Pig-feeding.

During the year ending March, 1930, the work of testing out meat-meals with different classes of feeds has been continued. The state of affairs has now arrived where most of the meat-meals on the market are of uniformly high quality, and if the ideal of an identical quality were possible a very forward step would be made. Meat-meals are valuable only for their protein content, and if one uniform quality were on the market the user of meat-meal would be benefited. Further work is being directed towards ascertaining the efficiency of "fat-free" meat-meal. Other aspects of pig-feeding that have been investigated during the year are—(1) The value of grazing for pigs; (2) the value of self-feeders as against hand feeders for pork-production; (3) methods of control of pleurisy; (4) costs of bacon as against pork-production; (5) investigation of relationship between eight-weeks weight and sixteen-weeks weight; (6) investigation of the composition of various (thirty-two) proprietary and other pig-meals. These subjects are fully reported on in the half-yearly reports for September, 1929, and March, 1930.

Export Carcasses.—In conjunction with the Meat Board and a Christchurch freezing company, all porkers reared have been exported and judged at Smithfield by the expert men whose services have been secured by the Meat Board. The history of every pig is known from birth to slaughter; each pig is tagged with a distinctive number, is judged before being sent away, and these judgments compared with those of Smithfield buyers. When sufficient of these tags come back it will be possible to define without further trial the type of carcass most suitable for the London Market.

Calf-feeding.

Two experiments on calf-rearing were conducted during the year. A dozen calves were reared on each farm on whey and meat-meal and 10 gallons of whole milk, with excellent results, at a cost of about 14s. per calf. The calves at twelve weeks, when weaned, were over 220 lb. live weight, and were in perfect health. Using meat-meal with whey puts an entirely new value on whey, and the practice, if adopted, should make a very great difference to farmers in whey areas. The results were published in the *Canterbury Chamber of Commerce Agricultural Bulletin No. 10.*

Sheep Investigation Work.

(1) *Grazing Trials on Small Top-dressing Trial Plots.*—The plots were originally laid down to test the value of different manures for grassland top-dressing by means of hay weights. For three years now the plots have been grazed by sheep, and records kept of the number of days of grazing and the live-weight increases obtained from each type of manuring. The results so far obtained show that neither hay weights nor days of grazing are a true criterion of the effects of the manures on the pasture, and that a more elaborate scheme should be started to investigate this work further.

(2) *Experimental Grazing on Large Fields.*—The object of these experiments is to demonstrate the value of intensive rotational grazing, and to show how it can be carried out in practice on a larger scale. The method of carrying out the work is to sow part of the pasture for hay or ensilage during periods of flush growth when there is more grass than the sheep can keep grazed moderately bare. The results so far have been very encouraging, and show that by adopting this system it is possible to keep the stock-carrying capacity fairly constant throughout the year and to increase the stock carried by about 50 per cent.

(3) *Winter Feeding of Ewes.*—These experiments are designed to find out the costs of and the returns from various systems of winter feeding. The results so far indicate that the better a ewe is fed during the winter the heavier will be the clip of wool and the quicker the lambs will thrive in the summer.

(4) *Lamb Investigation.*—Last spring all the crossbred experimental lambs were weighed and number marked at birth, and then weighed at intervals during the season. The results show a correlation between the weight of a lamb at birth and the way it will thrive subsequently—*i.e.*, the heavier a lamb is at birth, the sooner it will fatten. The experiments also show that the better the dam is fed in the winter the quicker the lamb will fatten; also, that the quicker-growing lambs have a better appearance when killed for freezing.

(5) *Wool Research.*—(*a*) Breeding experiment: A small breeding experiment is being carried out with stud Romney ewes to find out the relationship between birthcoat of the lamb and subsequent fleece of the grown sheep.

(*b*) Collection of fleeces: Last October and November ewe hogget fleeces from representative South Island Corriedale and Romney stud flocks were collected. These fleeces have been halved, and one half has been sent to Torridon, in Leeds, to be analysed and reported on; the other half has been returned here and has been reported on by local wool-buyers who buy for Bradford firms.

(6) *Iodine Feeding of Sheep.*—Since October 160 hoggets are being grazed on an iodine-deficient grazing-area, and of these eighty have been drenched weekly with iodine. They are weighed once per month. Approximately at monthly intervals four of each kind are killed and records kept of their rates of gain per cent. of carcass, size of thyroids, and, in conjunction with other Departments of the Department of Scientific and Industrial Research, thyroids and blood-samples have been collected and submitted for analysis. Results will be available at the end of the present year.

Pasture Investigations.

Pasture-management investigations were commenced in the autumn of 1928 with the main object of demonstrating advantages of proper grassland-treatment and controlled grazing. The work is being carried out on two distinct types of farms.

In the one case the complete management is under the direction of the College. These farms, two in number—one light land, the other heavy land—were made available to demonstrate the application, on a farm scale, of the principles of controlled grazing and intensive farming, with the purpose of making satisfactory farms that required improvement. Work of this nature requires a period of years in order to get good pastures—the foundation of subsequent success. Visible improvement has already been made in both cases.

In the second case, co-operating farmers, twenty-one in number, are managing two or more pastures as desired by the College. The pastures are being rotationally grazed, harrowed, and top-dressed, and grazing records are kept which enable comparisons with other pastures. These records show that increases in the carrying-capacity vary from 25 to 150 per cent. where controlled grazing on top-dressed pastures is being practised.

Single-field comparative manurial trials with sulphate of ammonia, Nitrophoska, Leunaphos, have been carried out on these fields. Additional trials with nitrochalk and potash will be commenced this coming season in a similar manner. This work is unique in that the grazing-animal is being used to measure the production of grass for the first time with any attempt at precision. In the past, methods, hay-weights, &c., were unsatisfactory: the results of top-dressing measured thus and by the eye were misleading. Very definite indications, though as yet not conclusive, to the effect that these manures must play an important part in economical pasture-management in Canterbury, have been secured on good pasture on heavy and medium soils.

Report on Farm Economic Research.

A. Farm Costing-service.

In order to obtain an accurate knowledge of farm costs and returns on the various types of farms, it was decided last year to inaugurate a farm costing-service at Lincoln College. During the year nine farms have been completely costed, and less detailed information has been collected on six other farms, enabling the compilation of monetary accounts only for these latter farms. The intention is to extend the work of farm costing to a great many farms, compiling more detailed cost accounts on a few farms selected as being typical of the average farm of that class, and compiling less detailed accounts alone on some hundreds of other farms. The method of costing is as follows:—

(i) The farmer signifies his intention of keeping the necessary diary record.

(ii) The farmer is visited by the costing officer, and (*a*) a complete inventory of quantity and value of all land, buildings, implements, stock, feed, seed, and manure, cultivations, &c., on hand at the beginning of the costing year made; (*b*) a rough sketch is made of the farm, each paddock is numbered, and the area and present and proposed crop in each paddock set down; (*c*) a diary is supplied, in which the farmer is required to set down daily full details of work done, shiftings of stock, materials or implements used, and all farm receipts and expenses. Details of interest payments, household and private expenses, are not required for the farm costing-accounts, but their inclusion enables a balancing of the accounts with the bank or stock agency account.

(iii) Monthly, quarterly, or half-yearly each farmer is visited, the diary collected, and a duplicate diary supplied. The accounts are then compiled to date.

(iv) At the end of the year the farmer is again visited, and a closing inventory of all land, stock, plant, &c., on hand at the end of the book-keeping year made. At the wish of the farmer, a new diary is supplied for the following year's accounts.

(v) The accounts are then compiled. Each farmer is handed back a report showing (*a*) the net improvement in the financial position for the year, and the gross or net profit obtained from each branch of the farm; (*b*) the net profit, the interest earned on the capital invested, and the actual producing value of the land for the year considered; (*c*) a brief summary of the year's operations, pointing out where returns are above or below the average, which branch of the farm proved most profitable, and which branch required readjusting.

Just as herd-testing has assisted and stimulated production on one branch of the farm—viz., dairy production—so it is anticipated from the experience already obtained, that this method of "farm testing" or "farm costing" will assist and stimulate production on the whole farm. An extension of the farm costing-work has been recommended by the Farmers' Research (Advisory) Committee recently established in Canterbury.

B. *Other Farm Economic Research.*

(1) *Farm Costs.*—Arising out of the data obtained from the farm accounts, reports showing the cost of horse labour and tractor labour, the relative profitableness of various crops and of live-stock in Canterbury, have been compiled. A report on the cost of harvesting wheat by use of the present large mill, the "tin" mill, the windrower and header, and the direct header, has been prepared, and is the subject of a report to the Wheat Research Institute.

(2) *Farm-management.*—A suggested normal diary of operations and normal receipts and expenses to be expected off the light Canterbury Plain land selling fat lambs, and cast for age, breeding-ewes only, has been compiled, and the effect of various deviations from this type of management on the farm returns studied.

(3) *General Farm Economics.*—Notes on each agricultural industry, endeavouring to show the stage in the production cycle reached by each industry, the recent effects of increased or diminished production or consumption abroad on production in New Zealand, and the immediate ends at which production in New Zealand should aim are being compiled.

RESEARCH SCHOLARSHIPS.

Four National Research Scholarships, of an annual value of £180, plus £25 additional for books and apparatus, are available each year. The present holders of these scholarships and the researches upon which they are respectively engaged are as follows:—

Name.	Research undertaken.
R. I. Nicholson, Otago University	(1) Action of Methylating Agents on Phenylhydrazones; (2) The Chemistry of Tuten (active principle of native tutu).
E. W. Hullett, Canterbury College	Chemistry of Ragwort.
Dr. R. S. Allan, Otago University	Geology.
T. H. McCombs, Canterbury College	The Essential Oils of Exotic Species of Pines grown in New Zealand. (Extension for three months.)

IMPERIAL AGRICULTURAL RESEARCH BUREAUX.

During the year the Dominion organization making for provision for co-operation in the Imperial Agricultural Research Bureaux scheme was completed with the appointment of local correspondents for the nine bureaux which were set up as the result of the Imperial Agricultural Research Conference of 1927. The actual work of the bureaux has been actively taken up by the local correspondents, who have forwarded particulars of the investigations proceeding in their respective spheres, together with surveys of the position in regard to the investigations proposed by the Imperial organization in so far as New Zealand was concerned.

"JOURNAL OF SCIENCE AND TECHNOLOGY."

The *Journal of Science and Technology* has been issued regularly during the past year at intervals of two months. The *Journal* is used for the publication of the reports of investigations carried out by the various branches of the Department, and also of the general scientific work submitted by investigators throughout New Zealand. In order to publish the additional number of scientific reports prepared, the size of the *Journal* had to be increased by one-third during the year. Considerable and extensive use of reprints from the *Journal* have been made use of for the purpose of conveying to industries and others concerned the results of the investigations completed.

PUBLICATIONS.

During the year twelve new bulletins have been published, and all, except one or two, have been issued. They are as follows:—

Bulletin No. 14: "Low-temperature Carbonization of New Zealand Coals: 1—Waikato Coal," by W. A. Joiner.
Bulletin No. 15: "Peach-culture," by T. Rigg and K. M. Curtis.
Bulletin No. 16: "Cold Storage of Fruit Investigations of 1927 and 1928," by L. W. Tiller.
Bulletin No. 17: "Pig Recording, Bacon-manufacture, and the Pig Industry in New Zealand," by M. J. Scott, C. R. Barnicoat, and F. R. Callaghan.
Bulletin No. 18: "Iodine and Goitre in New Zealand School-children," by R. A. Shore and R. L. Andrew.
Bulletin No. 19: "Moutere Hills Pastures," by T. Rigg and H. O. Askew.
Bulletin No. 20: "Low-temperature Carbonization of New Zealand Coals: 2—Kaitangata and Linton Coals," by W. A. Joiner.
Bulletin No. 21: "Standardized Cheese and Cheese Analysis," by F. H. McDowall.
Bulletin No. 22: "Preliminary Host-list of the Entomophagus Insects in New Zealand," by E. S. Gourlay.
Bulletin No. 23: "Relation of Storage Temperature to the Overseas Carriage of some Varieties of New Zealand Export Apples," by L. W. Tiller.
Bulletin No. 24: "The Nature of the Waikato Coal Types," by W. H. Penseler.
Bulletin No. 25: "Bronze-beetle Investigations," by A. M. Lysaght.
Bulletin No. 26: "Influence of Season and Fertilizer on the Yield and Composition of Typical Dairying-pastures," by T. Rigg.

REPORTS FROM BRANCH DEPARTMENTS.

DOMINION LABORATORY.

ANNUAL REPORT.

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, 319; Justice (Police), 16; Geological Survey, 83; Main Highways Board, 399; Mines (including prospectors' samples), 177; Post and Telegraph, 79; Health, 3,788; Public Works, 45; public bodies, 14; Railways, 60; Stores Control Board, 14; other Departments, 219; miscellaneous, 249: Total, 5,462. Health includes—Milks, Wellington City supply, 1,670; milks from country districts, 804; human milks (Plunket Society), 315; waters, 91; soils for goitre research, 356; foodstuffs, &c., 552. Miscellaneous includes—Samples for pig industry research, 33; other, 216.

Customs.—As in previous years, the samples submitted by the Customs Department were examined in order to determine their classification for tariff purposes, or, in some cases, to ascertain whether they complied with the regulations under the Sale of Food and Drugs Act.

Justice.—The samples submitted by the Commissioner of Police consisted of exhibits relating to cases of suspected poisoning. Poisons found in the exhibits comprised arsenic, strychnine, and hydrocyanic acid. Several samples of liquor seized by the Police at Taumarunui were also examined and found to be fermented beverages containing much more than the amount of proof spirit permitted for hop-beer.

Geological Survey.—The samples submitted included gas, wood petrified in sandstone, oil, wind-blown deposits, soils, resin, rocks (for superior analyses), rhyolitic ash, mudstone, sulphur, salts, diatomite, clay, mineral water, coal, and numerous samples for assay for gold and silver content. The results of these investigations are published separately in bulletins of the Geological Survey.

Main Highways Board.—The analyses carried out on behalf of the Main Highways Board again increased in volume, 399 samples being examined, as against 147 during the previous year. The samples comprised asphalt, asphaltic road-oil, bitumen, bituminous concrete, bituminous emulsion, "Bitubond," "Distar," "Mexrol," "Mexphalte," mastic flooring, Newcastle tar, pavement, "Resmex," road-oil, road-preparation, and water.

Mines.—The work for this Department consisted largely of assays of samples for gold, silver, and other metals. Other samples examined included coal, clay, diatomaceous earth, fireclay, gas, mine-air, mineral oil, samples of petroleum, rare earth, sand, scheelite, tar, and water.

The Mahler-Cook bomb calorimeter in use for many years in the Laboratory has been replaced by a Darroch calorimeter of a new and improved design, as recommended by the British Fuel Research Board. With this instrument the calorific values of coals and fuel oils can be determined with greater precision and convenience.

Post and Telegraph Department.—The samples examined included beeswax, "foam," detergent powder, "Ferrodor" paint, floor-oil, floor-polish, galvanized-steel wire, ink, jointers' metal, lineman's solder, lubricating-oil, motor-spirit, paint, petroleum-jelly, resin-core solder, shellac, and sulphuric acid.

Health.—A large variety of substances, chiefly foodstuffs, were examined. They included air, ammoniated quinine, asthma-cure, baking-powder, beer, boracic acid, brandy, bread, wholemeal bread, butter, "Cerbo," cheese, process cheese, consumption-cure, cordials, cream, creamy whip friz, "drinks," powder, flour (wholemeal), gin, hydrogen peroxide, ice-cream, jam, margarine, medicine, milk, orange-juice, sheep's thyroids, soap, soils (goitre research), turpentine substitutes, vinegar (malt), "Viscaline," water, whisky, and zinc oxide.

Of the butters examined, two samples contained excessive amounts of water. Boric acid, which is now prohibited, was not found in any of the samples.

Of the fifty-seven ice-creams examined, nine were definitely deficient in milk-fat, while two were slightly below the standard.

Of the cordials, one sample of lime-juice and two of lemon-squash were found to be low in citric acid. Much useful data as regards acidity of orange-juices was obtained by tests on Californian, island, and New Zealand oranges in this respect.

Out of the 153 soda-waters analysed during the year, lead was found to be present in at least fifty-one samples, copper (traces) in two, and iron in nine. It was noticed that soda-waters from Hastings and Lower Hutt, where the waters are hard, were practically free from lead. Many of the soda-waters were discoloured, due to the extraction of material from the corks.

Of the 30 boracic-acid samples tested, five had more than the permitted amount of lead, five had excess arsenic, and six were below the standard in acidity.

With one exception, the wholemeal breads examined were found to be correctly labelled.

In six cases whisky-samples were found to be incorrectly labelled. Two cases of incorrect labelling of gin were detected.

Milk.—Wellington City: The number of milk-samples taken in Wellington during the year was 1,670; of these, fourteen were deficient in fat and five contained added water.

Country districts under control of Medical Officers of Health—Wellington, Gisborne, and New Plymouth: 804 milk-samples were examined; of these, twelve were deficient in fat, five contained added water, and one was slightly below standard.

Plunket Society: 315 samples of human and humanized milk were analysed for the Plunket nurses in the Wellington District.

Stores.—As a guide in the purchase of Government supplies, numerous samples were analysed on behalf of the Post and Telegraph Stores, Public Works, Stores Control Board, and Railways Departments. The samples examined included: For Stores Control Board—Aluminium bowl, castor-oil, enamel mugs, fuel oil, "glazoline," floor-polish, heavy oil, lead-white, lubricating-oil, "manila" rope, sandstone, and toilet soap. For Public Works Department—Electric conduit (corrosion investigation), insulator-testing, oil, paint, "permoglaze" enamel, and steel. For Railways Department—Dark axle-oil, locomotive "bearing" oil, California orange-juice, cockroach-exterminator, calcium carbide, hydrogen phosphate, jam, raw linseed-oil, oil, orange-drink preparation, paint, protein, and wholemeal.

Other Departments.—Samples analysed for other Departments included blood sera from sheep (bush-sickness investigation), for Department of Agriculture; annatto, coconut-husks, fuel oil and gas from "Maui Pomare," for the Cook Islands Department; components of ammunition, brass, castor-oil, defective cartridge-cases, naphtha solvent, and red oxide, nickel and brass cups, and oils from "H.M.S. Dunedin," for Defence Department; fireworks composition, gas, and racing-fuel, for Explosives Branch; anhydrous lanoline, adhesive and cork, clay, and kauri-gum, for Industries and Commerce; boiler-plate and boiler-scale for Marine Department; metal-polish and sandsoap, for Prisons Department; creosote oil, samples for cyanide, opossum-skins, thermometers, and wood-preservatives for State Forest Service; waters for Internal Affairs (Fisheries) Department; aluminium strips, bauxite (supposed), bacon, boot-polish, binder for briquettes, conduit pipes (for corrosion), cement, "Faterine" and fish-meal, samples for bleaching of flax, gypsum, kauri-gum, lemons, metal from Taranaki sand, moth-killer, tobacco-leaf for miatine, oranges, phosphor-bronze wire, paper, soils, and sulphide ore, for Department of Scientific and Industrial Research.

Public Bodies (including Borough Councils, Harbour Boards, Hospital Boards, &c.).—Samples comprised bitumen, clay, cable, "Rabona" cleaner, fire-extinguisher, glycerine, "Resmex," and tar.

Research.

The first stage in the investigation of the incidence of goitre in relation to iodine content of soils and water was completed during the year, the results being published as a joint bulletin of the Departments of Health and of Scientific and Industrial Research. Further work upon the same problem is under way.

A considerable amount of work was also done to ascertain the suitability of New-Zealand-grown tobacco leaves and stems for the production of nicotine for use as an insecticide. A study of the methods used for the determination of nicotine was made in this connection, a slight modification of Young's method being finally adopted.

Further work on New Zealand clays was carried out during the year. A comparative study of various clay roofing-tiles from France, Australia, and New Zealand, as regards water-absorption, permeability, strength, and appearance, was also made. This work is nearing completion.

On behalf of the Cook Islands Department a determination was made of the calorific value of coconut-husks with a view to their possible utilization as fuel. A note on the results appears in the *New Zealand Journal of Science and Technology*.

Comparative tests upon Californian, island, and New Zealand lemons and oranges were continued during the year.

Fuel research work has been continued at the Dominion Laboratory during the past year. This work is being carried out under the direction of the Fuel Research Committee of the Council of Scientific and Industrial Research. The main subject of investigation has been the low-temperature carbonization of New Zealand coals. The yields of carbonized residue, tar-oil, gas, and light-spirit have been determined, and a preliminary examination of the tar-oil has been made. Two bulletins* have been published embodying the results obtained with Waikato coal, and Kaitangata and Linton coals. In addition to these experiments, analyses and carbonization of various coals have been carried out from time to time.

Various cases of corrosion were brought forward for investigation by Government Departments and local bodies. These included lead cable for the Hamilton Borough Council and electrical conduit pipe for the Public Works Department. The latter investigation is still under way.

Research into aspects of the meat industry was continued; special attention was devoted to pork and bacon, while samples of canned pork, ham, and pickling-liquors from England and Denmark were acquired as aids to the investigations. The problem of the freezing of bacon was specially studied.

As a contribution to the study of the causes of bush sickness among sheep, the estimation of potassium in blood sera from several affected animals was carried out at the request of the Department of Agriculture. A slightly modified Kramer volumetric cobaltinitrite method was used for the potassium determination.

For the Defence Department an investigation into the causes of defects in brass cartridge-cases was carried out. Analyses having shown the brass to be of good quality, a microscopic examination was made of some prepared sections. It was found that the cause of failure of the cases was due to "season cracking," a defect due to annealing at too high a temperature. A considerable amount of further work was also carried out for the same Department in connection with various aspects of corrosion, failure, &c., of components of ammunition.

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

Gas-control.

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

PETROLOGICAL LABORATORY.

Field-work.—Quarries that are used for the production of building-stone throughout New Zealand have been visited and examined, and specimens have been obtained for laboratory investigation. Sources for the supply of additional material considered to be suitable have been examined, with the result that it has been shown that New Zealand is actually provided with immense quantities of easily worked building-stone which will last indefinitely under intense acid action. In connection with this work buildings throughout New Zealand have been carefully observed in order to determine the amount of resistance their materials offer to atmospheric action.

Quarries for the supply of roadmaking-material for use in highways have been examined throughout the country. Reports have been made on the quantity and quality of suitable rock material available within reasonable distance of highways. In particular, a full investigation was made of the rock materials that could be used for the proposed Taupo–Rotorua highway. In all cases samples are taken for complete laboratory study.

Examination of the rocks is made along the lines of projected tunnels which have to be made in connection with railway development. The sites of hydraulic dams which have to be constructed for hydro-electric purposes are now systematically examined.

Much field-work has been done in connection with the dredging of materials from offshore localities near some of the harbours. This has been undertaken in order to determine the nature and amount of the drift of various grades of detritus along the coast. Work is being actively continued in this connection.

Laboratory-work.—Building-stones are examined with respect to specific gravity, porosity, absorption, compressive strength, and capacity for taking a high finish and polish. In each case a microscopical examination is made. The results of the field and laboratory work on New Zealand building-stones have been embodied in a pamphlet that has been issued by the Department.

Road materials are examined with the microscope, and the rock is classified. Rock material is submitted to tests for specific gravity, absorption, hardness, toughness, and resistance to abrasion, in accordance with the standard requirements. Gravels are submitted to standard tests for grading and abrasion.

Work has recently been done in testing the resistance of concrete to water moving with high velocity. The results obtained have proved of high value in regard to certain hydraulic works.

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* Low-temperature Carbonization of New Zealand Coals: (1) Waikato Coal (Bull. 14, N.Z. Dept. of Scientific and Industrial Research); (2) Kaitangata and Linton Coals (Bull. 20, N.Z. Dept. of Scientific and Industrial Research).

Practical experiments have been made in connection with the wearing of sand and gravel under conditions similar to those of wave-action on beaches. The development of fine detritus by this action has been carefully studied, especially with reference to difficulties in connection with harbour development throughout New Zealand. A large amount of most valuable information has already been obtained and has been embodied in two pamphlets on "The Wearing of Beach Materials" and "Gravel and Sand on Beaches."

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR.

Forecasting.

Progress has continued to be made along the lines referred to in last year's report. Increasing use is being made by the public and the shipping community of the reports issued by wireless every evening in Morse code by the Wellington Radio Station (ZLW) and by telephone from the stations of the Radio Broadcasting Co. in the four main centres.

Special forecasts giving indications of the conditions anticipated for as far ahead as possible over the wheat-growing areas of Canterbury and Otago during the harvest period from the beginning of February to the middle of March have been issued from the radio broadcasting stations at Christchurch and Dunedin at 12.45 p.m. Appreciation of these forecasts has been expressed by various institutions, and we have been requested to arrange for a repetition of the forecast in the evening during the next harvest season. Since the 2nd December similar forecasts, but of a more general nature, have been issued from the Wellington station (2YA) at 3.30 p.m. mean time each afternoon for the benefit of sheep-farmers, especially in connection with shearing operations. In addition, during the apple-picking season, special warnings of heavy rains or southerly gales were sent to growers in the principal producing districts.

Numbers of farmers have paid to have warnings of severe weather telegraphed to them while their flocks were being shorn. Aviators, also, have asked for forecasts preparatory to undertaking various flights. Very many other forecasts have been given either by telephone or telegraph to people in all parts of the country for special occasions of many kinds.

The number of reports received daily from ships at sea continues to increase. These reports are of very great value, and our thanks are due to the captains and officers who co-operate with us by sending them.

I desire also to acknowledge the continuous, regular, and prompt assistance given by the Post and Telegraph Department, on which our success is entirely dependent.

Observing-stations.

New climatological stations have been established during the year at Queenstown, Kapiti Island, the Chateau Tongariro in the National Park, and the Milford Sound Hostel. Owing to the sale of the farm, the station at the Weraroa State Farm has been abandoned. That at Matamata also was discontinued. Twenty-two new rainfall stations have been established, and five have ceased reporting.

Assistance has been given to the Cook Islands Department in the establishment of stations in some of the islands, and the records have been supervised.

The quality of the observations at climatological stations still continues to give concern, very few being thoroughly reliable. As much inspection as possible has been done, and some improvement has been made. It is clear, however, that repeated visits are necessary. There is no doubt that the outstanding need in the meteorological service in New Zealand is for improved observations. Forecasting is liable to eclipse the other activities of this Branch in the eyes of the public, but its most important duty is the collection of the statistics which are required for the advancement of agriculture, engineering, and other pursuits. We are very grateful to those observers who send us complete and accurate returns.

Rainfall Data.

During the year a bulletin has been completed giving a new annual rainfall chart for New Zealand. Another chart shows also the average number of rain days per annum. The rainfall data given are for the epoch from 1891 to 1925. The relation of the rainfall to the topography of the country and to the principal storm systems was described.

Hourly rainfalls for Kelburn have been tabulated regularly from the records of the automatic gauge.

Much information regarding heavy rainfalls has been collected and tabulated at various times and distributed to engineers.

Aviation Meteorology.

Observations of winds in the upper air have been made daily at Wellington, and monthly summaries have been prepared. A comparison is being made of the relative accuracy of the range-finder and "tail" methods of determining the height of the balloon.

At Auckland Mr. F. H. Sagar has made balloon ascents on most days, and presented a discussion of them for his thesis for the M.Sc. degree.

This Branch has co-operated with the Christchurch Magnetic Observatory in the inauguration of pilot-balloon ascents there daily. Results are now telegraphed each morning to Wellington.

Observations of visibility are now made at Beacon Hill (Wellington), at Blenheim, and at Kaikoura. For a period they were made also at Paekakariki, but since there was little demand for these they have, for the present, been discontinued. The observations are telephoned or telegraphed to the Meteorological Office.

A Dines pressure-tube anemograph giving continuous and instantaneous records of the wind velocity and direction has been established at the Air Force Base at Hobsonville, near Auckland. Advice and assistance was given, also, to the Wellington City Council in the erection of a similar instrument at the Rongotai Aerodrome.

There is thus considerably more information available regarding atmospheric conditions as they effect flying than has been the case in the past. We are consequently better able to give advice to aviators.

It may be mentioned that during the year the British airships R100 and R101 underwent their trials, which proved very successful. Considerable advances have yet to be made, particularly in engine design and construction, before the airship can be thoroughly successful commercially, but it is clear that the main difficulties have been overcome.

Miscellaneous.

Dust from Australia.—In last year's report a description was given of a very heavy deposit of dust brought over from Australia by westerly gales in the early part of October, 1928. It is extremely interesting to learn that this deposit is still visible on large areas of snow in the Southern Alps. Further falls have occurred during the past year, the most remarkable being that of the 26th November, when heavy coatings of the red deposit were received over large portions of the Taranaki, western Wellington, Nelson, and Marlborough Provinces. In October, 1929, also, clouds of smoke and dust from Australia were seen in the Island of Niue. These phenomena have been made the subject of communications to the *Journal of Science and Technology* and to *Nature*, the latter being discussed by Professor J. W. Gregory.

Publications.—Other contributions to the *Journal of Science and Technology* have been "Hourly Sunshine at Wellington," by Mr. D. C. Meldrum; "Surface Winds at Waitatapia, Bulls," by Mr. Andrew Thomson; "The Heavy Rainfall of 11th March, 1924, in the Hawke's Bay District," by Dr. E. Kidson; "Hourly Rainfall at Kelburn, 1928–29," by Dr. E. Kidson.

Director, Apia Observatory.—Mr. Andrew Thomson, Director of the Apia Observatory, Samoa, who had been suffering in health, was attached to my staff during the year and took charge of the upper-air work. In February Mr. Thomson returned temporarily to Samoa in order to get everything in good working-order at the Observatory before handing over to the new Director. In addition to the other work mentioned, Mr. Thomson, while here, prepared papers on the occurrence of thunder and hail in New Zealand, which will be printed shortly. He also published an article in *Nature* on the sounds heard at great distances from the great earthquake at Murchison on the 17th June, 1929. These sounds travelled to a great height in the atmosphere, probably about thirty miles, and were there reflected back to earth from a layer of warm air. The reflected wave reaches the earth at a great distance from the source, and the sound becomes audible beyond a zone of silence in which the direct wave has died out. Mr. Thomson found evidence of a similar happening during the Tarawera eruption. The phenomenon has been observed in connection with explosions in Europe, especially during the Great War, and gives information regarding conditions at high levels in the atmosphere.

Australian and New Zealand Antarctic Expedition.—Mr. R. G. Simmers, of the Meteorological Office staff, had the honour of being appointed meteorologist to Sir Douglas Mawson's British, Australian, and New Zealand Antarctic Expedition. Mr. Simmers proceeded to England in June, superintended the installation of his apparatus on board the "Discovery" in London, and after a short course of special instruction at the London Meteorological Office joined the vessel in Cape Town. Preliminary reports by Sir Douglas Mawson indicate that Mr. Simmers has successfully completed a programme of valuable observations.

Australian Antarctic Expedition, 1911–13.—A large amount of work has been done on the discussion of the meteorological results of the Australian Antarctic Expedition, 1911–13, and it is hoped that this will be completed in the course of the coming year. The writer's discussion of the results of the first Shackleton Expedition has now been published by the Commonwealth Government.

We have been asked to revise the meteorological data in the "New Zealand Pilot," issued by the British Admiralty, and which has hitherto been prepared in England.

I desire to acknowledge once more the loyal and cordial assistance of all members of my staff.

Short Summary of the Weather during 1929.

The year 1929 was similar to 1928 in that there was a comparative absence of westerly winds and in the unusual frequency of storms of cyclonic form. These latter were even more numerous than in 1928, and similar conditions have not previously been experienced since records have been kept in New Zealand.

As regards total rainfall, the year was approximately a normal one, but very dry and very wet periods alternated in most districts. Places which receive heavy rains in westerly winds had less than the average falls. January was dry, and February still more so. March and April were wet, but May and the first part of June rather dry. From the latter end of June right through to August wet and rather stormy weather prevailed; thereafter dry conditions again set in, especially in the South Island. In parts of Canterbury and Otago the dry spell was not broken until December, but otherwise both November and December were wet and stormy.

Owing to the frequency of cyclonic disturbances, there was an unusual number of heavy rainfalls recorded, and many parts of the country experienced flooding at some time or other of the year.

Tornadoes are not frequently recorded in New Zealand, but several were experienced in 1929. They were, however, of very small dimensions and not to be compared in destructiveness with the corresponding American phenomenon.

From June onwards unusually low mean temperatures were recorded in each month, and these conditions have continued right up to the present. The effect of these low temperatures on vegetation was quite marked, and in many respects development was about a fortnight later than normal. Thus harvesting, fruit-picking, &c., were delayed.

The year was, nevertheless, on the whole, a very good one for those engaged in agricultural pursuits. Pasture was abundant, and most crop yields were good. Difficulty was experienced in fattening lambs, and haymaking was seriously interfered with in many districts by wet weather.

GEOLOGICAL SURVEY.

TWENTY-FOURTH ANNUAL REPORT (NEW SERIES).

DIRECTOR'S REPORT.

Summary of Field Operations.

During the past field season detailed topographical and geological surveys were carried out in the following districts:—

1. Te Kuiti Subdivision, under Mr. H. T. Ferrar, M.A., F.G.S., Geologist.
2. Wairoa Subdivision, under Mr. M. Ongley, M.A., B.Sc., Geologist.
3. Tongariro Subdivision, under Mr. L. I. Grange, M.Sc., F.G.S., A.O.S.M., and Mr. J. H. Williamson, B.Sc., A.O.S.M., Assistant Geologists.
4. Maruia Subdivision, under Mr. H. E. Fyfe, B.Sc., A.O.S.M., Assistant Geologist.

Mr. N. H. Taylor, Assistant Geologist, borrowed by the Committee of Mineral Content of Pastures Research, made an intensive geological survey of several areas in the Mairoa district, west of Te Kuiti, and near Kopaki, south-east of the same town. From the 26th April until the 9th June Mr. L. I. Grange carried out for the same Committee a preliminary investigation of the distribution of the showers of volcanic ash over an area east of Te Kuiti, and extending thence north to Cambridge and north-east to Mamaku and Rotorua.

The Director made brief official visits for several purposes to Coromandel, Waihi, Te Kuiti, Havelock, Ward, Murchison, Reefton, Lyell, Seddonville, and Karamea. The visits to the Nelson Province were chiefly in connection with the severe earthquakes that began in that district last June and continued with diminishing intensity for many months. Messrs. Ferrar, Grange, Ongley, and Fyfe also made trips through the same region, the first two also visiting Blenheim and Takaka. Dr. Marwick spent about a fortnight in Canterbury, where he examined limestone deposits at Waikari and Mount Somers, and Mr. Grange a week at Taumarunui searching for indications of petroleum.

Progress of Areal Survey.

During the twelve months ended the 31st May, 1930, an area of approximately 1,130 square miles was geologically examined in detail. Of this area, 80 square miles was in the Te Kuiti Subdivision, 414 square miles in the Tongariro Subdivision, 141 square miles in the Rotorua-Taupo Subdivision, 170 square miles in the Wairoa Subdivision, and 325 square miles in the Murchison Subdivision. The table below shows the present state of the detailed areal survey, which was begun twenty-five years ago. The area of the three main islands of New Zealand is 103,658 square miles.

	Square Miles.
Surveys completed and work published	16,328
Surveys completed and work not yet published	11,891
Surveys in progress—area actually surveyed	409
Total area surveyed	28,628

Dargaville-Rodney Subdivision.

The maps to accompany the Dargaville-Rodney Subdivision have now been printed and the manuscript is nearly ready. It may here be stated that the preparation of this report and of several others was seriously delayed owing to the extra work that the Murchison earthquake caused to the staff.

Te Kuiti Subdivision.

Other duties occupied so much of Mr. Ferrar's time during the past year that only a small part of the season could be devoted to field-work. Mr. Ferrar's summary report is published on another page.

Rotorua-Taupo Subdivision.

The small area in the south-east corner that remained to be examined before field-work in the Rotorua-Taupo Subdivision was complete was surveyed this season. The manuscript will probably be finished this winter, and most of the maps are drawn but require revision.

Tongariro Subdivision.

Owing to the favourable season, Mr. Grange was able to finish the arduous field-work necessary for the examination and mapping of the Tongariro Subdivision, which consists of the survey districts of Tongariro, Pihanga, Ruapehu, and Kaimanawa. A preliminary account of the geology appears on another page.

Wairoa Subdivision.

Mr. Ongley completed field-work in the Wairoa Subdivision at the end of February. As now defined, the Wairoa Subdivision includes the survey districts of Moanui, Motu, Koranga, Ngatapa, Tuahu, Hangaroa, Waiau, Taramarama, Opoiti, Nuhaka North, Paritu, Waihua, Clyde, Nuhaka, Mahanga, and Mahia. Mr. Ongley's report of the stratigraphy and structure of the district is published on another page.

Motueka Subdivision.

The photo-lithographic drawings for the maps of the Motueka Subdivision are now in the printer's hands, but practically nothing has been done to the manuscript since the last annual report was issued.

Murchison Subdivision.

During the past two seasons Mr. Fyfe has geologically mapped the whole of the survey districts of Burnett, Matakitaki, Rahu, and Una, as well as parts of Lewis and Travers. The geology of this area, which has been called the Maruia Subdivision, has so much in common with that of the adjacent Murchison Subdivision that it seems advisable to write but one detailed report on a combined subdivision. This will include nearly the whole of Murchison County, together with parts of Buller, Waimea, and Inangahua counties.

St. Bathan's Subdivision.

Mr. Ferrar has been unable to do any work on the manuscript of the St. Bathan's bulletin.

Kaitangata-Green Island Subdivision.

Since March, when Mr. Ongley returned to Wellington, he has added considerably to the manuscript of the Kaitangata-Green Island report, which will probably be ready for publication before next field season. The photo-lithographic drawings of the maps are now complete.

Palæontological Work.

Dr. Marwick continued to work for the most part on the Tertiary fauna of the Gisborne region, of which the report will be much fuller and larger than was originally expected. The manuscript and plates are in the printer's hands.

Murchison Earthquake.

The earthquake, or series of earthquakes, beginning on the 17th June, 1929, that did so much damage to Murchison and the adjacent parts of western Nelson resulted from a sudden relief of pressure in the earth's crust. Probably the earthquakes that have shaken New Zealand during the last eighteen months are to be attributed to the same cause—that is, to the stresses that had accumulated along the great earth-ridge, parts of which rise above sea-level as the South Island and the eastern half of the North Island of New Zealand. The first intimation of unusual conditions along this ridge was perhaps the outflows of mud in the Gower Valley, in the northern part of Canterbury, in September to December, 1928. Next followed the earthquakes at Otira (9th March, 1929), Feilding (8th May, 1929), Murchison (17th June, 1929), Porangahau (12th February, 1930), and Opotiki (4th April, 1930). If the series is not yet complete this distribution suggests that the next relief of pressure along the elevated ridge will take place somewhere between Otira and Stewart Island, though the numerous minor shocks still occurring in the northern part of the South Island suggest that this region is not yet altogether stable.

The principal earthquake was due to movement along the well-known White Creek fault that crosses the Buller about seven miles west of Murchison. This fault has a general northerly course, and the country east of it was raised and tilted, the uplift at the fault being about 15 ft., but this diminished gradually eastward till at Mangarata, twelve miles away, it is not detectable. There is, unfortunately, but one line of levels available, that along the Buller River, and the movement north and south of this line is not known. Preliminary surveys indicate a horizontal movement of about 6 ft., by which amount the block east of the White Creek fault apparently overlaps the block west of it.

Tremors were felt at Murchison some hours before the principal shock and innumerable after-shocks, which for several days were so frequent that it was impossible to keep count of them. From the fact that the shocks are still continuing, nearly a year after the 17th June, it may be argued that the nice adjustment of very large masses of rock was disturbed and that the focus was a considerable depth below the surface. Observations of residents of the district and the records of distant seismographs prove that the after-shocks did not originate all from the same focus, and could not all be attributed to the growth of the White Creek fault. Indeed, adjustments of a considerable group of earth-blocks probably took place along all the major faults of the region. Slips from hillsides are conspicuous, and furnish some guide to the intensity of the earth movements, though the slope of the ground, the texture, structure, composition, and attitude of the rock forming the substrata, and, if the land is cleared, the time of clearing are important in determining the size and number of slips. Though the great landslides near Murchison were caused by the main shock, there is evidence that some slips at least were due rather to shakes from local centres of earth-movement. The distribution of the slips, combined with the evidence from the seismographs at Wellington and Christchurch, makes it probable that, in addition to the White Creek fault, the following fractures or fracture-zones were

among the faults that were active: (1) The faults bounding the Radiant and Glasgow Ranges on the east; (2) the faults along which the valleys of the Upper Mokihinui, the Upper Karamea, and Matiri valleys have been carved; (3) the faults about Mount Owen; and (4) the Waimea fault, south-west of the Nelson lowlands.

Several members of the Geological Survey visited the Murchison district shortly after the earthquake began, and Mr. Fyfe later carried out a more extended reconnaissance. Their observations, together with reports from the Government Seismologist, several Departments, and other sources, will be published as time and opportunity permit.

Publications.

The following official publications were issued during the year ended 31st May, 1930:—

"Twenty-third Annual Report (New Series) of the Geological Survey" (part of parliamentary paper H.–34, 1929).

Geological Survey Bulletin No. 33: "The Soils of Irrigation Areas in Otago Central," by H. T. Ferrar.

In addition, the following papers and reports by officers of the Geological Survey have appeared in the *New Zealand Journal of Science and Technology*: "The Faults and Geological Structure of New Zealand" and "Abstract of Geological Papers presented at the New Zealand Science Congress, Auckland, 1929," by J. Henderson; "Geological Reconnaissance in the Murchison Earthquake Area," by H. T. Ferrar and L. I. Grange; "Taitai Overthrust, Raukumara Peninsula," by M. Ongley; "Mudflows in the Cheviot District" and "Geological Evidence of Past Land Connections of New Zealand," by J. Marwick; "Spherulitic Obsidian, Lake Rotoiti, Rotorua District," by L. I. Grange; "Movement on White Creek Fault, New Zealand," by H. E. Fyfe; and "Clastic Dykes in Volcanic Breccia, Manukau North Head," by N. H. Taylor. "The late Cretaceous and Tertiary Rocks of New Zealand," by J. Henderson, was published in Vol. 60 of the *Transactions of the New Zealand Institute*, and "The Murchison (New Zealand) Earthquake, 17th June, 1929," by H. T. Ferrar, in Vol. 67 of the *Geological Magazine*.

Office-work, Library, etc.

A large amount of correspondence has been attended to, many requests for information more or less connected with the work of the Geological Survey have been answered, and samples of rocks, ore, and minerals examined and identified.

During the year Mr. G. E. Harris prepared ten drawings for photo-lithographic reproduction as maps to be published with the Rotorua–Taupo and Murchison bulletins. He also prepared twenty-seven other drawings, sixteen field sheets, and a number of tracings and charts.

Numerous publications were received in exchange for the reports and maps of the Geological Survey. Some text-books, chiefly relating to economic, structural, and stratigraphic geology, as well as a considerable number of technical journals and papers, were purchased.

Fifteenth International Geological Congress.

The Fifteenth International Geological Congress, to which the writer was the New Zealand representative, was officially opened at Pretoria on the 29th July and formally ended on the 7th August. Papers and discussions, however, occupied but a small part of the period of the Congress, and geological excursions into different parts of South Africa took up most of the visitors' time.

The purpose of these congresses is to bring together men of geological standing from all parts of the world, that they may meet each other and discuss questions of major importance. About 340 attended the 1929 Congress, including seventy-four official delegates from about forty different Governments. South Africans were, of course, most numerous, but Germany, the United States, and England sent strong contingents. The Congress was admirably planned, and great credit is due to the President (Dr. A. W. Rogers), the indefatigable Secretary (Dr. A. L. Hall), and the local committees. Financial and other help was freely given by several Governments, municipalities, mining companies, and private individuals, and the visitors greatly appreciated the open-handed hospitality and unfailing courtesy of all with whom it was their fortune to come into contact.

South Africa is unusually rich in economic deposits of many kinds, and the writer had the opportunity of examining gold-mines at Johannesburg and in Rhodesia, platinum and iron-ore deposits in the Transvaal, mines of asbestos, chrome, and coal in Rhodesia, and diamond-mines both in alluvial gravels and in volcanic pipes in Cape Colony and in the Transvaal. Time did not permit of a visit to the enormous copper deposits at present being explored and developed in Northern Rhodesia. In addition, places of scenic and geologic interest, including Victoria Falls, Matopo Hills, Hartebeest-poort Dam, parts of the Drakensberg, and the environs of Pretoria, Johannesburg, Pietermaritzburg, Durban, and Cape Town were seen.

SPECIAL REPORTS.

1. GEOLOGY AND SOILS OF PARTS OF THE KING-COUNTRY (TE KUITI SUBDIVISION).

(By H. T. Ferrar.)

Introduction.

The geological survey of the Te Kuiti Subdivision, that was begun in 1928, was this year subordinated to examinations of the geology and soils of special areas in the King-country where farmers are having difficulty in rearing sheep. Mr. N. H. Taylor, who worked as Assistant Geologist last year, was engaged upon intensive soil surveys of selected farms, and the writer, who spent only three months in the field between the 3rd March and 5th June, mapped the geology and soils of the districts surrounding the farms.

The first six weeks were spent in the Mairoa district west of Te Kuiti, where work was suspended last year and where geological maps were urgently required for detailed soil and pasture investigations in connection with the mineral content of pastures research (see pp. 3 and 23 in the 1929 Annual Report of the Department of Scientific and Industrial Research). During the month of May two small separated areas east of the Main Trunk Railway were surveyed, the one in the Kopaki district, where experiments with unhealthy sheep are being carried out by the Department of Agriculture, and the other in the Tiroa-Maraeroa district, where top-dressing experiments are being made by the Department of Native Affairs for the purpose of determining the suitability of the land for settlement under the Consolidation of Native Lands branch of that Department. In all, an area of about 80 square miles was surveyed in detail, and reconnaissances were made farther afield. Of this area, 60 square miles lie in Maungamangero and Pakaumanu survey districts that form part of Te Kuiti Subdivision, and 20 square miles lie in Hurakia Survey District.

Air Survey.

In addition to the reconnaissances on foot that will accelerate future work, the Air Survey and Transport Co., of Auckland, has photographed from a height of 10,000 ft. a large area of partially explored territory east of the railway in Pakaumanu, Pahi, and Hurakia survey districts. The series of overlapping photographs are "tied" to points on the railway between Puketutu and Mangapehi railway-stations, and the "mosaic" forms a pictorial map of districts that will be examined shortly. The photographs are of great value for present and future use. They will save much of the time now used by the field geologist in making topographical maps upon which to place the geology, and they show in great detail the configuration of the land and its present condition as regards forest cover and developed pastoral areas. The photographs are of permanent value in that they can be used time and again to provide accurate and minute detail for topographic maps on almost any scale. The value of aerial surveys both from an administrative and an economic point of view is so well recognized in several countries that an air-survey unit forms part of their establishment. In those parts of New Zealand where ground surveying is difficult, photographic mapping will expedite the work of the geological survey, and a desired increased rate of mapping will be thereby attained.

General Geology.

Mairoa District.—On the east side of the Mairoa district disordered Triassic rocks containing casts of *Pseudomonotis richmondiana* are succeeded westward by Jurassic strata containing casts of *Pseudaucella* sp. and *Inoceramus haasti*. These Mesozoic rocks form a broad plateau-like ridge, 1,200 ft. to 1,500 ft. high, flanked by Tertiary deposits which overlap upon them with marked unconformity, the Mesozoic rocks striking nearly north and having a nearly vertical dip, whereas the Tertiary deposits are almost horizontal. Inliers of Jurassic rocks rocks also occur in the area covered with Tertiary beds. To the west of this area Jurassic rocks are again exposed in the valley of the Mangaohae Stream, and thence extending westward gradually gain height and form the Herangi Range. This range is a serrate ridge culminating in Maungamangero Trig. Station, 2,656 ft. above sea-level. In the strata on its flanks *Inoceramus* casts are abundant, and high on the range are lenses of green glauconitic sandstone containing the phragmacones of *Belemnopsis* sp. and other fossils. Since the Herangi Range is an escarpment facing west, a fairly complete sequence of these Mesozoic beds will be obtained when the survey is extended.

The Tertiary deposits that occupy the middle part of the district consist of mudstones, sandstones, and massive limestones. The mudstones are correlated with the Whaingaroa beds of Kawhia (see Henderson and Grange, 1926), and the sandstones and limestones are an extension of the Te Kuiti beds, and in their upper parts contain bands made up almost entirely of shells of the large oyster *Ostrea wollastoni*. Overlying these older sedimentary rocks are Pleistocene deposits of sand and gravel in patches, and over all is a tattered shroud of recent volcanic ash. These ash-beds cover great areas and, where not removed by erosion, are the parent material of the soil.

Kopaki District.—In the Kopaki district fault-blocks of greywacke and argillite, of supposed Triassic age, form hills that rise 1,800 ft. to 2,000 ft. above sea-level. An almost continuous sheet, 200 ft. to 500 ft. thick, of consolidated "Mamaku" rhyolitic tuff (see Grange, 1928), of late Pliocene age, surrounds these greywacke fault-blocks. Where this sheet is cut through by streams, underlying Mahoenui and Mokau beds (*Cf.* Henderson and Ongley, 1923) appear. Overlying the greywacke and rhyolitic tuff are Pleistocene deposits of sand and gravel in patches, and a sheet of recent volcanic material almost covers the whole countryside. This recent volcanic material resembles that at Mairoa, in that bands of brown andesitic (?) and of yellow rhyolitic earth underlies soils containing pumice-fragments, but differs from it in that at Mairoa the latest or "Taupo" pumice shower (*Cf.* Grange, 1929) is thin or absent, whereas in the Kopaki district this volcanic shower forms high terraces, is more than a foot thick on the low country, and is 2½ ft. thick on hill-tops.

Tiroa-Maraeroa District.—In the Tiroa-Maraeroa district Triassic rocks crop out only on the eastern and western margins, and Tertiary deposits are absent or concealed. The area examined is a not-deeply-dissected plain consisting of Mamaku rhyolitic tuff. As in the Kopaki district, this consolidated tuff is overlain by sands and gravels in patches, and by extensive, though comparatively thin, beds of brown andesitic (?) and yellow rhyolitic earth, over which is a thinner subaerial deposit of "Taupo" pumice. This pumice deposit is about 18 in. thick on the average, but where it has drifted or been blown into hollows it may be as much as 20 ft. to 30 ft.

The Soils.

In the past the geological survey has usually focused its attention upon the rocks *in situ* that build up the land, or upon the possibility of the presence of mineral wealth concealed at depth beneath; but latterly more attention than heretofore has been given to pedology—that is, to the shallower

rock-material and to the superficial layers that form the soil upon which so much of the prosperity of the Dominion depends. The geological map forms the best basis for a soil survey of New Zealand, so it has been necessary to prepare a geological map in advance of a soil map in order adequately to describe and classify the soils with special reference to their full profile. This classification has been called for in order to trace the connection between soils and the incidence of malnutrition in stock.

In the area recently examined to the west of Mairoa, soil types similar to those at Mairoa occur. Taylor (1930 A) has established a causal connection between the intensity of sheep-sickness and some of the soil-types, and endeavours to show that leaching is primarily the cause of the Mairoa farms being unhealthy for stock. Grazing tests on patches of soils of the different types are required to confirm this hypothesis. In this connection, the presence of a thin coating of Taupo pumice and the work of Bruce Levy (1925) on the relation between pasture grasses and soils, should be borne in mind. It may be that the soils are inherently too poor to support pasture that gives a balanced ration in the absence of fertilizers (*Cf.* Orr, p. 52), as is the case on Waikato dairy-farms. The pedological survey now in progress must thus precede pasture research.

In the Kopaki district, where the soils and subsoils largely consist of pumice, malnutrition of sheep is prevalent, though cattle thrive where ragwort is held in check. The farmer, however, is on the horns of a dilemma, for he must keep sheep to eat down the ragwort. Where the pumice deposits are thin and mixed with older sedimentary rock material sheep remain healthy (Taylor, 1930 B), but such areas are small and steep. These healthy tracts will be delineated as the survey extends over wider areas. On the flat tops of the greywacke fault-blocks, on the rhyolite sheets, and on river-terraces the pumice deposits are thick and virtually form the soil and subsoil. These tracts, though easily farmed, are unhealthy. The alluvial flats in that part of the Kopaki district that has been examined are of small extent and are partly or wholly waterlogged, typical "pakihi" vegetation being visible in many places. The soils consist largely of resorted pumiceous material that improves in value with increase of distance from the sources of the alluviating streams.

In the Tiroa-Maraeroa district the soils consist almost entirely of pumice, though on its eastern and western margins, areas as yet unsurveyed, older sedimentary rocks introduce variations. Notable features of the Maraeroa area are the open tussock-covered plains similar to the well-known Waimarino Plain. Where the gradient of the land is appreciable apparently sound crops can be grown, but where the gradient is small, run-off of rain-water is reduced and tussock-grass gives place to an uninviting mossy sward. Stream-terraces, on the contrary, are drier; but farmers in neighbouring districts find these easily cultivated tracts lack humus, and active leaching causes a rapid loss of artificial fertilizer. As at Rotorua (see Grimmett and Simpson, 1928) so here, the situation factor seems to be of more importance than the textural.

The following lists of herbs, &c. (identified by Dr. H. H. Allan, of the Department of Scientific and Industrial Research), and of mosses (identified by Mr. G. O. K. Sainsbury, of Hawke's Bay), obtained from sods about one square foot in area, cut from well-grazed patches, show the nature of the vegetation that finds congenial environment on these volcanic soils and upon which stock are sometimes forced to subsist.

1.	2.	3.
Yorkshire fog (*Holcus lanatus*).	Cocksfoot (*Dactylis glomerata*).	Danthonia (*D. semiannularis* [5].
Self-heal (*Prunella vulgaris*).	Crested dogstail (*Cynosurus cristatus*).	Fescue tussock (*Festuca novae-zelandiae* [4].
Hawkbit (*Crepis capillaris*).	Yorkshire fog (*Holcus lanatus*).	Yorkshire fog (*Holcus lanatus*) [3].
Bracken-fern (*Pteridium esculentum*).	Catsear (*Hypochaeris radicata*).	Catsear (*Hypochaeris radicata*) [3].
A lichen (*Cladonia* sp.)	Meadow-grass (*Poa pratensis*).	Meadow-grass (*Poa pratensis*) [2].
Thuidium furfurosum.	Rib-grass (*Plantago lanceolata*).	White clover (*Trifolium repens*) [2].
Brachythecium salebrosum.	Suckling clover (*Trifolium dubium*).	Suckling clover (*Trifolium dubium*) [2]
Stereodon cupressiforme.	(?) Birdsfoot trefoil (*Lotus corniculatus*).	Hawkbit (*Leontodon hispidus*) [2].
Tortella calycina.	Self-heal (*Prunella vulgaris*).	Bracken-fern (*Pteridium esculentum*) [1]
Polytrichum juniperinum.	Hawkbit (*Crepis capillaris*).	—— *Leucopogon frazeri* [1].
	Chickweed (*Cerastium vulgatum*).	*Thuidium furfurosum.*
	Thuidium furfurosum.	*Hypnum cupressiforme.*
	Brachythecium salebrosum.	
	Stereodon cupressiforme.	
	Tortella calycina.	

1. From bracken-covered area in the Ngapaenga Road Reserve, Mairoa district.
2. From paddock of an abandoned farm, Mairoa district.
3. From tussock grassland, Tiroa-Maraeroa district. The figures in brackets denote the number of plants of each species found in the sod.

In the Tiroa-Maraeroa district, monoao (*Dracophyllum sublatum*) and manuka (*Leptospermum scoparium*) scrub cover much open country, and in the scrub common plants are koromiko (*Hebe salicifolia*), ragwort (*Senecio jacobaea*), Strathmore weed (*Pimelea prostrata*), tar-weed (*Bartsia viscosa*), *Helichrysum filicaule*, and *Lycopodium fastigiatum*. Mosses and lichens, such as *Dicranoloma pungentella, Campylopus clavatus, Cladonia aggregata, C. retepora, C. rangiferina, C. pyxidata, Parmelia physodes*, and *Usnea barbata*, growing abundantly on the shady faces of terraces, show that the "soil-climate" of the district is cold and damp.

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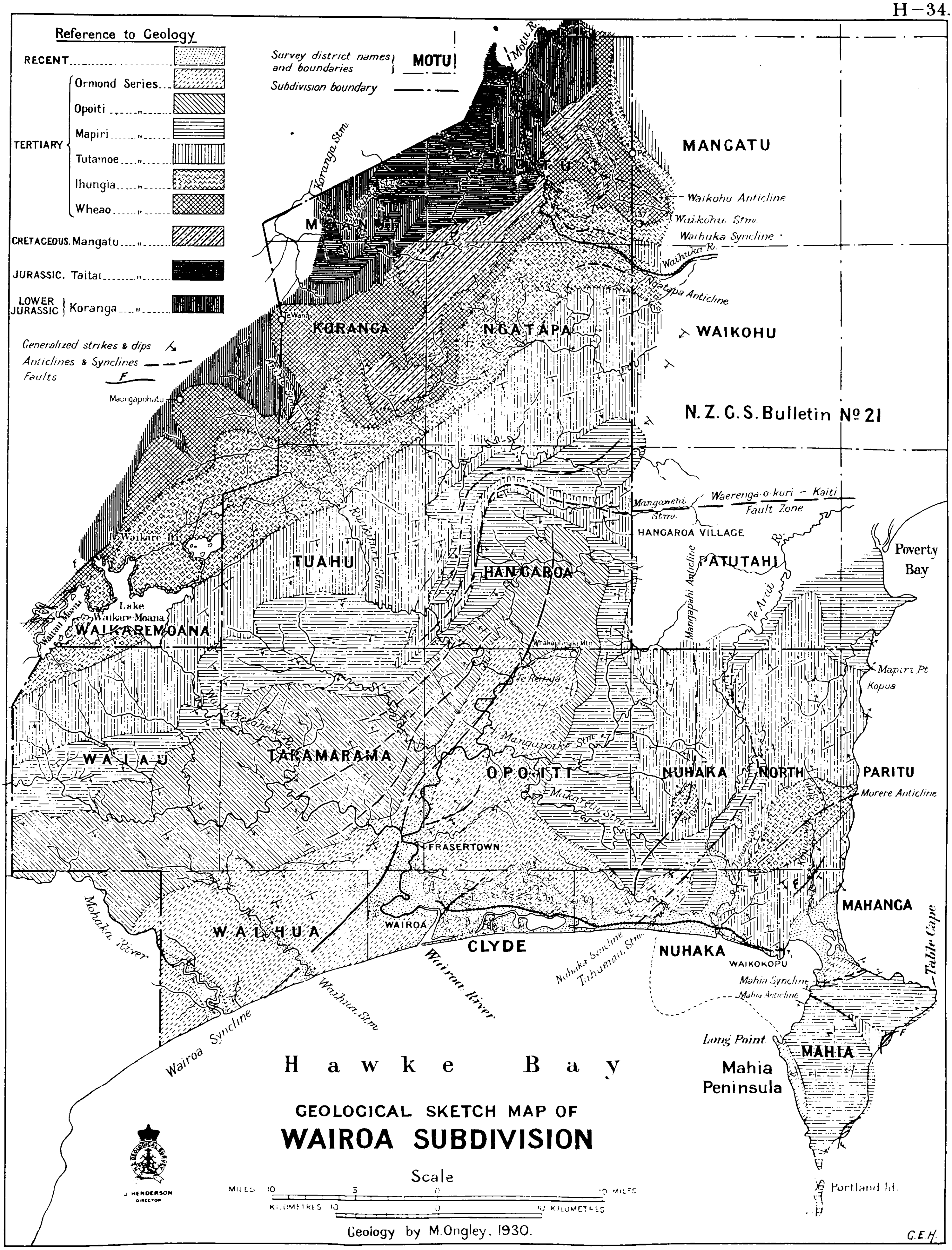

Reference to Geology
RECENT
TERTIARY
Ormond Series
Opoiti
Mapiri
Tutamoe
Ihungia
Wheao
CRETACEOUS. Mangatu
JURASSIC. Taitai
LOWER JURASSIC Koranga
Survey district names and boundaries
MOTU
Subdivision boundary
Generalized strikes & dips
Anticlines & Synclines
Faults
F
MANGATU
Waikohu Anticline
Waikohu Stm.
Waihuka Syncline
Waihuka R.
Ngatapa Anticline
WAIKOHU
KORANGA
NGATAPA
Koranga Stm.
Motu R.
Te Wera
Maungapohatu
N. Z. G. S. Bulletin Nº 21
Mangawehi Stm.
Waerenga-o-kuri – Kaiti Fault Zone
HANGAROA VILLAGE
PATUTAHI
Mangapahi Anticline
Te Arai
Poverty Bay
TUAHU
HANGAROA
Waikare-Iti
Lake Waikare-Moana
WAIKAREMOANA
Waiau
Mapiri Pt
Kopua
WAIAU
TAKAMARAMA
OPOITI
Mangapoike Stm.
NUHAKA NORTH
PARITU
Morere Anticline
FRASERTOWN
MAHANGA
WAIHUA
WAIROA
CLYDE
NUHAKA
WAIKOKOPU
Mahia Syncline
Mahia Anticline
Table Cape
Mohaka River
Wairoa River
Waihua Stm.
Nuhaka Syncline
Tahaenui Stm.
Wairoa Syncline
Long Point
MAHIA
Mahia Peninsula
Hawke Bay
GEOLOGICAL SKETCH MAP OF
WAIROA SUBDIVISION
Scale
MILES 10 5 0 10 MILES
KILOMETRES 10 0 10 KILOMETRES
Portland Id.
J. HENDERSON DIRECTOR
Geology by M. Ongley. 1930.
G.E.H.

2. WAIROA SUBDIVISION.

(By M. Ongley.)

Wairoa Subdivision is an area of 1,600 square miles on the east coast of the North Island, between 38° 15′ and 39° 20′ south latitude, adjoining the Gisborne Subdivision, described in Geological Survey Bulletin No. 21, and extending away to the south and west. Along part of its eastern boundary it faces the ocean and on the south is Hawke Bay. It includes the country from the east coast to the Huiarau Range as well as a small area west of that watershed.

The rocks of which it is formed are all sedimentary, Jurassic, Cretaceous, and Tertiary in age and are continuous with those of the Gisborne and Waiapu subdivisions, and, like them, have been favourably reported on by authoritative oilfield geologists. Consequently the solution of the geology is desirable. Since 1926 a party has been working there during each field season, and the results obtained will be reported in a Geological Survey bulletin to be issued later.

Topography.

The subdivision contains part of the Huiarau Range, the main divide between streams flowing to the Bay of Plenty and those flowing to the east coast, but consists chiefly of dissected plateau country descending gradually from 3,500 ft. in the west to 500 ft. at the coast. It is deeply dissected by many mature consequent streams flowing south of east down the slope of the plateau, and by the large, mature, subsequent Wairoa River, flowing west of south in entrenched meanders through a drowned, infilled valley along the Wairoa Syncline. Many of the smaller streams, too, have adjusted parts of their courses along the strike of the beds. Seen from a distance, the country appears flat, but it is made up of series of mature ridges, and no flat remnants are anywhere preserved.

Structure.

The subdivision contains two different types of country: the older, hard greywacke and argillite folded into closed folds and standing vertical; the younger, sandstone and mudstone in fairly regular, extensive, open folds.

Just west of the subdivision in Wakamarama West Survey District, and also in the west of the subdivision in west Koranga, greywacke with carbonaceous remains, argillite, and greenish mudstone, standing nearly vertical, strike east of north and have many of the soft beds crushed, slickensided, and pugged. These facts show that they have been tightly folded about axes trending east of north, and that the stress was severe enough to crush some beds and push the beds along on the crush-planes. In south-east Moanui and north-east Koranga, too, similar beds strike the same. In Moanui the beds are strong greywacke and argillite, and they dip steeply eastward; in Koranga and north-west Ngatapa the beds are fairly soft mudstone, and they dip 25° westward. The strata thus form an asymmetrical synclinal eight miles wide trending east of north to north-east across Motu Survey District to Matawai. Whether the axial part is bent in a fold or broken by a fault is not known. Above the steep greywacke on the west flank and in places reaching to the middle of the synclinal and running parallel with it are strong rugged ridges of Taitai sandstone and conglomerate, shattered, jointed, and slickensided, and mostly without recognizable bedding. Specimens of *Inoceramus* and a few other fossils have been got from the beds on both limbs, and *Aucella* from the Taitai; if these can be zoned the structure may be nearer solution.

The age of the tight folding is evidently post-Jurassic and it is pre-Tertiary. The severely distorted Mangatu beds in the south-east of the subdivision show that the tight folding was active in places after Mangatu time (Cretaceous).

In contrast to the older rocks, the Tertiary beds were not intensely folded, and the only places where they are steep are alongside faults. Generally they form extensive gentle dip-slopes running miles along the strike and meeting in broad open folds. In the south they strike generally north, but in the north of the subdivision they curve round and strike east.

In the south-east of the subdivision the Tertiary beds are in fault contact with Cretaceous rocks. From there, on Portland Island and south Mahia, they dip west and south-west over more than half the peninsula. In north-east Mahia the beds dip north-west for four miles. On the west coast of the peninsula the beds dip outwards from a point three miles north of Long Point. This pattern of beds is shown on the map. It indicates an anticline trending south of east across Mahia.

On the north of Mahia the beds dip inwards for four miles from Table Cape and one mile from the isthmus, forming the Mahia Syncline.

On the north-west side of the Mahia Syncline they rise for ten miles into the Morere Anticline. This is a big fold, covering more than 100 square miles. It trends east of north from the Nuhaka River to the east coast, where the axis lies three-quarters of a mile north of Paritu Stream. On it are two bulges, a large one extending north across Nuhaka North into Patutahi Survey District and a smaller one extending three miles north in Paritu Survey District.

The west limb of the Morere Anticline dips west for three miles into the Nuhaka Syncline, which crosses the subdivision from Tahaenui, on Hawke Bay, to Te Arai, in Patutahi Survey District, in the north, and is constricted by a saddle which divides it into northern and southern parts. The west limb of this syncline, in turn, rises westward for four miles into the Mangapahi (Mangaone) Anticline, which is another structure more than 100 square miles in area. It trends north for fifteen miles in the west of Nuhaka North Survey District. West of this again the beds dip west for eleven miles into the Wairoa Syncline, which was mapped trending north for thirty miles, inland almost to Hangaroa Village site. It has several small puckers in it, and at the south end broadens out and, branching, swings away to the south-west and south-east.

In Taramarama Survey District, three and a half and seven miles west of the axis of the Wairoa Syncline at Frasertown, two smaller anticlines extend north for seven miles. West of this in the south the Tertiary beds rise continuously westward at from 5° to 20° for twenty miles to the edge of the subdivision forming the Waikaremoana Homocline. A few miles beyond it they are turned up vertical by a fault in contact with greywacke and argillite; but in the north another anticline, sharp and steep, begins in Tuahu Survey District six miles up the Ruakituri River from Te Reinga, which lies in the middle of the Wairoa Syncline. This Hangaroa Anticline marks an important change in the structure. It trends east of north and north for ten miles across Hangaroa Survey District, turns east across the Hangaroa River at Hangaroa Village site, and up Mangawehi Stream, where it joins the Waerenga-o-kuri–Kaiti fault-zone, described in Bulletin No. 21 as trending east across Patutahi Survey District and probably to the east coast.

West of this, throughout Tuahu Survey District, the strong sandstone dip-slopes strike continuously north-east from Waikaremoana and dip 15°–20° south-east. These Tertiary dip-slopes extend some miles west of the subdivision, and the lowest Tertiary bed forms the dip-slopes of Maungapohatu and Te Wana mountains.

North-east of the bend in the Hangaroa Anticline the beds form a shallow basin in Hangaroa north-east, and this extends into the three adjoining survey districts.

The sandstone dip-slopes that cross Tuahu Survey District from Waikaremoana continue north-east through Koranga and Ngatapa survey districts, and in east Ngatapa swing to the east. In north-east Ngatapa they turn over and dip north for five miles along Waihuka River, forming the Ngatapa Anticline. In south-east Motu they again dip south and so form the Waihuka Syncline, which trends south of east along Waihuka River for six miles from Rakauroa into Waikohu Survey District.

Four miles farther north the Waikohu Anticline trends south of east for five miles across Motu Survey District and extends three miles into Mangatu Survey District.

Geology.

The rocks of the subdivision are all unmetamorphosed sedimentary, and are classed as follows:—

Series and Thicknes.	Beds.	Age.
Recent	Beaches, terraces, dunes, and subaerial pumice	..
Ormond (5,000 ft.) ..	Shelly limestone, pebbly sandstone, thick tuffaceous sandstone, argillaceous sandstone	Waitotaran.
Opotiti (4,000 ft.) ..	Pebbly shelly limestone, alternating sandstone and mudstone, arenaceous mudstone	Taranakian.
Mapiri (12,000 ft.) ..	Mudstone, tuffaceous sandstone, arenaceous mudstone, shell-rock, alternating mudstone and sandstone	Taranakian.
Tutamoe (5,500 ft.)	Conglomerate, thick coarse concretionary sandstone, alternating sandstone and mudstone, massive mudstone	Awamoan.
Ihungia (3,500 ft.) ..	Thin bedded mudstone and sandstone, thick, coarse concretionary sandstone	Hutchinsonian.
Wheao (4,500 ft.) ..	Thick sandstone, shell-rock, alternating sandstone and mudstone ..	Oligocene (?)
Mangatu (3,000 ft.)	Argillaceous limestone, light mudstone, greensandstone	Senonian.
Taitai (15,000 ft.) ..	Coarse greywacke and sandstone, dark argillite, igneous conglomerate ..	Jurassic.
Koranga (6,000 ft.) ..	Grey argillite, dark mudstone, and greensandstone, dark argillite, alternating greywacke and argillite	Jurassic.

Koranga Series.—In the north-west of the subdivision, in Koranga, Moanui, and Motu survey districts, occur beds of hard coarse greywacke interbedded with dark argillite exposed typically in Anini and Moanui streams. In both places the beds are nearly vertical and strike north. In the Anini they are in contact, along faults, with light, fairly soft mudstones that resemble the Mangatu beds, and, as they present a strong contrast lithologically, they are separated tentatively into the Koranga Series.

These rocks extend down Koranga Stream to the western boundary of the subdivision and beyond it. Along Moanui Road the interbedded greywacke and argillite, standing nearly vertical, extend three miles across the strike and appear to be 15,000 ft. thick. In places the beds of nearly black argillite are laminated with streaks of white sandstone, about ten to the inch. This interlamination in particular, and the general appearance gf the interbedded coarse greywacke and dark argillite, resemble the Tapuwaeroa Series of the Waiapu Subdivision. The conglomerate and fossils of the Tapuwaeroa beds were not found, however, the only fossils being poorly preserved *Inoceramus* and a few other small unidentified mollusca.

Taitai Series.—In the north-west of the subdivision occur sharp pinnacles and steep-sided rugged ridges that recall Taitai, Hikurangi, Aorangi mountains in Waiapu Subdivision, and, like them, are formed of coarse, greenish-grey, slickensided sandstone with pockets and beds of igneous pebbles, but generally without distinct bedding. Apparently underlying these are alternating beds of coarse greenish greywacke and dark argillite with some layers of the igneous conglomerate. These rocks stand nearly vertical for miles in south-east Moanui and north-west Motu. In the east front of one of these rugged ridges in the south-west corner of Motu Survey District the shattered sandstone has in it scattered igneous pebbles, as well as specimens of *Aucella*. These beds are so complicated that it is impossible to make much out of them, but the ridges they form run with the strike of the big Koranga–Motu synclinal and appear to have the same attitude as the steep beds on its north-west limb.

There is, however, one good section where the relation of the *Aucella*-bearing sandstone is evident, and that is in north-east Koranga, in the tributary that joins Koranga Stream from the south about the middle of the north boundary of Koranga Survey District. There the under-beds are dark

argillite, in places streaked with thin laminæ of light sandstone, striking south-east continuously for a mile along the stream and dipping south-west at 30°. The argillite is overlain evenly by a flaggy sandstone 3 ft. thick, the lowest 3 in. of which is closely packed with subround and subangular pebbles of mudstone ½ in. through, and many shells of *Aucella* set in a coarse sandy matrix. The contact is straight, even, smooth, and parallel to the bedding. Above the pebbly part the sandstone contains laminæ black with carbonized wood, and in places there are three or four black laminæ interbedded with fossiliferous sandstone beds 1 in. thick.

Down-stream, evidently above the contact, is dark argillite which, higher in the sequence, becomes more arenaceous, and rises a mile down-stream, at the gorge, into hard, massive, coarse greywacke. On the right bank of Koranga Stream, below the junction, the argillite underlies the greywacke, above which is the pebbly greensandstone. The bed last mentioned forms the extensive gentle dip-slopes between the Koranga and the Moanui. In the stream above the gorge the greywacke is steep, and it continues steep for half a mile to the north along the strike.

Mangatu Series.—In the south-east of the subdivision at two places on the east coast of Mahia Peninsula, and also in Kopuawhara Valley at the north of Mahanga Survey District, argillaceous limestone, light-coloured mudstone with fucoids, and greensandstone occupy small areas where they are faulted against Tertiary strata. From lithology they are correlated with the Mangatu (Upper Cretaceous) beds of Waiapu and Gisborne subdivisions. At the biggest outcrop they extend for 50 chains along the beach, dipping 60°–70°, and are evidently 3,000 ft. thick. They crop out, striking in a semicircle with an overturned fold in the centre, both limbs dipping south at 80°. From the coast an anticline strikes north-west towards the gas and brine springs a mile inland. Both limbs are steep, one dipping north at 60° the other south at 80°.

In Motu Survey District dark argillite, greensandstone, and light mudstone occupy the middle of the west end of the Waikohu Anticline. These probably belong to the Mangatu Series, but fossils are wanting. The similar Mangatu (?) beds in Anini Stream have already been mentioned. In west Ngatapa and east Koranga a large area is occupied by similar beds. Dark-brown mudstone, bluish-grey mudstone, and greensandstone, striking east of north, dip continuously westward at 26°–30° for five miles along Koranga Stream, exposing 6,000 ft. of strata. The beds of greensandstone form extensive dip-slopes over more than 20 square miles. The mudstone and concretionary beds contain *Inoceramus* and fragments of *Belemnites*, but no definite age can be given to them. They are not indurated, and on lithology are tentatively placed in the Mangatu Series.

Their stratigraphic relation to the argillite that underlies the *Aucella* bed is not clear. They may be the same beds, but on lithology they appear younger and have accordingly been regarded as part of the Mangatu Series.

Wheao Series.—So much of the district is unfossiliferous that it is impossible to be sure what beds are present in certain places, and this applies especially to the low Tertiary strata, in which the shallow-water beds differ much from place to place. Still, there is no difficulty about superposition and the beds remain similar for distances sufficient to enable the geology to be worked out fairly satisfactorily.

Continuous with the Wheao Series of the type locality described in Bulletin No. 21, beds of alternating sandstone and mudstone extend up Waikohu River in the north-east of the subdivision, occupying the middle of the Waikohu Anticline. Near the base occur beds of shelly limestone and pebbly greensandstone, and above them beds of alternating sandstone and mudstone. It is difficult to say where this series ends, for the igneous conglomerate characteristic of the base of the overlying series is not present. By projecting the boundary from the igneous conglomerate in the Gisborne Subdivision along the strike of the rocks the Wheao Series appears to be two miles wide, and, since the beds dip at 25°, the formation is estimated as 4,500 ft. thick.

Ihungia Series.—There are no beds in the subdivision like the Ihungia Series of the type locality in Waiapu Subdivision, but two miles to the east the basal Ihungia conglomerate is known, although it does not persist into the subdivision. The approximate Wheao-Ihungia contact, drawn as stated in the preceding section, places the base of the Ihungia Series in Motu Survey District out on the flanks of the Waikohu Anticline, two miles from the axis; and there strong sandstone beds form extensive dip-slopes at Trig. Pc in the north and at Trig. 137 in the south. On the south limb of the anticline this ridge-making sandstone crosses Waikohu River three-quarters of a mile east of Kokupara Stream. There it contains lenses of coal ½ in. thick and pebbles of mudstone. The basal sandstone is 60 ft. thick, and the sandstone beds aggregate 200 ft. Above these follow thin beds of alternating sandstone and mudstone, 1 in. thick, strikingly evenly bedded and uniform over large areas in the Waihuka and upper Waikohu valleys.

In the south of the subdivision the beds classed as Ihungia on palæontology are different; but, since they occur below a conglomerate containing the fauna of the overlying Tutamoe Series, they are placed in the Ihungia Series. They crop out conspicuously near Waikokopu, for two miles along the coast of Paritu Survey District, and in Tunanui Stream, in Nuhaka North Survey District, as thick beds of coarse concretionary sandstone. Many of the beds consist almost wholly of concretions 4 ft. to 6 ft. through. The sandstone contains a great deal of broken shell. Between the beds of sandstone lie thin layers of dark mudstone, in places so black with carbonaceous material as to be locally reported as coal. Many of the mudstone beds are eroded and formed into edgewise conglomerate. Along the coast these beds are 3,500 ft. thick, and the base is not exposed.

Tutamoe Series.—A conglomerate containing the characteristic Tutamoe fauna crops out in several places in the east of the subdivision; and above it lies a series of thick beds of coarse concretionary shelly sandstone just like the underlying beds. Higher in the sequence the sandstone is finer, and the beds of sandstone thinner, the intervening mudstone beds thicker, and the series grades up into the massive Morere mudstone, which crops out in many places with the same characteristics, and so affords a useful horizon-marker. The lower part of the series is 4,500 ft. thick, and the Morere mudstone 1,000 ft.

The Tutamoe sandstones are conspicuous on the east coast on both sides of the Morere Anticline, and outside them on both flanks is the Morere mudstone, forming the coast at Kopua in the north, and the north of Mahia in the south. They cover the larger part of both the Morere and Mangapahi anticlines.

Mapiri Series.—Above the featureless country occupied by the Morere mudstone extend great dip-slopes formed of thick beds of white tuffaceous sandstone. The lowest thick bed is taken as the base of the Mapiri Series. On the coast at Mapiri Point it is 6 ft. thick, and the lowest part, 6 in. thick, is packed with crystals of quartz, felspar, and mica. The upper part is homogeneous, dense, white, tuffaceous sandstone. Above the tuff occur beds of mudstone, similar to the Morere mudstone, and there is no erosion break between the two series. The basal Mapiri tuffaceous sandstone overlying the weak Morere mudstone occurs throughout the subdivision and affords the best horizon-marker in it. Higher in the sequence the mudstone is interbedded with many similar beds of tuffaceous sandstone, and the mudstone itself is coarser and more arenaceous higher up. Altogether the series is 12,000 ft. thick, and no doubt it will be subdivided when more work is done. At several places local erosion intervals were seen, but none is extensive enough to enable the series to be subdivided at present.

These beds cover nearly all Mahia Peninsula, and large areas towards the middle of the Nuhaka and Wairoa synclines. They occur, too, in the south-west and run north-east near the foot of the big Waikaremoana Homocline from the Waiau River to Hangaroa.

Opoiti Series.—In Opoiti Survey District, upon the fine argillaceous sandstone of the Mapiri Series rests a bed of pebbly, shelly limestone, about half of which consists of subangular pieces of mudstone welded into the rock, and evidently formed by contemporaneous erosion. In addition, it contains worn pebbles of hard dark argillite, ½ in. through, and rare ones, 6 in. through, riddled with small holes and coated with greenish varnish. Above the limestone is a bed of coarse, pebbly, greenish sandstone, packed with pebbles a ¼ in. through, and above that, more beds of coarse sandstone with rare pebbles. Higher still, the rock is fine argillaceous sandstone interbedded with many thin beds, 1 ft. thick, of shell-rock and some thick beds of white tuffaceous sandstone. Altogether the beds are 4,000 ft. thick. They occupy the foot of the Waikaremoana Homocline, and the small folds in front of it in Waiau, Taramarama, and Hangaroa survey districts.

Ormond Series.—Above the Opoiti beds in Opoiti Survey District is a thick bed of pebbly, shelly limestone with beds of tuff in it, 400 ft. thick, and grading westward into alternating beds of coarse greenish sandstone, tuffaceous sandstone, and shell-rock. Above these are argillaceous sandstone and thick massive bluish-grey mudstone with some beds of white tuffaceous sandstone. These strata form the middle part of the Wairoa Syncline, including Whakapunake Mountain and the limestone dip-slope that runs from it to Tahaenui and forms Long Point and Black Reef on the west of Mahia. Altogether these beds are 5,000 ft. thick. The rocks previously classed as belonging to the Waihua Series are now, on their field relations, included in the Ormond Series, as their less calcareous, more arenaceous equivalent. Just south of the subdivision the Petane Series overlie the Ormond Series.

Recent Deposits.—Among the recent deposits are the gravel, loam, and pumice silts covering the terraces of the Mohaka and Wairoa valleys, the gravel and sand beaches, and the immense deposits of sand forming the dunes east of Nuhaka and joining Mahia to the mainland, the shell beaches of Mahanga and Mahia, and the infertile aeolian pumice layer that covers the whole district.

Economic Geology.

The subdivision is being examined primarily as a possible oilfield. Now, although oilfields differ, they have features in common that distinguish them from unpetroliferous areas, so that impossible areas can be rejected and possible fields recognized. Different authorities insist on different details, but agree generally on the main criteria. These were set out for the Dominion Mining Conference in 1926 by Clapp, who listed ten essentials to successful oil-development, seven fundamental geologic conditions, and thirteen secondary geologic criteria. He remarked that the list was not complete. All the criteria mentioned indicate that the subdivision should produce oil.

3. TONGARIRO SUBDIVISION.

(By L. I. Grange and J. H. Williamson.)

Introduction.

The geological and volcanological survey of the volcanic belt of the North Island, the progress of which has been outlined in previous reports, was completed during the field season, which lasted from the 7th November, 1929, to the 31st May, 1930. During this period Kaimanawa and portions of Ruapehu, Tongariro, and Pihanga survey districts, which include Tongariro National Park, were mapped. A great deal of topographical work was done around the volcanoes. In all, an area of 414 square miles was examined in detail. Mr. W. M. Jones, M.Sc., assisted in the field during the whole of the season, and Mr. M. J. O'Sullivan during the University summer vacation.

Structure and Physiography.

The Kaimanawa Mountains, which form the watershed between the Rangitikei and Waikato rivers, trend north-north-east through the eastern portion of the subdivision and rise to a general height of from 4,500 ft. to 5,000 ft. The lower slopes are, in general, heavily bushed, especially towards the northern end. The streams draining the mature upland surface of the range debouch through steep gorges on to the plain between it and the volcanoes. This plain, known in the southern part

as Onetapu Desert and in the northern part as Rangipo Desert (?), is 2,500 ft. above sea-level in the south and rises to 3,500 ft. in the central portion, whence it slopes gradually to the north to 1,200 ft. The southern portion is drained by the Wangaehu River, and the northern by the tributaries of the Waikato River. The Onetapu Desert is barren and windswept, with shifting sand-dunes and desert flora. Northward the vegetation gradually increases.

To the west rise the volcanoes Ruapehu, Ngauruhoe, and Tongariro, described in last year's annual report. From the foot of these peaks the country slopes down and merges into the dissected peneplain of the Wanganui.

Lying to the west of Ruapehu is Hauhungatahi, a small cone 4,983 ft. high. Viewed from the Waimarino Plain, it is seen to slope down to a high level flat about a mile wide, from which there is an abrupt drop of 1,000 ft. to the plain below.

Taurewa Mountain, which rises to a height of 3,530 ft. in the north-west corner of the subdivision, is a fault-bounded block of greywacke sloping to the north-west. The fault on the south-east side follows the Otamawairua Stream; that on the west passes along the Whakapapa River and through Raurimu.

A strong fault with downthrow to the west trends north-north-east along the western edge of the Kaimanawas. The spurs are all rounded off, and the valleys on the southern end are now filled with Upper Pliocene beds, not affected by the fault, which is thus of pre-Upper Pliocene age.

Another fault striking slightly east of north with downthrow to the west occurs in Pliocene beds between the Kaimanawa Range and Ruapehu, its scarp forming the east bank of the Wangaehu River in the southerly part of its course in the subdivision. A small fault running north-east and dipping west appears north of the Oturere River. Other faults in the subdivision have already been described in last year's report.

General Geology.

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

1. Andesitic ash and scoria from Ngauruhoe, &c. (Recent).
2. White rhyolite pumice from near Lake Taupo (Recent).
3. Dark andesite flows, scorias, and ash from Ruapehu, Tongariro, and Ngauruhoe (Recent and Pleistocene).
4. Grey andesite flows and agglomerates from vents beneath Ruapehu and Tongariro (Pleistocene).
5. Fluviatile gravels and conglomerates (Recent and Pleistocene).

(Unconformity.)

6. Sandstones and mudstones of Nukumaruan age (Upper Pliocene).

(Unconformity, not seen.)

7. Sandstones and mudstones of Taranakian age (Upper Miocene).
8. Sandstones of the Mokau Series (Lower Miocene).

(Unconformity.)

9. Greywacke, argillite, and sandstone (Mesozoic or Palæozoic).

The rocks of the Kaimanawa Range, which are the oldest of the subdivision, form a broad strip along its eastern edge. Their western boundary generally corresponds to the course of the Waikato River—known locally as the Tongariro River until it enters Lake Taupo. At the junction of the Waipa Stream the boundary turns to the north-east and runs out of the subdivision; on the south the Moawhanga River marks the limit of the outcrop of these rocks, which are strongly folded grey and green sandstones, dark argillites, and greywacke, striking north-north-east and dipping 80°. In the western portion, which was examined in detail, the rocks are much crushed, and in places show a schistose structure. The greywacke of Taurewa Mountain is of the same formation.

Greywacke and argillite were found as boulders and small fragments on the north-east slopes of Ruapehu, and as inclusions in lava-flows. From the fact that the argillite boulders show no sign of alteration it may perhaps be concluded that they occur at a shallow depth below the volcanoes.

Mokau Beds.—Sandstones and argillaceous sandstones containing greywacke pebbles, and having an easterly strike and a dip of 2° south, outcrop more or less continuously in the steep cliffs bordering the Whakapapa River. Three-quarters of a mile east from the junction of the Papamanuka Stream the beds contain fossils of Mokau age. Beds of similar age outcrop on the upper Wanganui River, and the exposures between this and the Whakapapa River are probably part of the same formation. Small outcrops in the Waimarino and Mahuia Streams, and sandstones and mudstones between the bed of the Mahuia Stream and the 3,750 ft. level in a steep washout on the north-east corner of Hauhungatahi, which were unfossiliferous, may also belong to this series. It is, however, extremely difficult to trace the Tertiary rocks in this part of the district, for beneath the heavy bush lies a thick covering of lava-flows and volcanic ejectamenta, which in many cases filled the stream-beds after considerable erosion of the Tertiary rocks.

Beds of Taranakian Age.—A cutting on the railway-line a mile and a half north of Ohakune contains Taranakian fossils. Unfossiliferous blue mudstone 50 ft. thick outcropping in the Toatoa Stream, about two miles east of this cutting, and sandstone, also unfossiliferous, exposed in a small nearby tributary of the Mangawhero River, are probably of this age.

Nukumaru Beds.—Fossiliferous beds of calcareous and soft sandstones, mudstone, and shale, 300 ft. thick, are exposed in the Mangaio River south-west of the Kaimanawa Range, and similar beds outcrop half a mile south-east outside the subdivision. Dr. Marwick, who examined the fossils, reports that they are of Nukumaruan age. The beds contain occasional small greywacke pebbles up to a $\frac{1}{4}$ in. across, but andesitic material is absent, indicating that Ruapehu and Tongariro were not active when the beds were laid down.

Pleistocene and Recent.—Alternating beds of coarse and fine conglomerate of fresh-water origin, the upper of which contain volcanic ash, are exposed for a height of 125 ft. on the east bank of the

Wangaehu River. Similar beds outcrop in the Waikato River just below the bridge on the Waiouru–Tokaanu Road. In many of the stream-valleys, and particularly along the Waikato River, beds of fluviatile gravels and conglomerates occur, and most of the valleys running into the Kaimanawa Range are similarly filled.

Igneous Rocks.—Lava-flows from the volcanoes have been numerous, and some have been very extensive. An early flow of dark vesicular andesite from Ruapehu reaches the Waikato River twelve miles away on the east side and extends at least six miles west of Ruapehu. The lavas range in colour from greyish to black, and in texture from coarsely crystalline to fine-grained, but are all hypersthene andesite. Black andesite pumice was found in the upper reaches of the Mangatoetoenui Stream. The lavas contain inclusions of greywacke, already referred to; but none of Tertiary rocks was found.

Evidence of recent activity of the volcanoes is shown by the covering of loose andesitic material which follows the contour of the underlying surface. The principal ash-showers and average thicknesses in downward order are—

Andesite ash from Ngauruhoe	Maximum 6 in.
White rhyolite pumice from vent near Lake Taupo	1 ft.–3 ft.
Thinly bedded steel-grey andesite ash containing leaves ..	1 ft. 3 in.
Fine brown andesite ash	3 ft. 6 in.
Andesite Lapilli	6 in.

In addition to these, several older coarse and fine showers, usually water-sorted, are exposed in some sections. In a few places on the western side of Ruapehu two older showers of fine andesite ash containing roots were observed.

The fine brown andesite shower extends over the whole of the subdivision, and beyond the limits of the Taupo shower forms the surface soil. It has a thickness of 2 ft. 6in. on the eastern boundary. The succeeding shower has been carried north and east from its source of origin. It is 9 in. thick on the Kaimanawa Range and slightly thicker on the north of Lake Roto Aira, but is absent at Waiouru and on the west of Ruapehu. Though branches and roots are rarely found, it contains numerous leaves resembling those of *Gaultheria* and *Nothofagus cliffortioides*, or mountain-beech; but their indentification is difficult. The overlying white rhyolite pumice shower covers the whole of the subdivision, though at Horopito it thins to a few inches. In many places it contains charred tree trunks and stems up to 6 in. in diameter.

Unlike the previous showers, the andesite shower from Ngauruhoe is unconsolidated. It extends beyond the boundaries of the subdivision as a thin coating on the soil.

Volcanoes.

Ruapehu.—Apparently there was originally one large crater on Ruapehu, the northern and southern limits being Ruapehu and Te Heuheu, peaks on the irregular crater-rim. As the result of a later explosion two craters were formed within the large crater, the eastern one being bounded by a line passing through Scoria Peak, Cathedral Rock, Mitre Peak, and the spur leading to Mitre Peak, and the western one by the rim of rocks enclosing the Crater Lake. Possibly a third crater lay between Mitre and Girdlestone peaks, on the south-eastern corner of the mountain. The names "East Crater," "West Crater," and "Girdlestone Crater," respectively are proposed for these. The eastern edges of East and Girdlestone craters have been blown out, and West Crater is now the most clearly defined.

The most impressive feature of the mountain-top is the Crater Lake, a circular basin having a diameter of about 30 chains. Lying towards the eastern edge of West Crater, it is bounded on the south and west sides by vertical cliffs of ice; on the north-east side the original lava walls are visible; on the east is a cinder cone rising to a height of 250 ft. above the level of the lake. The strongly acid water has a chalky green colour and emits a sulphurous smell. The temperature of the water at the south-eastern corner of the lake at the time it was visited (April, 1930) was below blood-heat. No steam was seen rising from the lake, nor was the water swirling; previous observers have, however, recorded both these phenomena, indicating higher temperatures. The result of an analysis by the Dominion Analyst of a sample of the water is shown in column 1 of the following table. Column 2 shows the analysis of water from the Wangaehu River, collected four miles east of Crater Lake, and columns 3 and 4 shows both analysis reduced to a percentage basis.

		Total Dissolved Solids in Parts per 100,000.		Percentage Composition of Dissolved Solids.	
		1. Crater Lake.	2. Wangaehu River.	3. Crater Lake.	4. Wangaehu River.
Ammonium chloride	NH_4Cl	2·4	0·4	0·3	0·3
Potassium chloride	K Cl	6·3	1·1	0·8	0·8
Sodium chloride	Na Cl	65·6	10·8	9·0	7·7
Calcium chloride	$CaCl_2$	143·0	32·1	19·5	22·9
Magnesium chloride	$MgCl_2$	82·3	16·9	11·3	12·1
Ferric chloride	$FeCl_3$	16·9	4·0	2·3	2·9
Aluminium chloride	$AlCl_3$	84·7	1·5	11·6	1·1
Aluminium sulphate	$Al_2(SO_4)_3$ ..	104·9	46·4	14·4	33·2
Sulphuric acid (free)	H_2SO_4	194·1	20·9	26·6	14·9
Silica	SiO_2	29·8	5·6	4·1	4·0
Total dissolved solids	.. ..	730·0	139·7	99·9	99·9

The analysis show a marked resemblance between the waters of the river and the lake; and the fact that the water, unlike that of other streams rising on the mountain, is turbid and acid further supports the suggestion that this river is fed through an underground passage from the Crater Lake.

Small glaciers, some of them fed from the ice in the crater, are found at the heads of several of the larger streams which drain the mountain. A striated boulder was found on the spur north of, and some 600 ft. above, the Wahianoa Stream, about three miles from the snout of the Waihianoa Glacier. Here extremely course gravels were also seen, and similar gravels were found in the upper reaches of the Whakapapaiti Stream, about a mile from the Whakapapa Glacier. This is evidence of stronger past glaciation. No evidence of glaciation was, however, found on the Kaimanawa Mountains.

Te Mari.—Te Mari, an active scoria cone on the northern slope of Tongariro, has within tolerably recent times poured out a dark andesite lava, which cut a path through the bush at the foot of the mountain. At present the only sign of activity is a line of weak fumaroles high on the eastern rim of the crater. To the north there is another old crater, Sulphur Lagoon, which, although sometimes filled with water, was dry in April of this year. Some weak fumaroles on the south-west wall were then emitting steam.

4. MURCHISON AND MARUIA SUBDIVISIONS.

(By H. E. Fyfe.)

Introduction.

Field-work in the Murchison and Maruia subdivisions was completed during the past season, when an area of 325 square miles, chiefly in Burnett, Rahu, Travers, and Lewis survey districts was examined in detail. Of the 1,850 square miles of the two subdivisions, about 500 square miles are occupied by Tertiary rocks which, in places, contain workable coal-seams and yield indications of mineral oil. The following preliminary account of the geology of these subdivisions contain more detail of the Tertiary strata than of the rocks of older age.

Structure.

The Murchison depression is a much-fractured depressed zone over fifty miles long in a north-south direction, and averaging about eight miles across. Tertiary rocks occupy the bulk of this area, and the tangential compression which effected the folding and fracturing of these weak rocks thrust up resistant earth-blocks of the strong undermass on both sides of the depression. The chief mountain-masses to the east are the highlands from the Long Lookout and Hope ranges to the Cann Range, and, farther to the east, the blocks of the St. Arnaud, Mount Robert, and Spencer mountains. On the west the upthrust blocks form the Matiri Highlands and the Lyell, Brunner, and Victoria ranges. The crustal shortening was not inconsiderable, and this finds expression in anticlinal and synclinal folds in the less-resistant Tertiary covering strata. The Tertiary beds on the upthrust blocks are but gently warped, whereas in the depression high dips predominate.

The compressive forces were from the south-of-east, and the main fractures trend, on the average, north-north-east. These fractures, which are shown on the map, were doubtless accompanied by minor transverse fractures. As a whole, the synclinal structures are decidedly less broken and more easily traced than the anticlinal. The syncline traversed by the Mangles River and occupying the greater portion of the eastern half of the Tutaki Survey District is little fractured. Another synclinal stretches from the Owen to Longford, and apparently continues, thence to the Matakitaki near Horse Terrace; but south of Longford this structure is obscure. The western portion of a third synclinal in the Upper Matiri Basin is cut off by the fault traversing the headwaters of that river.

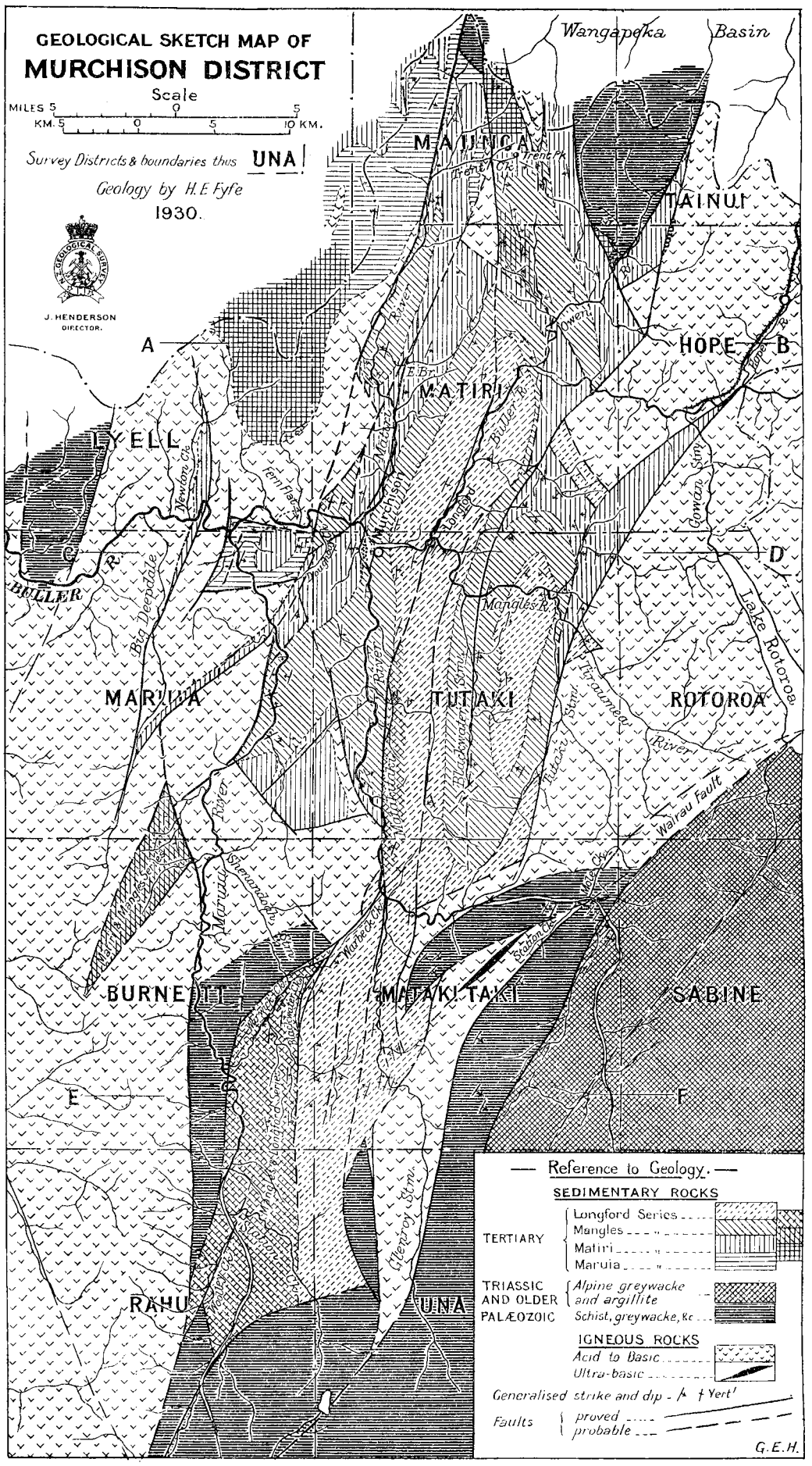
The main anticlinal structures are those of the Blackwater (Tutaki Survey District) and the Lower Matiri. Another anticlinal occupies the country between the Maruia and Matakitaki rivers from a point approximately due east of the Glengarry-Maruia junction southwards towards Mount Mantell.

Physiography.

The Buller River and its tributaries, chief of which are the Maruia, Matakitaki, Matiri, Mangles, Owen, Gowan, and Hope, drain the whole area. This drainage system has a rectangular pattern controlled almost entirely by structure, the main streams flowing throughout parts of their courses along fracture-zones. The Buller traverses two mountain axes in considerable gorges—the Lyell-Brunner Range in the western part of the district, and the Hope-Murchison Range in the eastern; between, valley-plains of greater or less extent border its course. Other considerable areas of flat land form the Upper Maruia Plain, and Hunter's Plain, in the Upper Matakitaki; but for the most part the streams, though mature, have narrow flood-plains. High-level terrace-remnants, as much as 1,000 ft. above the present river-beds, are conspicuous in some of the valleys.

Some of the streams have changed their courses since the retreat of the glaciers. The headwaters of the Maruia, from the Ada Pass southward, follow a glaciated valley that continued over the Lewis Pass to the Waiau River system. After the ice-retreat the waters draining this valley were either diverted to the Maruia by the morainic barrier which now occupies the Lewis Pass or were captured by rapid headward erosion of a tributary of the Maruia along a shatter-zone.

That some of the headwaters of the Grey River must at one time have joined the Maruia is indicated by the underfit streams which drain the Bog Saddle and are tributary to the Maruia. On the other hand, the surface of the high-level spur between this saddle and Palmer's Road slopes towards the Grey Valley, and is covered with fluviatile gravels and fluvio-glacial debris, indicating a former drainage of some of the Maruia headwaters to the Grey.


GEOLOGICAL SKETCH MAP OF
MURCHISON DISTRICT
Scale
MILES 5 0 5
KM. 5 0 5 10 KM.
Survey Districts & boundaries thus UNA!
Geology by H.E. Fyfe
1930.
J. HENDERSON
DIRECTOR.
Wangapeka Basin
MAITUNGA
TAINUI
HOPE
MATIRI
LYELL
MARUIA
TUTAKI
ROTOROA
BURNETT
MATAKITAKI
SABINE
RAHU
UNA
A
B
D
E
F
BULLER R.
Mangles R.
Lake Rotoroa
Walrau Fault
— Reference to Geology. —
SEDIMENTARY ROCKS
TERTIARY
Longford Series
Mangles
Matiri
Maruia
TRIASSIC AND OLDER PALÆOZOIC
Alpine greywacke and argillite
Schist, greywacke, &c
IGNEOUS ROCKS
Acid to Basic
Ultra-basic
Generalised strike and dip
Vert'l
Faults
proved
probable
G.E.H.

The Upper Matakitaki formerly flowed down the Tutaki along the head of the Mangles Valley, and thence to the Buller by Murchison (Nuggety) Creek.

All the mountain-masses are of the fault-block type. They range from comparatively small blocks, such as the Mantell Highlands, to large rectilinear masses, such as the Victoria Range. A more massive group of blocks forms the Spenser Mountains, of which the St. Arnaud, Mount Robert, Mount Misery, and Mount Ella ranges are subsidiary ridges.

Everywhere on the highlands and in the headwaters of the main drainage-channels the effects of former glaciation are marked by such features as cirques, tarns, truncated spurs, and U-shaped valleys. On the lowlands Lakes Rotoroa and Rotoiti occupy extensive glaciated rock basins, and morainic debris stretches for some distance beyond the lakes down the Buller and Gowan valleys. Glacial and fluvio-glacial debris cover wide areas distant from the mountain-masses.

Pre-Tertiary Rocks.

There is no internal evidence of age in any of the pre-Tertiary rocks, and the following correlations are based largely on lithology.

Older Palæozoic.—The greywackes, argillites, slates, and phyllites of the Lyell are similar to and continuous with the auriferous rocks of Reefton, and, like them, contain quartz reefs and leaders, which formerly were worked for their gold content. Near granite contacts they have been metamorphosed to hornfels. Similar rocks of Mount Mantell, Mount Rutland, and of the east flank of the Victoria Range are probably of the same age. Most of these rocks show thermal metamorphic effects, and in some localities they are traversed by weakly mineralized quartz veins.

Mount Arthur Series.—The schists, greywacke, and marble of Mount Owen are continuous with Lower Ordovician graptolite-bearing rocks of the Motueka Subdivision, to the north. Some greywacke and argillite on the Matiri–Wangapeka divide are probably of the same age. A finely banded limestone (marble), at least 300 ft. thick at its maximum, outcrops with argillite and greywacke in the hills to the south of Hunter's Plains, Upper Matakitaki. The dominant strike of these rocks is north-east and the dip south-east. There is an outlier of the marble between the Mole Stream and Watson Creek. Similar greywackes and a massive marble in the headwaters of Station Creek (Rahu Survey District) are continuous with the marble, carbonaceous slates, and phyllites at the Sluice-box and Marble Hill. Some banded greywackes and dark argillites at the headwaters of Coal Creek are probably of the same age, but no marble crops out here. A few chains north of Trig. G.A., Rahu Survey District, the limestone is contorted and involved in fault movements. The mass of marble outcropping about 60 chains east of Palmer's Road junction is probably the continuation of the band a few chains west of Trig. B, Rahu Survey District. In the Upper Maruia three bands of marble may be represented by the various outcrops, or more probably the repetition of a single band by folding or faulting along a north-north-east direction. Except at Mount Owen, these rocks are intruded by plutonic rocks ranging from acid to basic, and ultrabasic in composition.

Haupiri Conglomerates and Greywacke.—Conglomerates typical of the Haupiri conglomerate of the Motueka Subdivision crop out at the spur-ends on the south bank of the Matakitaki, about 100 chains west of Station Creek (Matakitaki Survey District). The conglomerates are interbedded with greywacke and red, green, and grey argillite. The rocks strike north-north-east and dip north-of-west at high angles. Their relation to the Mount Arthur beds is obscure, but their attitude and proximity to the Wairau fault suggests faulted relations.

Triassic and Older Rocks.—The main mass of the eastern highlands consists of greywacke, quartzite, and argillite typical of the sedimentary rocks which form the bulk of the alpine chain. These rocks outcrop to the east of the Wairau fault, and extend from the vicinity of Tophouse to beyond the southern boundary of the subdivision. They strike north-east and dip at high angles predominantly to the south-east. In the Upper Maruia Valley chlorite-schist, talc-schist, mica-schist, and garnet-mica-schist appear to underlie and grade gradually into less metamorphosed quartzose semi-schists, which in turn appear to grade into greywacke. Actinolite-talc rock occurs in the watershed of Mill Creek, where it is probably interbedded with talc and chlorite schists. The section from the schistose rocks to the greywacke is apparently unbroken, but the transition from the metamorphosed rocks to the unaltered sediments is so rapid as to suggest faulting.

Although all the pre-Tertiary rocks are traversed by quartz stringers and veins, some of which are locally rich in sulphides but apparently poor in any precious metal, the older Palæozoic rocks are the more favourable repositories of payable reefs.

Tertiary Rocks.

The Tertiary beds are predominantly of a shallow-water type, and, since they are enormously thick, aggregating about 20,000 ft., the sea-floor must have sunk progressively as the beds were laid down. Minor breaks, representing probably uplifts of short duration, divide the sequence into four series, in descending order, as follows :—

	Approximate Thickness. Ft.
Longford Series	6,000
Mangles Series	4,500
Matiri Series	5,500–7,500
Maruia Series..	1,800–2,000

Fossils are decidedly rare in these rapidly deposited beds, and owing to the general sameness of sections in different parts of the sequence and the absence of readily traceable key beds the structure was found difficult to work out in most parts.

Maruia Series.—The oldest Tertiary rocks are conglomerates and breccia-conglomerates, consisting of angular and subangular fragments of greywacke, argillite, schist, and quartz strongly cemented in a gritty matrix. The conglomerate is roughly stratified, and bands of carbonaceous shale and sandstone are sparingly interbedded. These rocks, which are about 150 ft. thick, outcrop on and occupy a small area a little to the west of the divide between the Matiri and Wangapeka rivers. They closely resemble the Hawk's Crag breccia of the adjacent Buller-Mokihinui Subdivision, and probably accumulated under similar conditions at the base of the Tertiary sequence.

In Trent Creek, a tributary of the Matiri from Trent Peak, the basal Tertiaries, arkositic grits and sandstones with bands of granitic conglomerate, rest on granite not appreciably weathered and with a surface parallel to the bedding-planes. These strata, which are about 35 ft. thick, contain a 2 in. seam of sub-bituminous coal, and grade upward into massive blue to dark-grey mottled mudstone, in places almost black with carbonaceous material. About 1,750 ft. of these beds are exposed along Trent Creek, their dip averaging 45° slightly north of west. A boulder of fossiliferous mudstone with a matrix comparable only with a carbonaceous mudstone of the basal Tertiaries of Trent Creek was found in that creek. It contained numerous *Turritella* of a type that ranges from the Eocene to the Lower Miocene. The same species was obtained from a similar carbonaceous mudstone outcropping on the track from Matiri Lake westward to the Matiri Tops, where gently dipping mudstone rests on granite.

The thin impure coal-seams contained in grits and sandstones, outcropping in the bed of the Maruia near its junction with the Buller, are probably contemporaneous with the lowest beds of the Trent Creek section. Massive and banded sandstones and mudstones, in places concretionary, overlie. The sandstone at the bridge-site on the Maruia, about 40 chains from the Buller, contains *Cucullaea* and a massive oyster, fossils not characteristic of any definite horizon; the *Turritella* found in Trent Creek is not present. A basal granitic conglomerate containing a coal-seam outcrops about 10 chains down-stream from Glen Cairn Creek, and the sequence northward from this point along the Maruia resembles that farther down-stream, except that there is no fossiliferous band. The total thickness of the Maruia Series in this locality is about 2,000 ft.

The coal in Frying-pan Creek, and the conglomerates and grits outcropping 20 chains below the junction of this stream with the west branch of the Owen River, are referred to the Maruia Series. The rocks are here much faulted, and the thickness of the beds and even the sequence are not clear.

Matiri Series.—The Matiri Series consists chiefly of sandstones and mudstones. There are minor conglomerate bands, and the mudstones in places are calcareous and tend to grade into limestone.

In Trent Creek the basal beds of the Matiri Series are gritty sandstones, and fine-grained conglomerates containing pebbles of the Maruia beds up to 3 in. across, as well as smaller pebbles of granite and quartz. They accord in strike and dip with the Maruia beds, but the conglomerate is believed to mark a minor break. Overlying the grits and conglomerates, which are 6 ft. thick, are light blue-grey calcareous mudstones 4,000 ft. thick. These, though banded in places, are for the most part massive and at horizons respectively about 2,000 ft., and 3,500 ft. from their base grade into impure limestones. Above the lower limestone is massive mudstone 700 ft. thick, followed by a 15 ft. band of sandy mudstone showing the effects of subaqueous gliding. Banded sandstones overlie the upper limestone. The total thickness of the Matiri beds in this section is about 5,500 ft.

The Matiri Tops are formed of gently undulating Maruia and Matiri beds, some 2,500 ft. thick. The highest layers, which form the top of the Haystack, are bryozoan limestones, the equivalent of the lower limestone of the Trent Creek section.

Near Fern Flat the calcareous sandstones, grits, and limestones of the Sphinx Rock plateau (north-east corner of Maruia Survey District) overlie the Maruia mudstone.

The 7,500 ft. of strata exposed east of Doughboy Stream are probably the equivalent of the Matiri beds of the Trent Creek section. The calcareous rocks outcropping on the ridge east of the Doughboy valley are the same set of strata as the argillaceous limestone exposed near where the Doughboy track joins the main road. Thick massive mudstone, showing slight banding in places, overlies this limestone and grades upward into banded sandstone containing calcareous layers which outcrop 40 chains north-west of the bridge over the Matakitaki near Murchison. The same calcareous layers are exposed at several points west of the Matakitaki, and again nine miles to the south 5 chains south-west of the suspension bridge over the Matakitaki near Ten-mile Creek.

The banded sandstones outcropping along the Matiri valley east of the river are on the strike of the rocks of the Doughboy section, and are probably their continuation north of the Buller. The limestone on the hillside about 30 chains east of the junction of Valley Creek with the Matiri is probably of the same horizon as the lower limestone of the Doughboy section. It is somewhat broken by faulting and underlies mudstone about 3,000 ft. thick. West of the Matiri strongly calcareous mudstone crops out near All Nations Point (immediately west of the Buller–Matiri junction), and again about six miles to the north, at a point in the bed of the Matiri 60 chains up-stream from Sandstone Creek.

In the section from Maggie Creek west down the Owen River the calcareous Matiri mudstones grade into impure limestone bands which form the ridge between Sandstone Creek and the middle Owen, and extend south of that river toward Owen Junction. About 7,000 ft. of Matiri strata are exposed in this locality.

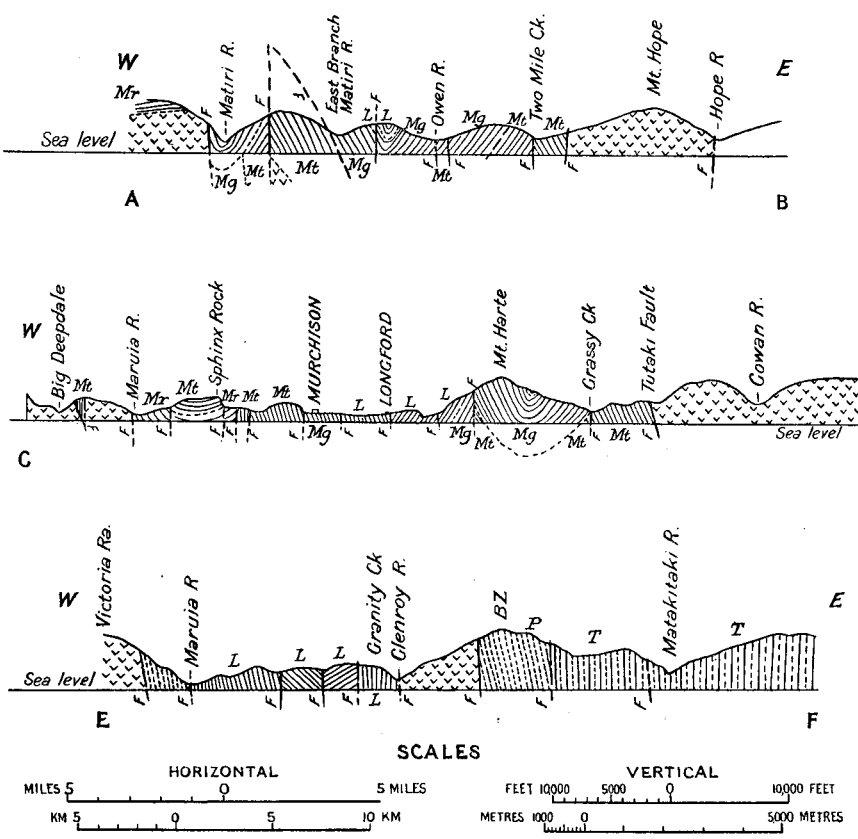
The Matiri beds also outcrop in the headwaters of Murchison Creek (Nuggety Creek), and in the Grassy and Upper Mangles valleys, where they are about 6,500 ft. thick. Though calcareous throughout in this locality, no distinct limestone bands were observed.

Mangles Series.—A group of banded sandstones and mudstones outcropping up-stream from the Blackwater almost to the upper end of the Mangles Gorge forms the Mangles Series. In the valley of the Upper Mangles they are about 6,000 ft. thick. In this locality their contact with the Matiri mudstones, underlying in parallel position, was not observed, but in Taylor and Johnson creeks, joining the Matakitaki from the west, a thin conglomerate containing sandstone pebbles separates

the two series. The Mangles sandstones form the greater part of the high ridge between the Matiri and Buller valleys. The Owen has cut a gorge through 6,000 ft. of the steeply-dipping banded sandstones more or less characteristic of this series, and the sandstones forming the bluffs on the west bank of the Owen northward of the junction of that river with the Buller are believed to be the upper portion of the Mangles sandstones repeated by faulting. The massive sandstone immediately west of the Blackwater at its junction with the Mangles, together with banded sandstones which outcrop up the Blackwater valley, belong to the Mangles Series. In the lower valley of the Maruia fine-grained conglomerates and arkositic sandstones, decidedly more coarse-grained than the Mangles beds elsewhere, are referred to this series. In the upper valley of the Maruia, Mangles beds probably occupy a considerable extent of country, but it was impossible to determine the boundaries between these beds and the Longford beds, so the area in which either may be present has been indicated on the map by a combination of the rulings of the respective beds.

Longford Series.—The Longford coal-measures and conglomerates comprise about 6,000 ft. of strata. The basal conglomerates, which are coarse-grained at the Owen but fine-grained or absent in some localities, are overlain by banded to massive sandstones and grits. They are succeeded by massive conglomerate bands alternating with sandstone or mudstone. The coal-seams, which appear to be lenticular, are at the Owen and Longford interbedded with the lower sandstones, grits, and conglomerates of this series, but carbonaceous layers also occur in the higher members. In localities where the seams are tilted at high angles or have been involved in faults they are crushed over the whole or part of their width. Occasionally shale or stone bands interrupt the continuity of a seam.

The main mass of this series outcrops from the vicinity of the Owen to the upper valley of the Maruia. The conglomerates and sandstones occupying the synclinal basin in the upper Mangles do not appear to contain any coal-seams, though some of the Longford beds involved in the Tutaki fault (which separates the granite from the sedimentary rocks of this locality) are coal-bearing. Leaf-impressions are abundant throughout these beds.



Longford Series, L. Mangles Series, Mg. Matiri Series, Mt. Maruia Series, Mr. Triassic, T. Palæozoic, P. Igneous, ٧٧. Faults, ↑.

Sections AB, CD, EF, Murchison District.

Igneous Rocks.

Plutonic rocks occupy considerable areas on each side of the Tertiary rocks. On the east they appear in plan as a wedge-shaped mass tapering from the northern boundary towards the south, where they become fault-involved in complex movements and appear as isolated blocks surrounded by sedimentary rocks. The rocks of this group of blocks range from acidic to basic composition.

On the west igneous rocks underlie the Tertiaries of the Matiri Highlands, and are thence continuous with the granites and gneisses of Victoria Range. Few basic rocks, except as small dykes and xenoliths, occur among these rocks.

Basic and ultrabasic rocks crop out on the Baldy Highlands (central part of Matakitiki Survey District) and in the upper valley of the Maruia, where they cover only a small area.

Economic Geology.

Coal.—Coal-seams occur in the basal Maruia beds and in the Longford beds. Though the coal of the former beds is bituminous, the seams are thin and impure, and so far have been little worked. These seams were prospected in the lower Maruia and Frying-pan Creek.

The seams of the Longford beds have been worked for some time in the vicinity of Longford, and a 6 ft. seam is now being developed at the Owen. At the Glenroy the coal was worked during the mining-days for forge-fuel. There are several seams in the Longford beds and all of them appear to be more or less lenticular. The coal is usually bituminous and cokes well.

Gold.—Both reef and alluvial mining were important industries in the district in former days, but the failure to locate any more payable reefs at the Lyell led to the abandonment of reef mining in that locality about the year 1910. Alluvial mining is a dying industry, for, though gold is still profitably won at the Howard and Horse Terrace, the annual yield from the whole district is but a fraction of what it once was.

The areas in which payable reefs are likely to occur are those where schists, greywacke, and spotted slate outcrop—in fact, in any of the pre-Tertiary rocks except the granites. Though reefs do occur in the plutonic rocks of the neighbouring Reefton Subdivision, they are usually much dislocated and of poor value. Prospectors have reported finding gold from the areas of Triassic rocks, but these have not been proved to be payably auriferous; the gold of the Alfred River (south-east corner of Rahu Survey District) was derived either from these rocks or from the underlying schists of doubtful age. Some specks were obtained by washing gravel from a creek joining the Maruia 60 chains above the bathhouses at the springs. This creek is incised entirely within the Triassic rocks.

The old rocks have attracted the attention of generations of prospectors, but so far, with the exception of the Lyell and the Owen, no reefs of economic importance have been found. The area is also much traversed by deer-stalkers, most of whom are keen observers, so the likelihood of any payable reef being discovered is poor. As regards alluvial gold, the areas where wash exists in quantities favourable for large-scale operations are apparently too poor to be profitably worked, and where richer ground is believed to exist conditions are unfavourable for economic working.

The gravels of the Matakitaki and of the Buller between the Matakitaki and Fern Flat were formerly extensively worked by dredges. Of recent years river-flats near Murchison and in the Matakitaki and Maruia valleys have been bored more or less systematically, with the intention of dredging the areas should prospects warrant.

Oil.—The surface indications of oil within the subdivisions are oil seepages, natural gas emanations, and outcrops of sandstone impregnated with petroleum.

Perhaps the most widely known oil seepages are those of the Warwick basin, where oil seeps at several localities along a fault-zone in the Longford beds. The oil is of a dark greenish-black colour by reflected light. The following analysis by the Dominion Analyst is of a sample of seepage oil:—

Temperature. °C.	Distillate. Per Cent.
200–250	13·2
300	33·1
350	52·8
400	74·1

During the distillation the sample showed sharp rises in temperature between 200° C. and 240° C., between 270° C. and 300° C., and between 310° C. and 380° C.

Oil-seepages have been reported in the Mangles close to the Murchison Oil Co.'s well. About 20 chains north-west of Mr. McAuliffe's house, in the Grassy Valley, oil seeps in small amounts from the mudstones, probably along the fractures of a fault-zone. Oil-seepages have also been reported in the lower Owen Valley.

The largest gas-emanation seen by the writer is in the Blackwater Valley (Tutaki Survey District), about six miles above the Mangles junction, and a few chains from the east bank of the river. When seen, the gas was burning with a flame from 12 in. to 18 in. high. The Dominion Analyst examined a sample of this gas collected by Mr. H. J. Stewart, and found it had the following composition:—

		Per Cent.
Carbon dioxide	(CO_2)	0·45
Olefines and unsaturated hydrocarbons		1·15
Carbon monoxide	(CO)	1·00
Hydrogen	(H_2)	Nil
Methane	(CH_4)	76·60
Ethane	(C_2H_6)	18·40
Oxygen	(O_2)	0·50
Nitrogen	(N_2)	1·90
		100·00

Natural gas emanates from the strata in minor amount at other localities, and usually a little gas escapes at the oil-seepages.

At the Valley Creek – Matiri junction films of oil have been obtained on the water in holes drilled by a crowbar into the sandstone outcropping there. At several localities the odour of petroleum may be obtained from mudstones and sandstones on fresh fracture and an oil film obtained by crushing the rocks in water.

The surface indications of oil in the Murchison area are encouraging to the prospector. The seepages are small, and may be interpreted as indicating that little oil exists in the area and most of it is escaping, or that some quantity of oil is present and a little is escaping. The fact that the largest seepages are along the major fractures may be interpreted as favouring the latter alternative. Whichever is the case cannot be foretold, and the presence or absence of oil in payable quantities can be proved only by boring. Though the structures are not ideal for oil-accumulation, they are not prohibitive of the possibility of oil occurring in payable amounts. The thickness of the strata and usually high angle of inclination of the beds demand that any plant used in prospecting this field must be capable of drilling a deep hole, and the installation of such a plant will be warranted only upon a satisfactory report after much detailed work on the most promising structures.

Mineral Springs.—The Maruia springs (Travers Survey District) issue from river-gravel on the north bank of the Maruia River, about nine miles by good motor-road from the junction of the Springs and the Reefton–Murchison roads. They are weakly mineralized chloro-carbonate thermal waters.

The maximum observed temperature of any of the springs was 140° F., but the temperature at the bathhouses is variable, as the springs-water is tapped after it leaves the country rock and has percolated through some thickness of alluvium. Both the flow and temperature of the spring-water increase as the river rises and forces more spring-water to the surface, and there is a corresponding diminution of flow and temperature as the river falls and allows the thermal waters to percolate through the gravels. The springs feeding the baths, when gauged, were flowing at the rate of about 20 gallons per minute. This flow could probably be increased by tapping the waters as they leave the country rock. Some small cold springs of identical taste and odour as those at the baths issue from fractures at other localities in the area of Triassic rocks, and some hot springs have been reported near the Ada Pass.

Marble, &c.—There are many outcrops of marble within the subdivisions, but most are inaccessible. In grain-size the marbles range from fine compact to coarsely crystalline, and colour from white to shades of gray. At the present time the only value attaching to the marble is the use made of it by a few farmers as an agricultural lime after burning.

Foliated talc-schist practically free from any impurity crops out in a branch of Mill Creek.

5. ROTORUA-TAUPO SUBDIVISION.

(By J. H. Williamson.)

At the end of the 1928–29 field season an area of 141 square miles in Waitahanui Survey District was mapped in order to complete the examination of the Rotorua-Taupo Subdivision.

The Waitahanui Survey District lies between the Kaimanawa Range and Lake Taupo, immediately north of the boundary-line between Auckland and Wellington land districts. The Kaimanawa Range trends in a north-easterly direction across the south-east corner of the district, and rises to a height of from 3,000 ft. to 4,000 ft. Extending westward from the range is a well-dissected plain underlain by hard rhyolite tuff, which forms flat-topped ridges running parallel to the stream-courses, and ranges in height from about 2,300 ft. near the Kaimanawas to about 2,000 ft. near Lake Taupo. The wide valley-bottoms between the ridges are well terraced. The streams draining the area flow in a north-westerly direction, and are deeply entrenched, especially in their lower reaches.

The Kaimanawa Range was not examined, but doubtless the rocks are similar to those in the Tongariro Subdivision, which are sandstone, greywacke, and argillite of Palæozoic or early Mesozoic age. These are overlain unconformably by cemented and well-jointed rhyolite tuff, similar to the tuff at Mamaku, and probably of Pliocene age. After the erosion of the rhyolite tuff into long valleys, there were strong eruptions from Lake Taupo. The outbreak filled the valleys with thick deposits of pumice breccia and silt which is now pink in colour, and somewhat consolidated. This material, at the head of the Waitahanui, is 1,550 ft. above sea-level. Much water-sorting took place, and terraces were formed. Remnants of high-level terraces indicate that the lake about this time was 370 ft. above its present level. Later eruptions of pumice took place, the covering reaching a thickness of 20 ft. or more near the lake, but thinning towards the Kaimanawas. This forms the present surface of the district. The late Taupo pumice on the 110 ft. terrace around the lake-margin is water-sorted; the lake at this time was 110 ft. above its present level.

6. PALÆONTOLOGICAL WORK, 1929–30.

(By J. Marwick.)

Most of the past year was occupied in finishing the report on the Tertiary Mollusca of the Gisborne district, and Palæontological Bulletin No. 13, which contains this work, is now being printed.

The molluscan faunas described were collected chiefly by the geologists of the Taranaki Oil Fields, Ltd., from many horizons and from many different types of rock. They should, therefore, be of considerable use in working out the stratigraphy of much of the eastern part of the North Island.

Further attention has been given to building up the foreign collections of the Geological Survey. An exchange was carried through with the Natural History Museum, New York, and one is now being completed with the Marine Biological Station, Woods Hole, Massachusetts.

7. SOIL RESEARCH IN THE KING-COUNTRY.

(By N. H. Taylor.)

During the past field season soil investigations were carried out in parts of the King-country where farmers were experiencing difficulty in raising sheep. The soils of these areas have been derived mainly from showers of volcanic ash that mantle the surface, and it is hoped that a combined geological and soil investigation will help to explain why some areas are healthy and others unhealthy for sheep.

Mairoa Area.

In company with Mr. C. M. Wright, who had previously made a study of the stock-history of the district, visits of inspection were made to about twenty farms. A comparison of the geological data and of the stock-history led to the conclusion that the unhealthiness was due to the excessive leaching of the volcanic ash that gives rise to the predominating soil of the district. Where conditions were such as to reduce leaching or where the soil from the ash was mixed with clayey material derived from the underlying formations, the soils were comparatively healthy. Most of the evidence and the deductions therefrom have already been stated in an interim report to the Council of Scientific and Industrial Research.*

A special study was made of Section 2, Block IV, Maungamangero Survey District, in order to assist in the interpretation of results obtained from manurial experiments and from soil and pasture analyses. As the soils of this farm show great differences and are truly representative of the district, it was decided to map it geologically in order to help place future experiments upon a sounder basis. Time would not permit of a detailed soil map being prepared, but this should certainly be done before further manurial experiments are begun.

From November to March the writer co-operated with Mr. J. K. Dixon, of the University of Otago, who investigated the lime status of the soils. Soil-samples were taken from selected localities and tested by Mr. Dixon in a temporary laboratory at Te Kuiti. The results were at first inconclusive, and in February, when Mr. T. Rigg reviewed the work, he suggested that further information might be obtained by making a more minute classification of the soils into types and subtypes. After exploring the district for a fortnight the following table was drawn up and samples collected accordingly :—

Tentative Classification of Soils occurring at and near Mairoa.

Types.	Aria.	Mairoa.	Mangapohue.	Waitanguru.	Kihikihi.	Mangaotaki.	Mangatea.
	3 ft. to 4 ft. of ash without iron pan (60 in. to 70 in. rainfall)	3 ft. to 4 ft. ash with iron pan (100 in. rainfall)	Thin ash on sands	Thin ash on limestone and residual clay derived from limestone	Thin ash on greywacke	Thin ash on indurated mudstone (Jurassic)	Thin ash on soft calcareous mudstone and shale (Tertiary).
Sub-types ..	(*a*) Over sandstone	(*a*) Over sands ..	(*a*) Topsoil, ash; subsoil, sands	(*a*) Topsoil, ash; subsoil, residual clay	(*a*) Topsoil, ash; subsoil, greywacke	(*a*) Topsoil, ash; subsoil, mudstone	(*a*) Topsoil, ash; subsoil, mudstone.
	(*b*) Over limestone	(*b*) Over limestone	(*b*) Soil, mixed ash and sand	(*b*) Soil, mixed ash and residual clay	(*b*) Soil, mixed ash and greywacke	(*b*) Soil, mixed ash and mudstone	(*b*) Soil, mixed ash and mudstone.
	(*c*) Over mudstone	(*c*) Over mudstone	(*c*) Soil, almost entirely sand	(*c*) Soil, almost entirely residual clay	(*c*) Soil, almost entirely greywacke	(*c*) Soil, almost entirely mudstone	(*c*) Soil, almost entirely mudstone.
	(*d*) Over greywacke	(*d*) Over greywacke	..	(*d*) Soil, ash affected by leachings from limestone outcrops	..	..	..

Note.—It is realized that many of the types defined are very variable and that each may really form a soil series or subseries. The word " type " is applied to these groups because they are thought to be the smallest units that can be conveniently mapped.

A portion of each sample was tested by Mr. Dixon, other portions being reserved for estimation of available phosphate and for mechanical analysis. The results obtained will be submitted later in the reports of the chemists who co-operated.

A week was spent with Mr. C. Sutherland, of the Department of Agriculture, who collects samples of pasture for analysis. Owing to the complexity of the soils of the district, difficulty had been experienced in collecting suitable pasture-samples, and so it was decided to mark out definite areas on well-recognized soil-types for this purpose.

A fortnight was also spent with Mr. R. E. R. Grimmett, of the Department of Agriculture, demarcating areas for trial manurial plots. Here again the complexity of the soil cover was the main difficulty, and much careful work had to be done before strictly comparable groups of plots could be set out.

On Section 4, Block VII, Maungamangero Survey District, where experiments had been made with top-dressings of lime and superphosphate, excellent results had been obtained. In April these experimental paddocks were examined and mapped in detail in order to see how far the results obtained could be applied to the remainder of the district. A separate report on this work will be issued later.

Kopaki and Kahuroa Areas.

Preliminary soil investigations have been carried out in a sheep-sick area nine miles east of Kopaki, and at Kahuroa, in the Tiroa-Maraeroa district, ten miles east of Mangapehi. These will form the subject of separate reports.

* N. H. Taylor: " The Relation of Geology to Sheep Sickness in the Mairoa District." N.Z. Jour. Sci. & Tech., vol. xii, pp. 1–10, 1930.

8. RECONNAISSANCE SURVEY OF VOLCANIC ASH SHOWERS OF THE CENTRAL PART OF THE NORTH ISLAND.

(By L. I. Grange.)

During the early part of April and from the 28th April to the 9th June of this year the writer examined the volcanic-ash deposits derived from the Rotorua-Taupo-Tongariro zone. The Hamilton, Rotorua, Taupo, Ruapehu, Te Kuiti, and Napier districts were visited. Several soil-forming showers were examined in more or less detail, and information bearing on the incidence of bush sickness obtained. Details of this work will be published in the *Journal of Science and Technology* as opportunity permits.

9. GOLD-BEARING QUARTZ-VEINS NEAR HAVELOCK, PELORUS SOUND.

(By J. Henderson.)

From the 16th to the 22nd January I was in the neighbourhood of Havelock, and examined a number of outcrops of quartz veins and prospect cuts on them. A number of samples were taken for assay.

McKay,* in several reports, has described the geology of the district. Briefly, schists form the great part of the country between the valleys of the Wairau and Pelorus rivers, and the whole of it between Queen Charlotte and Pelorus sounds. The foliation-planes have a general north-east strike, and dip north-west, so that younger and less metamorphosed rocks occur along the north-west border of the area. Havelock is situated in this upper part of the sequence, where the alteration is not so complete but that the original texture and composition of the beds still can be distinguished.

McKay notes that the broken, rugged highland west of the Wakamarina Valley is carved from a dip-slope of quartzite and quartzose schist tilted to the north-west, and, further, that most of the ridges of the area have precipitous faces to the south-east, and gentler slopes to the north-west. The present writer also observed that the foliation of the schist similarly controls the shape of many of the mountains and hills of the Sounds district.

At Moetapu Bay, on the south side of Pelorus Sound, five miles east-north-east from Havelock, the general north-east strike of the schists is broken by a sharp, southward-plunging anticline. Erosion along the weakened beds of this structure has formed the valley Moetapu Bay now occupies, also that extending north from the head of Mahakipawa Arm. Along the same line, and probably controlled by the same structure, are the Hikapu Reach of Pelorus Sound to the north, and the valley of Cullen Creek to the south. The straight, swampy-bottomed Kaituna Valley lies parallel with, and about four miles west of, the Moetapu structure. It cuts right through the schist highlands, and gives easy access between the Wairau Plain and Pelorus Sound, for there is no perceptible saddle at its head. On its west side from Havelock to four miles south to the bridge across the Kaituna, on the Blenheim Road, the foliation-planes dip nearly west. On the east side, the ridge between the Kaituna and the Mahakipawa arms shows an extensive dip-slope tilted north-east. These facts suggest that the Kaituna Valley marks some structural change, either a fault or a fold sufficiently sharp to weaken the rocks.

The great bulk of the gold of Marlborough has been won from stream-gravels, the principal diggings being at Wakamarina, Mahakipawa, Waikakaho, Onamalutu, Bartlett Creek, and Top Valley. The first three localities are within ten miles of Havelock; the others are in south-flowing branches of the Wairau, draining the schists and subschists of Marlborough. Quartz veins are known in each of these localities, and one lode at Wakamarina has yielded over 100,000 tons of ore containing gold and scheelite. The lodes of other localities have been worked much less extensively. The best account of the lode-mining in the Wakamarina, Mahakipawa-Waikakaho, and Top Valley areas is given by Downey,† and Hector‡ describes Sutherland's reef, outcropping in the Onamalutu basin, and Turner's reef, near Cape Jackson. The present writer§ also has described and discussed the origin of the lode worked at Wakamarina.

Mr. P. W. Soanes has carried out a good deal of trenching on the hill at the back of Moetapu Point in order to trace a lode found near the beach. The surface soil and loose rocks have been stripped from the hillside about 50 ft. above sea-level, and a formation of shattered schist lying between two well-marked "heads" and containing branching veinlets and irregular masses of quartz, most abundantly near the hanging-wall. Quartz veinlets also occur in the schist on either side of the formation, though much less plentifully. The foliation-planes of the schist strike nearly north, and dip west at about 40°. The hanging-wall "head" strikes a little south of east, and dips south at 70°. The foot-wall "head" strikes east, is nearly vertical, and terminates upwards against the hanging-wall.

The hanging-wall "head" was traced by trenching to a point some 20 ft. higher than the top of the vertical "head," where it turned into the country. It contained a few inches of quartz throughout. It was not certainly found at higher levels, though most of the many cuts put in to the top of the hill (245 ft. above sea-level) contained reef quartz. It should be noted that the schist weathers deeply, and that prospecting, except on very steep slopes, is slow and difficult work.

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* A. McKay: "The District between the Wairau and Motueka Valley"—Rep. Geol. Explor. during 1878–79, No. 12, pp. 102–5, 1879. "On the Mahakipawa Goldfield"—Rep. Geol. Explor. during 1888–89, No. 20, pp. 36–44, 1890. "On the Geology of Marlborough and the Amuri District of Nelson"—*Ibid.*, pp. 104–11.

† J. F. Downey: "Quartz Reefs of the West Coast Mining District, New Zealand," pp. 7–16, 1928.

‡ J. Hector: "Reports on Gold-mines in Province of Marlborough." Rep. Geol. Explor. during 1871–72, pp. 119–29, 1872.

§ J. Henderson: "Notes on the Geology and Mineral Occurrences of the Wakamarina Valley." Jour. Sci. & Tech., Vol. 1, pp. 11–15, 1918, and N.Z.G.S., 11th Ann. Rep., p. 6, 1917.

The waste from the stripped area covers the hillside to the beach, where the hanging-wall "head" was readily picked up, though here it carries no quartz. The schist on the foreshore between the "heads" contains a few stringers of quartz. At the point on the shore where the vertical head should outcrop, debris from above completely concealed the solid rock. Some weeks after the writer's visit this was cleared away, but only a narrow "track" was found.

All the quartz seen was stained brown to nearly black by oxides of iron and manganese, and no gold was seen. Mr. Soanes took two samples across the formation where exposed in the stripped area at points about 8 ft. apart, vertically. The higher contained 7 grains of gold, and the lower 22 grains of gold and 7 grains of silver per ton. Other samples from this locality, no doubt picked, have been found to contain up to several ounces of gold per ton.

A bedded quartz-vein striking a little east of north and dipping west at 45° outcrops prominently for 20 chains at a height of about 1,800 ft. along the steep hillside to the west of the stream draining through Havelock from Takorika Hill. Prospect cuts across the vein at several points show it to consist of iron-stained quartz and very siliceous, perhaps silicified, schist, to range in thickness from 2 ft. to 4 ft., and to contain iron pyrites near the foot-wall. Samples from two prospect cuts were found on assay each to contain but 7 grains of gold per ton.

A fracture-zone occurs on the east bank of Kaituna Stream at a point about two miles south-east of Havelock. The formation, which strikes a little east of north, and dips west at 70°, is about 4 ft. wide, and contains branching veinlets of quartz.

10. WAIKARI AND MOUNT SOMERS DISTRICTS, CANTERBURY.

(By J. Marwick.)

In April an examination of the Waikari district, North Canterbury, was made in order to find out the amount and quality of limestone suitable for agricultural purposes. Numerous samples were taken for analysis, the results of which, however, are not yet to hand. As the report cannot be finished until these analyses are available, only an indication of the probable result can be given here.

The railway and the road from Waipara northward to Waikari ascend in a grade through Weka Pass, where limestone cliffs tower conspicuously on either hand. The section exposed here has been perhaps more studied and debated by geologists than any other in New Zealand, the question being what is the significance of the contact between the lower part (the Amuri limestone) and the upper part (the Weka Pass stone). In the small area under review this question is not likely to have a direct bearing on the problem of the location of lime-crushing works, and so need not be discussed.

On the whole, the limestones of the district are not of high grade, and analyses published by Park (1905), Speight and Wild (1918), and Morgan (1919) indicate that only the upper 50 ft. to 60 ft. of the Amuri limestone is sufficiently high in $CaCO_3$ (over 80 per cent.) to be worth considering as a fertilizer. To this may perhaps be added a few feet at the base of the Weka Pass stone, which contains some phosphate and much glauconite.

If the analyses now being made agree with those already known, as in all probability they will, the problem is where the upper part of the Amuri limestone can be most conveniently quarried with respect to railway access.

In Weka Pass itself the railway is cut through the limestone, but a difficulty here is that sidings on a grade are not favoured by the Railway Department.

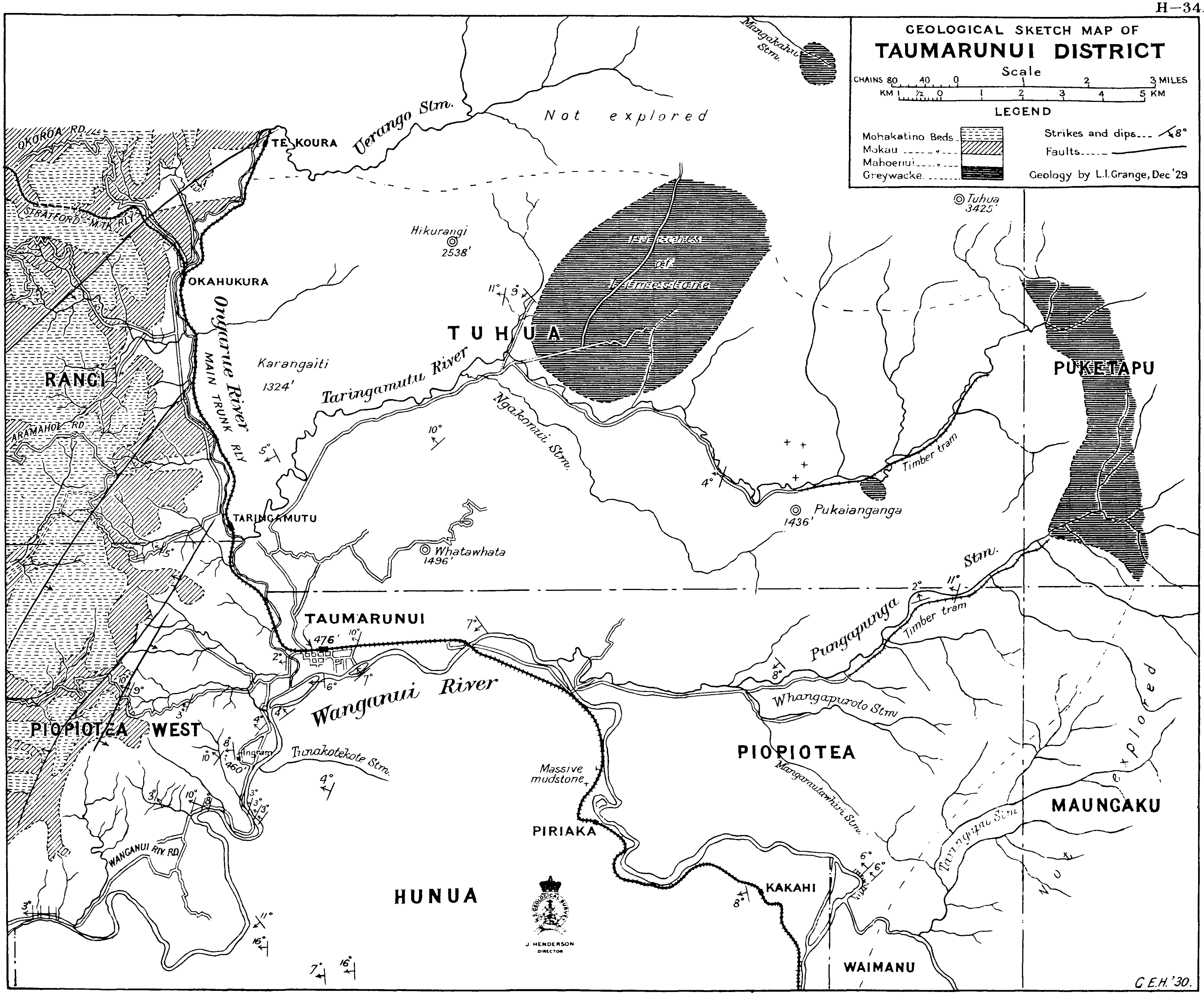
From the head of the pass the railway bends to the west and skirts the north side of the high east-west ridge lying south of the Waikari Township. The eastern end of this ridge is formed by Monument Hill, rising some 250 ft. above the railway, which intersects the toe of the slope. The ridge extends westward about a mile and a half, diverging from the railway and rising to 500 ft. above it.

Weka Pass stone overlying Amuri limestone caps most of this ridge, dipping south and forming the north side of a small physiographic and structural basin that is open on the east side. Monument Hill lies outside this basin. It is formed mostly of Amuri limestone, dipping north-west, but an outlier of Weka Pass stone outcrops on the north slope.

Immediately west of Monument Hill, on the north-east edge of the basin, the Weka Pass stone has been stripped back by weathering, leaving a platform of Amuri limestone several chains wide at about 300 ft. above the railway. Westwards this platform narrows, and where the ridge bends to the south round the head of the basin it disappears, the Amuri limestone outcropping only in the face of the hill.

The upper part of the Amuri limestone can therefore be quarried most conveniently along the face of the ridge from Monument Hill westward for about half a mile. This locality is easily accessible to the railway, and a siding could be run back from Waikari Station.

A short visit was also paid to Mount Somers, where limestone-quarries have been worked intermittently for many years. The Government railway-line is about four miles from the quarries but a full-gauge line now being laid by a private company to a coal property passes within a few chains of them. Two large quarry-faces have been opened on the limestone, each about 60 ft. high. The stone on the eastern quarry is mostly hard and strong, and will probably show a high percentage of $CaCO_3$. The stone in the western quarry is stratigraphically at a somewhat lower horizon, is much softer, and contains a considerable amount of volcanic tuff scattered through it. The total thickness of the limestone is over 200 ft., so that the amount of stone available is very large. The lime-kiln, not working at the time of visit, is situated about half-way between the quarries and Mount Somers Railway-station.


GEOLOGICAL SKETCH MAP OF
TAUMARUNUI DISTRICT
Scale
CHAINS 80 40 0 1 2 3 MILES
KM 1 ½ 0 1 2 3 4 5 KM
LEGEND
Mohakatino Beds
Mokau
Mahoenui
Greywacke
Strikes and dips
Faults
Geology by L.I. Grange, Dec '29
Not explored
Uerango Stm.
Mangakahu Stm.
TE KOURA
OKOROA RD.
STRATFORD–MTK. RLY.
OKAHUKURA
Ongarue River
MAIN TRUNK RLY
Hikurangi
2538'
TUHUA
Tuhua
3425'
Karangaiti
1324'
Taringamutu River
Ngakonui Stm.
RANGI
ARAMAHOE RD.
PUKETAPU
Timber tram
Pukaiananga
1436'
TARINGAMUTU
Whatawhata
1496'
TAUMARUNUI
476'
Pungapunga Stm.
Wanganui River
Whangapurotu Stm
PIOPIOTEA WEST
Ingram
460'
Tunakotekote Stm.
PIOPIOTEA
Mangarautawhiri Stm.
Massive mudstone
PIRIAKA
MAUNGAKU
Taringapu Stm.
Not explored
WANGANUI RIV. RD.
HUNUA
KAKAHI
WAIMANU
J. HENDERSON
DIRECTOR
G.E.H. '30.

11. TAUMARUNUI AS A POTENTIAL OIL-FIELD.

(By L. I. Grange.)

Between the 10th and 17th December the writer stayed at Taumarunui and examined the country for several miles in all directions to ascertain whether there is a likelihood of oil-pools being present. Mr. E. R. Martin, of Taumarunui, who knows the district well, accompanied the writer on all his trips and pointed out his discoveries.

General Geology.

The following beds, in descending order, occur in the district:—

Mokau beds—argillaceous sandstone.
Mahoenui beds—alternating mudstone and sandstone, with pebbly limestone and conglomerate at the base.
Mesozoic beds—greywacke and argillites.

The oldest rocks are greywackes, argillites, and grits of Mesozoic age, which outcrop in the Mangakahu, Taringamutu, and Pungapunga valleys. The exposure in a branch of the Taringamutu five miles up from the Ongarue Stream appears to be faulted up. The writer did not see the outcrop, but was informed of its presence there by the Taumarunui County Clerk. The beds are shattered, and consequently strikes and dips could not be obtained.

Lying with great unconformity on the Mesozoic strata are the Tertiary beds. At the bottom are shallow-water deposits, consisting of greywacke conglomerate, pebbly limestone, and calcareous sandstone. Patches of these beds, totalling about 100 ft. in thickness, lie on the upfaulted block of greywacke in the Taringamutu valley. In the Pungapunga conglomerates (about 25 ft. thick) were found. These beds are the basal members of the Mahoenui Series, or possibly belong to the underlying Te Kuiti Series of the Mokau Bulletin. Resting on the beach beds is a thick series of alternating mudstones and sandstones belonging to the Mahoenui Series. Generally the mudstone bands are 18 in. thick and the sandstone 4 in. A 12 ft. band of sandstone outcrops near the mouth of the Taringamutu, but thicknesses greater than 1 ft. are rare. In places, as at Piriaka and near the end of the Taringamutu Road, the sandstone bands are absent. The beds, which outcrop over a wide area, have, according to the observations made, a westerly dip averaging about 6°. Their total thickness is probably between 6,000 ft. and 7,000 ft. West of the Ongarue River the Mahoenui beds are overlain by the Mokau beds, composed of argillaceous sandstone, and these in turn by strata referred to the Mohakatino Series.

Supposed Indications of Oil.

Mr. Martin showed the writer a weak gas-vent on Mr. Ingram's farm, on the Wanganui River Road, two miles south of Taumarunui. A rod was pushed down about 18 ft. in a swampy abandoned course of the Wanganui River, and when it was withdrawn gas bubbled up for three or four minutes. The gas burnt with an ordinary flame. After it ceased to bubble up, the rod was pushed down again, but no gas came up. A sample of the gas sent to the Dominion Analyst was found to have the following composition:—

		Per Cent.
Carbon dioxide	CO_2	.. 4·23
Methane	CH_4	.. 33·41
Oxygen	O_2	.. 0·39
Nitrogen	N_2	.. 61·97
		100·00

Several strong salt springs issue from the limestone and conglomerates resting on the greywacke in the Taringamutu valley, but occurring thus they cannot be taken as evidence of the existence of oil. The irredescent films on the surface of the stagnant water at many points are iron oxide, and are not indications of oil.

Prospects of Oil.

In considering oil in the Taumarunui district, only the Mahoenui beds have to be taken into account. The Mahoenui beds do not contain any thick reservoir rocks; the limestones and conglomerates are tight. The observations of the structure of the series do not indicate a favourable structure for the accumulation of oil, and the prospects of obtaining oil in the Taumarunui district are decidedly poor.

DOMINION OBSERVATORY.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR THE YEAR 1929.

Buildings and Equipment.

The buildings and equipment have been kept in good order and condition. The Observatory grounds have 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 observed on every fine day, except on Saturdays, Sundays, and Government holidays, and the stars are observed whenever necessary.

Reception of Radio Time Signals at the Observatory.

The following radio mean time signals were received at the Observatory :—

Station.	Call Sign.	Hour (G.M.T.).	Number.
Honolulu	NPM	00	284
Nauen	DFY	00	188
Malabar	PKX	01	156
Annapolis..	NSS	03	23
Arlington	NAA	08	133
Annapolis..	NSS	08	16
Bordeaux	FYL	08	59
Rugby	GBR	10	7
Bordeaux	FYL	20	29
Total	..	..	895

Scientific time signals were also received at the Observatory as follows : Nauen, 33 ; Bordeaux, 2.

The radio time signals received at the Observatory generally agreed with the Observatory clock within one second of time.

Time Service.

The time service has been maintained, and the regular signals have been sent out. The signals have been transmitted daily. The total number of time signals sent from the Observatory was 1,755. Of these, 465 were sent by wireless telegraph, 673 were sent by special circuit to the Telegraph-office, 365 by the signal lights at the Observatory, 102 by switching off lights at the Harbour Board building at Auckland, 101 by dropping the time-ball at Lyttelton, and 49 by telephone.

No radio time signals were sent out on the following dates owing to line interruptions between the Observatory and the Wellington Radio Station : 1929—June 14 ; October 11, 15, 18 ; November 15.

Signals could not be sent on June 17, owing to the derangement of the clocks by the strong earthquake which occurred at 22 h. 47 m. G.M.T., just before the time of sending the signals.

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

Automatic Time Signals—

(1) To the General Post Office and to the Railway Department, Wellington, by telegraph, daily, except 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 on Government holidays.
(4) To the South Island telegraph-offices, by telegraph, on Tuesdays and Fridays, except on 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 Wellington Radio Station (ZLW), on Tuesday and Friday evenings at 8.30 p.m., except on Government holidays.
(7) Radio time signals through the Wellington Radio Station (ZLW) every day at 10.30 a.m. The radio call signal for the Observatory is ZLO, and this sign is used in transmitting radio time signals.

Non-automatic Time Signals—

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

Sun-spots.

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

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 sunspot numbers.

Spectrohelioscope.

A letter, dated October 10th, was received from Dr. Walter S. Adams, the Director of the Mount Wilson Observatory, Pasadena, California, in which he intimated that Dr. G. E. Hale, the designer

of the spectrohelioscope, had offered to present one of these instruments to New Zealand. The instrument will be one of a number placed at different observatories around the world. The longitude of New Zealand is such as to make it a very valuable station, and it is hoped to obtain funds to install the instrument and keep it actively and regularly in use in order to assist in the international programme.

"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 9 h. G.M.T., and every day at 23 h. G.M.T. It will be necessary to supply additional time signals to obtain the required accuracy in these observations. In addition to the ordinary occultation observations, a photographic method is in use at the Wellington Observatory by means of which the moon and surrounding stars are photographed on the same plate, and the time of the exposure 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 occultations of stars were observed at Wellington on May 20th and 22nd, September 11th, October 16th, November 11th. Good observations were made of the occultation of Jupiter and its satellites on February 15th.

Meteors.

SUMMARY OF METEORS FOR 1929.

Place.	New Zealand Date.				Notes.
		d.	h.	m.	
Auckland	September	5	22	30	Newspaper reports. Meteorite observed to fall to ground.
Auckland	September	10	22	30	Newspaper reports. Meteorite observed to fall to ground.
Oamaru	October	7	18	40	Newspaper report.
Christchurch	October	7	18	40	Newspaper report. Meteorite observed to fall into sea.

The path of the last-mentioned meteorite was investigated by Mr. R. A. McIntosh, of Auckland. Many observations of meteors are made by the members of the Meteor Section of the New Zealand Astronomical Society.

Precision Pendulum.

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

Photographs of Moon and Surrounding Stars.

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

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

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

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, 13th October, 1929, and ending at 2 a.m., New Zealand standard time, on Sunday, 16th March, 1930.

SEISMOLOGY.

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

The number of earthquakes recorded on the Milne-Shaw (north-south component) was 832. On the Milne-Shaw (east-west component) 930 earthquakes were recorded. Particulars of the numbers of the earthquakes registered on the two machines are given in the following table :—

1929.	Machine Milne-Shaw (N.–S.).	Machine Milne-Shaw (E.–W.).	Total Earthquakes.
January	32	22	32
February	26	19	26
March	38	34	38
April	24	23	24
May	30	32	32
June	444	379	444
July	122	125	125
August	57	56	57
September	29	30	30
October	41	37	41
November	34	32	34
December	53	43	53
Totals for year	930	832	936

Inequality in the number of shocks recorded on each seismograph is due to the following causes :—

(1) The Milne-Shaw (N.-S.) component appears to be specially susceptible to disturbance by high winds; therefore very small shocks are occasionally not traceable on the records.

(2) A very few feeble shocks have been recorded on one Milne-Shaw machine only, possibly on account of directional effect.

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

Four hundred and seventy-nine reports were received from the officers of the Post and Telegraph Departments, seventy-eight from the Marine Department, 175 from other observers, and 663 from the newspapers.

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

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

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

During the year 1929 earthquake reports have been received from sixty-three observatories.

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

Earthquakes in New Zealand, 1929.

The outstanding seismic phenomenon of the year 1929 was the disastrous earthquake which visited the north-western portion of the South Island on June 17th. This shock was distinctly felt over the whole of New Zealand, and resulted in the loss of 14 lives, and serious damage to property in the Buller District, South Island. Table I gives a list of stations at which the shock reached, or exceeded intensity 8 on the Rossi-Forel scale :—

Table I.—Earthquake of June 17th, 1929.

Station.	Intensity (R.-F.).	Station.	Intensity (R.-F.)
Hawera	8	Murchison	9–10
Wanganui	8	Lyell	9–10
Farewell Spit	7–8	Westport	9
Bainham	8	Inangahua	9
Kahurangi Point	8–9	Reefton	8–9
Nelson	8–9	Greymouth	8–9
Blenheim	7–8	Hanmer	7–8

As in the case of other great earthquakes, hundreds of after-shocks occurred, some of them severe enough to cause further harm in the damaged areas. From June 17th to December 31st, 1929, 632 after-shocks were recorded on the seismographs at the Observatory.

Fig. 1 is a map showing the distribution of seismic intensity of the earthquake of June 17th. The map was prepared from the numerous reports of observers, newspapers, &c.

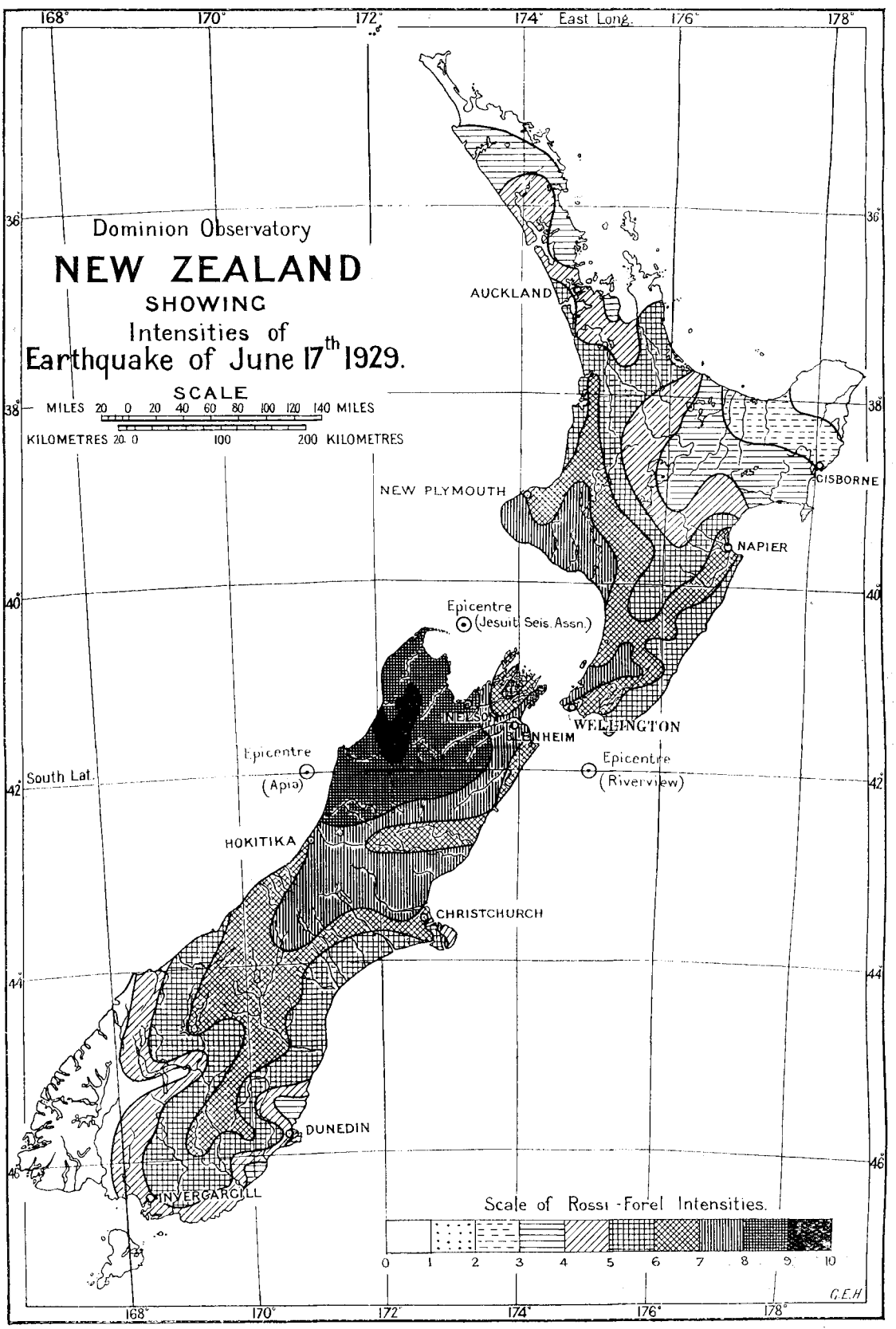


Fig. 1.

Three other severe earthquakes occurred during 1929 :—

(1) March 9th—Felt over practically the whole of New Zealand, exceeding R.-F. 8 at Arthur's Pass, where some damage was done.

(2) May 8th—Affected chiefly the North Island, reaching R.-F. 8 at Feilding and Hunterville.

(3) May 29th—Affected the southern portion of the North Island, reaching R.-F. 7 at Woodville.

TABLE II.—SUMMARY OF EARTHQUAKES FOR 1929.

Month.	Number of Earthquakes reported.				Maximum Intensity (R.-F. Scale).	Locality.
	North Island.	South Island.	Both Islands.	Total.		
January ..	1	5	1	5	4	Havelock, Bainham, Nelson.
February ..	3	1	0	4	5	Dannevirke.
March	3	5	1	7	9	Lake Sumner, Arthur's Pass.
April	2	1	0	3	5	Otira.
May	15	4	1	18	7	Woodville.
June	29	88	22	95	10	Murchison, Lyell.
July	17	234	9	242	8	Glenhope.
August	1	72	0	73	6	Takaka, Westport.
September ..	6	62	3	65	6	Havelock, Takaka, Arthur's Pass.
October ..	5	44	0	49	6	Takaka.
November ..	7	56	1	62	6	Tophouse, Karamea, Westport, Murchison, Greymouth.
December ..	4	52	1	55	6	Takaka, Kahurangi Point, Tophouse, Westport, Murchison, Reefton, Greymouth.
Totals for year..	93	624	39	678	10	

Table II gives the distribution of earthquakes in each month of 1929, the number occurring in each Island, and the maximum intensities. The total number of shocks felt during the year was 678, 93 of which were felt in the North Island and 624 in the South Island, 39 being felt in both Islands. The maximum intensity was between 9 and 10 on the Rossi-Forel scale. This occurred at Murchison and Lyell on June 17th. The lowest maximum intensities occurred in January, during which month no shocks above 4 were experienced. The maximum intensity of shocks felt in 1921 and 1922 was 8 ; in 1923 was 6 ; in 1924 was 7 ; in 1925, 1926, 1927, and 1928 was 8 on the same scale.

TABLE III.—DISTRIBUTION OF 1929 EARTHQUAKES, IN TIME.

Month.	Morning : 0 h. – 8 h.	Daytime : 8 h. – 16 h.	Evening : 16 h. – 24 h.
January	1	1	3
February	1	3	..
March	2	1	4
April	..	2	1
May	9	3	6
June	39	23	33
July	95	56	91
August	34	15	24
September	31	9	25
October	21	18	10
November	26	15	21
December	11	23	21
Totals	270	169	239

Table III shows the diurnal distribution of earthquakes in 1929. The total figures indicate that more shocks were felt during the night than during the daytime. This result is probably due in part to the fact that many feeble shocks which would be felt at night would pass by unnoticed in the daytime.

TABLE IV.—MAXIMUM INTENSITY OF EARTHQUAKES, 1929.

Month.	R.-F. Intensity										Totals.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
January	..	..	2	2	1	..	..	..	..	..	5
February	..	1	2	..	1	..	..	..	..	..	4
March	..	..	4	1	..	1	..	..	1	..	7
April	..	..	1	1	1	..	..	..	..	..	3
May	..	1	11	3	..	1	1	1	..	..	18
June	..	1	27	35	16	6	3	6	..	1	95
July	..	43	117	45	23	9	4	1	..	..	242
August	..	8	23	24	15	3	..	..	..	..	73
September	5	12	29	9	5	4	1	..	..	..	65
October	1	6	15	12	13	2	..	..	..	..	49
November	..	3	30	23	4	2	..	..	..	..	62
December	..	..	24	16	12	3	..	..	..	..	55
Totals ..	6	75	285	171	91	31	9	8	1	1	678

Table IV gives the number of earthquakes whose maximum intensity fell in different numbers of the Rossi-Forel scale. The table shows that earthquakes of all intensities were recorded, whilst more shocks occurred of intensity 3 than of any other number.

The accompanying map (Fig. 2) shows the approximate epicentres* of the most outstanding earthquakes in 1929. The epicentres were determined by reports from observers in conjunction with data from the seismograms of the Observatory. The small inset map shows the epicentres in the south-west Pacific. Those outside New Zealand were determined from the seismograms at Wellington and Suva, in conjunction with seismological reports from the following stations: Zi-ka-wei, Hong Kong, Manila, Apia, Riverview, and Melbourne.

GENERAL.

Publications.

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

Bulletin No. 76.—New Zealand Time Service Arrangements.
Bulletin No. 77.—Report of the Dominion Astronomer and Seismologist for the year 1928.
E.–16.—Earthquake Report for 1928, January to March.
E.–17.—Earthquake Report for 1928, April to June.
E.–18.—Earthquake Report for 1928, July to September.
E.–19.—Earthquake Report for 1928, October to December.

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

Meteorological Records, 1929.

The following are the meteorological records for 1929:—

Barometer (height above sea-level, 415 ft.)—
Maximum reading, 30·24—3rd June, 1929.
Minimum reading, 28·79—April 29th, 1929.

Temperature (in transit-room)—
Maximum reading, 68°·7 F.—January 20th, 1929.
Minimum reading, 54°·1 F.—August 26th, 1929.

Temperature (in clock-room)—
Maximum reading, 68°·6 F.—January 20th, 1929.
Minimum reading, 56°·0 F.—August 27th, 1929.

STAFF.

The staff for 1929 was as follows: Mr. R. C. Hayes, Professional Assistant. Mr. T. S. Wyman, clerk, who had been attached to the Observatory staff since 1924, was transferred to the Forestry Department on April 26th. On the same date Mr. I. L. Thomsen, clerical cadet, was transferred from the Department of Agriculture to the Observatory staff. Mr. D. B. Hopcroft, of the Lands and Survey

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

Department, was at the Observatory from March 5th to 18th. Mr. R. D. Thompson, Temporary Professional Assistant, was engaged in Observatory work from June 29th to July 23rd. Mr. W. M. Jones was engaged at the Observatory from August 27th to November 6th. Mr. A. G. C. Crust has assisted in the overtime at the Observatory.

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

C. E. Adams,
Dominion Astronomer and Seismologist.

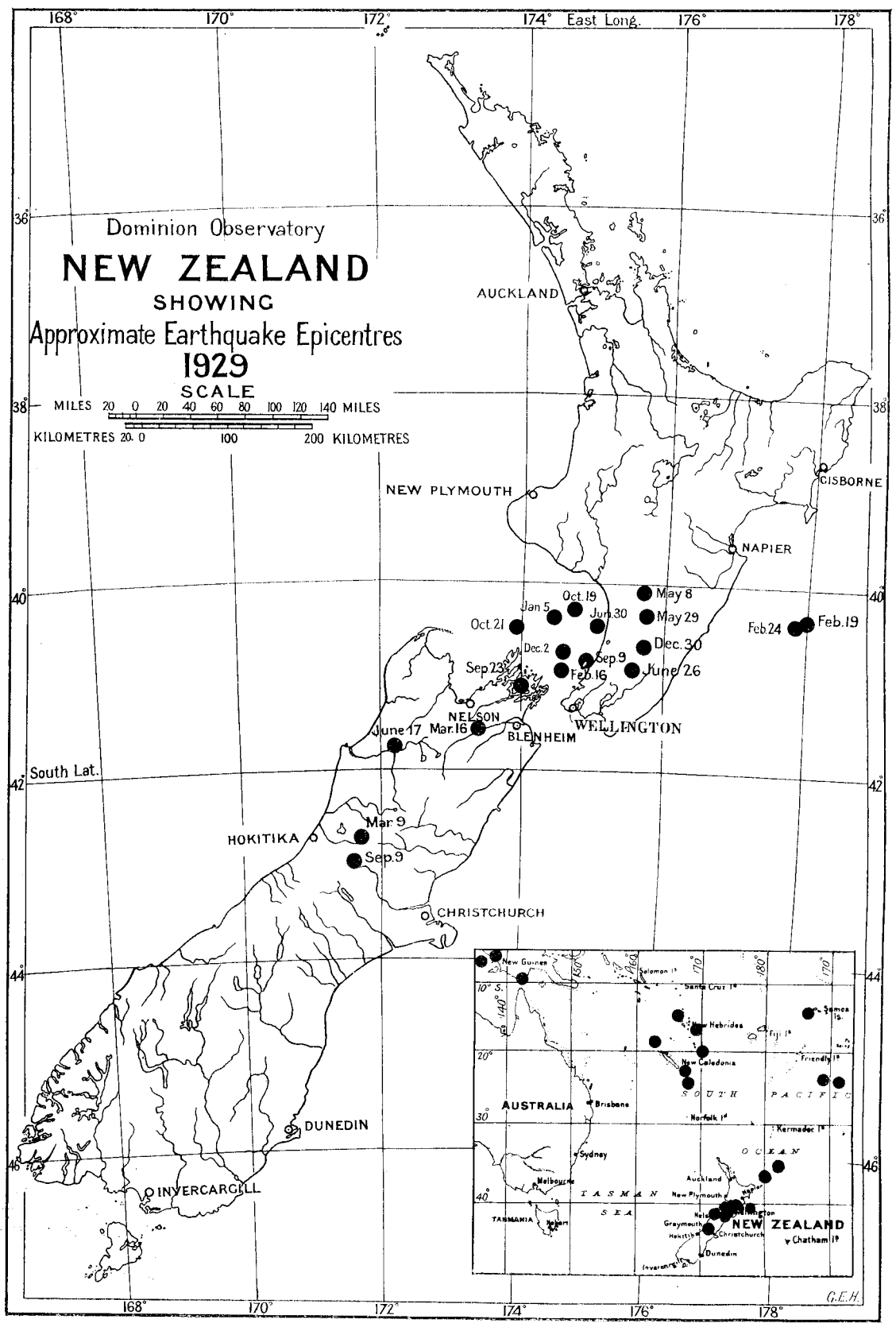


Fig. 2.

APIA OBSERVATORY.

THE Apia Observatory has continued during 1929 its programme of observation in terrestrial magnetism, seismology, and meteorology.

In July, 1928, the control of the Observatory was transferred from the Department of External Affairs to the Department of Scientific and Industrial Research. This change was brought about through the consolidation in one Administrative Department of all the various scientific activities of the country. The British Admiralty has contributed £400 and the Carnegie Institution of Washington £250 for the maintenance of the scientific programme. The New Zealand Reparation Estates has discontinued repairing the Observatory buildings, which has been a generous contribution of that Department made to this Observatory since 1921.

The fundamental purpose for which the Observatory was established was to observe, measure, and record with the highest attainable accuracy the various physical elements affecting the earth and atmosphere at an isolated station in the South Pacific Ocean. During the year, although the staff was depleted, all essential records were secured and the founders' high purpose fully maintained.

The visit in April of the non-magnetic research yacht "Carnegie" afforded an opportunity for the intercomparison of instruments and the discussion of observations and technique. During her second visit, in November, the "Carnegie" was totally destroyed by explosion and fire in the Apia Harbour. The death of Captain J. P. Ault and the destruction of this world-famed research ship was felt as a great personal loss.

The various activities of the Observatory will be considered under the three divisions of terrestrial magnetism, seismology, and meteorology.

TERRESTRIAL MAGNETISM.

Continuous photographic records were obtained throughout the year of the changes in the declination and horizontal force of the earth's magnetic field. Owing the failure of the earth's inductor, no observations of the inclination were obtained in January, February, and March. The behaviour of the variometer in April, May, and June was not satisfactory, and failed to give a record that could be used. Thus the values of vertical intensity are obtainable only from July to December. In order to compute the actual declination and horizontal force from the magnetograms the following absolute determinations of these elements were made at evenly spaced intervals:—

Declination: 112 determinations on fifty-four different days.
Horizontal force: 23.
Inclination: 45, on forty-three days.

The mean values of the magnetic elements—the so-called "all-days value"—for the past three years are given below:—

TABLE I.—MAGNETIC ELEMENTS AT APIA, 1927–29.

——	1927.	1928.	1929.
Declination ..	10° 29·5′	10° 32·1′	10° 33·5′
Horizontal force ..	35223 gammas	35225 gammas	35209 gammas.
Vertical intensity..	..	20408 gammas (five months)	20418 gammas (six months).

The days were classified according as the daily magnetic variation was normal, slightly or considerably disturbed. The individual daily character values were supplied quarterly to the Secretariat of the Comité International at De Bilt Observatory, Holland.

Magnetic storms occurred on February 26–28, March 11–12, May 23, July 15, and September 22. Although the number of disturbed days was unusually high, the disturbances were not intense, but continued for a longer time than usual. The number of sun-spots observed in 1929 was above the average, which is closely related to the unusually disturbed magnetic state of the earth observed.

The Observatory's magnetic standards were intercompared with those of the yacht "Carnegie." It was satisfactory to find that they had altered only very slightly since last compared in 1921.

SEISMOLOGY.

The Observatory is equipped with 1,000 kgm. Wiechert seismograph for recording horizontal earth-movements, and a 180 kgm. Wiechert seismograph for recording vertical movements. From January 1 to February 9, and from June 9 to 24, the larger seismograph was out of action through the breakdown of its driving-clock. Except for those periods, a complete record was obtained from both instruments throughout the year.

The two seismographs recorded a total of 269 earthquakes during the year, of which twenty-one were reported felt by people living in the vicinity of Apia. More than half (144) of the earth-movements recorded were exceedingly small tremors which originated within seventy-five miles of Apia. The amplitude of the earth-movement in the tremor rarely exceeded one five-hundredth of an inch, and the vibration continued less than five minutes. The larger earthquakes recorded were classified in Table II according to the distance of their epicentre from Apia.

TABLE II.—DISTANCE OF EPICENTRES OF EARTHQUAKES RECORDED AT APIA DURING 1929.

Epicentres more distant than 5,000 km.	14
Epicentres 5,000–1,000 km. distant	17
Epicentres 1,000–500 km.	33
Epicentres less than 500 km.	53

The most severe earthquake of the year at Apia occurred on August 4, which was just violent enough to shake some articles off shelves. (Intensity 4 on the Rossi-Forel scale.)

The seismograms were promptly analysed and quarterly bulletins issued to about eighty seismological stations and seismologists. Reports of specially severe earthquakes were sent by radio to the United States Coast and Geodetic Survey, Washington, D.C., and to the Dominion Observatory, Wellington.

METEOROLOGY.

Continuous records were obtained of atmospheric pressure, temperature, wind force and direction, sunshine, humidity, and rainfall. Table III gives a summary of the monthly values of some of these elements.

TABLE III.—SUMMARY OF METEOROLOGICAL OBSERVATIONS, 1929.

Month.	Pressure.	Temperature.	Rainfall.	Humidity.	Sunshine.	Wind.
	In.	° F.	In.	Per Cent.	Hours.	m/h.
January	29·705	80·04	24·22	96	111·3	4·65
February	29·789	79·48	14·97	82	88·8	2·60
March	29·808	79·58	11·85	82	181·1	3·15
April	29·820	80·82	2·03	76	274·2	1·78
May..	29·840	79·72	4·51	73	224·8	2·41
June	29·877	79·52	3·77	75	175·3	4·34
July	29·871	78·42	2·95	74	213·2	2·28
August	29·882	75·58	2·89	74	244·8	4·31
September	29·869	78·68	2·29	74	221·3	2·29
October	29·848	79·81	12·58	80	205·3	3·73
November	29·750	80·42	9·43	78	205·3	3·03
December	29·727	80·61	18·52	82	133·5	3·30
Mean or total ..	29·822	79·64	110·01	780	189·9	3·17

The mean temperature for every month in the year was above normal, April being 1·93° F. in excess; June, 1·72° F.; and November, 1·73° F. As generally occurs in the southern Pacific when the temperature continues persistently high, the barometric pressure remains lower than normal. The barometric pressure was accordingly below the average throughout the year, with a mean value of 29·822 in.—0·013 in. less than the normal. The yearly rainfall slightly exceeded the normal, amounting at Apia to 110·01 in. From February to September the rainfall continued less than normal, but heavy falls in January, October, and December produced an excess for the year.

Although six cyclones were reported during the rainy season in the south-western Pacific, only the cyclone on January 17–18 caused damage to the plantations in the Territory. The barometer dropped to 29·492 in. on January 18, while the wind-velocity in gusts reached a velocity of forty-eight miles per hour. The violent winds blew for only brief periods and the financial loss resulting largely from bananas being blown down was small.

SOUTH PACIFIC WEATHER SYSTEM.

The Observatory prepares a report of weather conditions prevailing at 9 a.m. and 4 p.m., which is sent to the Radio Station for broadcasting and to the Harbourmaster's office. Owing to the settled weather conditions occurring in the South Seas from May to October, the morning report is not sent out by wireless during these months.

The following stations now issue daily reports under the supervision of the Apia Observatory: Papeete, Tahiti; Norfolk Island; Vila, New Hebrides; and Ocean Island. These reports, which during the year number about 2,900, render useful service to shipping in those waters by giving timely warning of the development and progress of cyclones. All the weather observers have been extremely conscientious, but closer personal supervision and occasional inspection of instruments are desirable. On the other hand, special praise should be given to the Suva Weather Station, under Captain E. W. G. Twentyman, which approaches the ideal.

UPPER-AIR WORK.

The observation of winds at high altitudes has been carried on. Sixty pilot balloons were released, of which thirteen were followed to heights of 10 km. or more. These long flights invariably disclosed the presence of strong westerly winds at great heights moving contrary to the south-east trades blowing at levels below 10,000 ft. The advent of airship travel makes it most desirable to secure further data of upper winds not limited, as hitherto, to days with unclouded skies.

Solar Radiation.

The intensity of solar radiation falling on a lamp-black surface was measured on a few sunny days by a Gorcynski recording pyrheliometer. Unfortunately, owing to depleted staff, little time could be spared for this important line of investigation, by means of which a direct measure is obtained of the sun's heat transmitted through the humid atmosphere of a tropical island.

Time Service.

A time service accurate to about three-tenths of a second has been maintained throughout the year. The Standard Observatory clock has been checked by fortnightly observations of the solar transit at noon. The high accuracy in time necessary for the magnetic programme has served a double purpose, as it permitted rating the chronometers of numerous small trading-vessels calling at Apia.

Atmospheric Electricity.

The atmospheric electric potential was measured as heretofore, both in the Observatory grounds and at a house erected on piles in shallow water about one-third mile off shore. For the first year since its erection, the records at the latter station were practically uninterrupted. In view of the absolutely unvarying surroundings existing in the lagoon, the records have a special value in showing any change occurring in the potential from year to year. Although the results from the two stations closely resemble each other, the daily maxima and minima are more pronounced in the records at the lagoon station than at the station in the Observatory grounds. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington have given generous assistance for carrying on the atmospheric electrical programme.

Publication and Personnel.

During the year the annual report for 1926 was published, giving the complete observational data obtained during that year. Also a monograph of seventy-nine pages was issued on the upper-air data, based on 239 pilot-balloon flights made from February, 1925, to December, 1928.

The resident staff of the Observatory consisted of the Acting-Director, Scientific Assistant, and three Samoan clerks.

Approximate Cost of Paper.—Preparation, not given; printing (950 copies, including graphs), £127 10s.

By Authority: W. A. G. Skinner, Government Printer, Wellington.—1930.

Price 2s. 3d