1934.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(EIGHTH ANNUAL REPORT OF THE).

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

CONTENTS.

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

I have the honour to submit herewith the annual report of the Department for the year 1933–34.

E. MARSDEN.

SECRETARY'S REPORT.

The Council of Scientific and Industrial Research has held six meetings during the year. In addition, there have been several meetings of the Wellington members, who constitute an executive.

The personnel of the Council is as follows:—

Mr. George Shirtcliffe, O.B.E. (Chairman).
Professor Henry George Denham, D.Sc., M.A., Ph.D., Professor of Chemistry, Canterbury College, Christchurch.
Professor John Malcolm, M.B., Ch.B., Professor of Physiology, University of Otago, Dunedin.
Mr. Theodore Rigg, M.Sc., Director, Cawthron Institute, Nelson.
Mr. Hugh Vickerman, D.S.O., O.B.E., M.Sc., M.Inst.C.E., Wellington.
Mr. George A. Pascoe, Chairman, Development of Industries Committee.
Mr. Archibald M. Seaman, F.P.A.N.Z., Public Accountant, Auckland.
Mr. Alfred H. Cockayne, Assistant-Director-General of Agriculture, Wellington.
Dr. Ernest Marsden, M.C., D.Sc., F.R.S.N.Z. (Secretary).

During the year the Development of Industries Committee met on three occasions.

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

Permanent services—	£
Head Office, publications, Research Scholarships, and miscellaneous	5,633
Dominion Laboratory (with branches)	11,229
Geological Survey	4,957
Meteorological Office	6,804
Apia Observatory	1,937
Dominion Observatory	1,615
Magnetic Observatory	1,891
Lincoln College	4,822
Research investigations	31,188
Total	64,443

The funds devoted to research work were derived from the following sources:—

	£
Empire Marketing Board	6,608
Industries	6,142
Sales and miscellaneous recoveries	4,918
Consolidated Fund	13,520
	31,188

The year was one in which a great number of financial difficulties were experienced, partly because of the Empire Marketing Board ceasing to function, and of the difficulty of knowing, far in advance, what action was being taken to deal with the unexpended balances, and the unexpended terms of various researches which had been inaugurated by the assistance of this Board.

During the year the services of the Department have been called upon to an increasing extent, and apart from the main lines of research development, upon which it is engaged, there is a rapidly increasing number of what might be termed "minor" inquiries from numerous industries. These inquiries have involved a great deal of additional work, and despite the restrictions imposed by reduction of financial resources, very full service has been rendered as the result of the loyal co-operation of all scientific workers.

DOMINION LABORATORY.

The Dominion Laboratory has continued to perform the chemical investigations required by all Government Departments, except that of Agriculture. A good deal of the work is of a routine character, such as is required in the testing of materials purchased under specifications by various Departments, and for the enforcement of regulations. This routine work, however, often reveals certain major lines of investigation, and leads to research activities being undertaken.

The wide range of problems brought to the Laboratory renders it essential that each member of the staff, in addition to possessing qualifications in special directions, should co-operate with other members. The staffing and facilities of the Dominion Laboratory, in view of this possibility of co-ordination, are in a position to render a very complete chemical service for Government requirements.

The Health Department makes the greatest use of the Laboratory in connection with the administration of the Food and Drugs Act, some three thousand examinations of foodstuffs and drinks being made during the year. The influence of this continuous supervision of the composition of foodstuffs exerts a marked influence upon the quality of all materials offered for sale in the Dominion. Improvements in quality are most marked in the case of milk, some 7,500 samples of which were examined during the year. The quality of the milk now sold in the Dominion may be very advantageously contrasted with that which prevailed prior to the enforcement of the Sale of Food and Drugs Act. Tests made of enamelware imported revealed that certain types of this material were sufficiently defective in quality to adversely affect the health of users, and therefore the manufacturers have been notified accordingly. Drinking-water supplies have been subjected to close supervision, as the risks from stream-pollution continue steadily to increase from year to year.

The revival in mining has led to increased demands upon the assaying work of the Laboratory. Gold-saving devices have been tested, while problems concerning mine-ventilation have continued to receive attention. Following the coal-briquetting investigations conducted a few years ago by the Laboratory, it is gratifying to know that one commercial plant for dealing with slack coal has now commenced operations.

Through the examination of materials for all Government purchasing Departments, the quality of these has been kept up to standard, and considerable savings must necessarily result therefrom. The gas supplies of the main towns has been under constant inspection for calorific value, purity, and pressure, and this has shown that all were of satisfactory quality.

For the Police Department over six hundred analyses have been made, and there has been an increasing demand from this Department for work connected with the detection of crime.

This summary of the routine work of the Laboratory has been prepared to show the considerable extent to which chemistry is regularly called upon to assist the Government in ways which are seldom realized as being essential to the adequate operation of its various departmental activities.

Definite research work has been undertaken upon the incidence of goitre, production of low-temperature tar, fruit-tree sprays, pyrethrum, and ragwort, and kauri-gum. The manufacture of sodium chlorate has also been the subject of investigation, while considerable headway has been made towards the determination of the chemical constitution of the active principle involved in ragwort-poisoning.

METEOROLOGICAL BRANCH.

The Director's report refers to the scheme for an international polar year, which was very successfully carried out so far as the Northern Hemisphere was concerned. Unfortunately, little could be done in the Antarctic. A certain amount of extra work was undertaken in connection with it by the Dominion Meteorological Service.

Forecasting problems are discussed in some detail. The most noticeable tendency as regards the public attitude to weather forecasts is the increasing appreciation of, and demand for, from the farming community per medium of wireless. The Director lays especial stress on the importance of the forecasting methods introduced by the Norwegian School. These methods are now almost universally accepted as constituting a very notable advance on anything previously in vogue. Particularly is the method of value in connection with the short period forecasts which are required for aviation services. There seems little doubt that within a very few years there will be regular air services not only in New Zealand, but also across the Tasman Sea. It follows that the building-up of an adequate meteorological service for aviation should be commenced as early as possible. This will involve facilities for the modern methods of forecasting mentioned above. It will take some years for the necessary additional staff to gain the requisite experience. The means of collecting and distributing information by telegraph and wireless will need to be expanded.

It has been found necessary to refuse numerous requests for the establishment of additional meteorological stations. The maintenance of the stations involves a great deal of work in the Meteorological Office in addition to the expenses of equipment and inspection. The present number is as many as it is possible to cope with under existing conditions.

In addition to the making of the usual observations of wind in the upper air at Wellington, facilities have been given Mr. J. Holmboe, of the Ellsworth Antarctic Expedition, to prepare and send up a number of "radio-sondes." These instruments are carried by large balloons to high levels in the atmosphere and, in the course of their ascent, signal down by wireless the temperature and pressure in the layers through which they pass. Mr. Holmboe has been assisted by Mr. R. G. Simmers and at times by other members of the Meteorological Office staff. The information gathered will be of great interest, since in the Southern Hemisphere, data from great altitudes are almost entirely lacking.

The usual periodical publications containing various meteorological statistics have been printed. Two papers on winds, which will be of value especially to aviation, were also published during the year.

The Meteorological Branch is to a large extent dependent for the daily observational data, without which it could not exist, on the gratuitious services of public-spirited persons; and the Director's remarks regarding the country's indebtedness to them are heartily endorsed.

GEOLOGICAL SURVEY.

The application of the science of geology in all its branches to the public welfare is the ideal of the Geological Survey. Systematic surveys, including the collection of facts, their comparison with those from other districts and countries, and their presentation to the public, together with inferences deduced from them, are but means to this end. Another equally important objective is the working-out of new generalizations and principles. Basic geological investigations, such as in New Zealand only the State can support, are essential for any planned national economy.

The increasing demands which industry, in its various branches, is making on the Geological Survey shows clearly that practical men realize that pure geology of to-day is applied in industrial science of to-morrow, and they look to the State to furnish the fundamentals as a basis for their local and specific problems.

The general policy has been to push ahead with the systematic geological reconnaissance of the whole country, since only one-third has so far been systematically mapped. Progress is necessarily slow with a much curtailed staff. In view of the depression and the importance of development of the gold-mining industry, from the point of view of employment, part of the activities of the Geological Survey has been directed more towards the problems of economic geology.

One officer was allotted to the Naseby Subdivision, and another has devoted his whole time to the study of deposits of detrital gold in Otago and Southland, in general, on areas not covered by the routine survey. Bulletins are already available for Hauraki and the West Coast, but additional work on special portions of these areas has been undertaken.

In addition to the above, systematic work has been pursued in the Eketahuna and Amuri Subdivision and, in all, an area of about 1,035 square miles was mapped in detail. During the year, the Annual Report and Bulletin No. 34, "The Geology of the Dargaville-Rodney Subdivision," by the late Dr. H. T. Ferrar, was published.

The geological reports published in this Annual Report deal with, and are included because of, their more immediate economic significance and as a preliminary to their more extensive publication in Bulletin form in due course.

GEOPHYSICS.

So far, geophysical methods have been little used in any country in relation to alluvial-gold deposits, but the researches carried out by the Department have shown that they possess considerable value, and routine seismic methods have now been developed. Moreover, it is confidently anticipated that these methods will become simpler in application as experience is gained, while the apparatus may be expected to become more portable.

During the year geophysical methods have been applied to a variety of problems. Old river-beds have been traced across the Cromwell Flat, and, at Cornish Point, the geophysical findings may be said to have proved useful. Work was also carried out in connection with contouring the basement rock and quartz conglomerates on several areas in the Manuherikia Valley, and several interesting further details have been indicated, bearing out the general theory of their origin put forward in Bulletin No. (S.I.R.) 40. A comprehensive series of measurements was made in connection with an ancient buried river-bed in the Waikaia area. These are illustrated in the section of the report by Mr. Macpherson (see page 46).

The work so far carried out has indicated possibilities of discovery and investigation of detrital deposits formed millions of years ago, at times when the topography and drainage of the region were very different from what they are now. The crust has been deformed, and parts of the auriferous deposits, depressed by faulting and folding, were covered with geologically younger beds or otherwise protected from erosion. Then more accessible portions, or gold derived therefrom by subsequent cross drainage, were worked for many years and are now for the most part exhausted, rendering necessary continued geological and geophysical data to prospect them in depth to the best advantage. Geological mapping indicated important points in the structure while geophysical work gave more detailed information as to their approximate position and depth. Each deposit has its own difficulties and requires careful consideration, as to the methods to be used to attack the problem and overcome unexpected features. The geophysical party was fortunate in having behind it the resources of the Department in its Geological Survey, the Magnetic and Seismological Observatories, and the Dominion Laboratory. It must be stressed, however, that geophysical prospecting does not render unnecessary the older well-established methods. Its usefulness lies in reducing their cost by eliminating unlikely areas, and by giving more precise information regarding locations and hidden structures.

In many cases complete geophysical survey as to depths, &c., was not practicable from considerations of finance available, and owing to a full programme, but work has been carried out during the year at Millar's Flat, Clutha, Cromwell Flat, Cornish Point, Upper Waikaia, King Solomon and neighbouring claims, Mahakipawa, several alluvial areas near Murchison, Matakanui, Vinegar Hill, Drybread, Round Hill. A site for a dam in the Upper Shotover was investigated for depth to basement rock. A similar investigation was carried out for the Dunedin City Corporation in connection with the carrying of water-supply pipes across the Taieri River.

Work is in progress at Wetherstones, Waihi, and Progress Mine, Reefton, while there are many applications for work under consideration. Arrangements are in train with the Mines Department and Unemployment Board so that the paramount consideration with the programme of work shall be that of likelihood of developments for definite employment and gold-production.

OBSERVATORIES.

Three observatories—the Dominion Observatory, Christchurch Magnetic Observatory, and Apia Observatory—come under the jurisdiction of the Department, and during the year there have been improvements made towards rendering fuller co-operation in the work of all three and in the compilation of data relevant to magnetism, astronomy, atmospheric electricity, and seismology. The Dominion is now much better equipped than in the past with a range of earthquake-recording instruments, which have been placed in suitable locations. A comprehensive Bulletin on the Napier earthquake was published during the year (No. 43).

The continuance of the work at the Apia Observatory has only been made possible through general financial assistance provided by the Rockefeller Foundation of New York, the Carnegie Institution, and the British Admiralty. The Department desires to place on record its indebtedness for the appreciated support provided by these bodies.

MINERAL CONTENT OF PASTURES.

Unfortunately, the research work in this connection has been seriously curtailed owing to cessation of the Empire Marketing Board grant, but it has been possible for the Cawthron Institute to continue investigations dealing with iron metabolism and its relation to deficiency diseases of the bush-sickness type. Simultaneously, it has also been possible at the Plant Research Station to continue work on the varying mineral content of pastures at all seasons of the year, and any modifications therein which may be induced by manurial or other treatments.

Apart from the general work on pastures showing deficiency of lime and phosphates, there are areas where unthriftiness of sheep appears to be connected with deficiencies of elements normally present in minute quantity. In these cases, treatment by drenching with soil from certain "healthy" areas has shown astonishingly beneficial results. Apart from the results in the case of bush sickness, this has been well exemplified by work at Morton Mains in Southland, and, as in the case of bush sickness, there is evidence that the fundamental factor is the geological origin of the soil. This interesting study will be continued during the coming year. A donation from the Southland Frozen Meat Co. towards the work is gratefully acknowledged.

Some work has been carried out on the efficacy of different types of limonite for treatment of bush sickness and the causes of the different results attending the use of various forms of this iron compound. The problem is not yet solved, however.

PHORMIUM TENAX.

The nursery areas at Massey College have continued to be used for the selection, breeding, and propagation of strains of phormium. With the likelihood of there being a specialized demand for fibre suitable for fabric purposes, now that the manufacture of wool-packs has been commenced, attention is being devoted to the qualities of strains of phormium for this purpose, while, for cordage purposes, several outstanding varieties have been fully tried out, and certain of these have been supplied for field propagation. The possibility of the utilization of phormium as a source of cellulose has been the subject of considerable investigation, both in New Zealand and overseas, and it is hoped that the work will be completed during the coming year.

WHEAT RESEARCH INSTITUTE.

This research activity has exemplified well the value of scientific co-operation with the three sections of the wheat industry. A new wheat, Cross 7, has been brought to the stage of commercial exploitation, and, after exhaustive trials, has shown a high per-acre yield capacity, and an increased yield of flour associated with a definitely higher baking-quality. Further testing and selection has enabled some of the less desirable varieties of wheat to be eliminated and replaced by varieties of better quality. The research experience gained in previous years has now made it possible to give guidance to matters which help to overcome the difficulties associated with the gristing of wheat harvested in difficult conditions. Bakers have had a number of their own specific problems dealt with, while the incidence of the whole research, carried out as it has been with the fullest co-ordination through all stages from the sowing of the seed to the baking of the bread, has resulted in a standardized product of more even and higher quality than would otherwise have been possible.

KAURI-GUM.

Continued investigations of kauri-gum, both that extracted from swamp material and from wood, have shown that this material is capable of being refined, and so improved in colour as to be used in the production of high-grade varnishes and lacquers. The results of these researches now await more large-scale development on a commercial scale.

PLANT RESEARCH STATION.

Research work at this Station has been directed towards all phases of plant growth, as these concern the farmer. Much emphasis continues to be laid upon strain influences as they occur both in pasture grasses and clovers, and in the range of agricultural crops. The influence of manurial applications on the yield of crops, the measures whereby the maximum returns can be secured from expenditure on fertilizers, is still being subjected to constant investigation. Plant-diseases, as occasioned by insects, fungi, bacteria, and virus, have been subjected to steady research, and a fair measure of success has attended many of the efforts devised to control the losses occasioned by these pests. The Station is so organized that it can readily deal both with fundamental research and with its testing-out in agricultural practice. Much of the valuable applied work now in operation—*e.g.*, seed certification, standardization of sprays—owes its value to the fundamental researches which have preceded it at the Station, which is, moreover, also in a position to maintain a constant check upon all such applied activities.

DAIRY RESEARCH.

The principal aim of the investigations at the Dairy Research Institute has been the improvement in the quality of butter and cheese, and investigations have proceeded in every direction which appeared to have any bearing upon quality. As a consequence, the industry has been assisted in a number of matters connected with handling of milk on the farm, with manufacturing-processes, and with transport conditions, whereby it has been possible to raise the general level of the quality of butter and cheese exported. An important factor to this end has been the annual weekly discussion with factory-managers, at which all the year's research results are discussed. The enthusiastic interest of factory-managers in these meetings is a pleasing feature. Marked progress has attended efforts designed to improve the flavour and spreadability of butter exported to the British market, and it now seems possible to cater for some of the distinctive tastes which are characteristic of butter-consumers in various portions of Great Britain. The reduction of the trouble of open texture in cheese has been shown to be most effectively dealt with by paying due attention to pure milk-supply, pure active starters, and to careful manufacturing and curing. Much advance has been made in our knowledge of the factors controlling the behaviour of "starters," so that it is now possible for factory-managers to ascertain the potency of their starters through the use of certain simple tests. These tests are also of use in detecting non-acid milk, the presence of which is a serious trouble to the cheesemaker.

Other possible products manufactured from milk have been the subject of investigation by the Institute.

FRUIT.

The progress of the fruit research programme has been very satisfactory largely owing to the ready measure of co-operation which has proceeded among the various bodies undertaking the actual research work. In all the research activities steady advances have been made, though the year's results have not been characterized by anything of a conspicuous nature. The value of the orchard at Appleby for assisting in the research work has been amply demonstrated, and it has produced a large amount of the fundamental data required in connection with the various researches in progress. It has been shown that methods of propagation exert a marked influence upon the root systems of fruit-trees, and that this ultimately will affect to a marked extent the constitution and production of the trees. Manurial trials have continued to show that the greatest response has been shown where nitrogen has been applied. Dressings of phosphates or potash have shown very little result in any of the trials conducted. The efficacy of the sprays now in use as the results of previous investigations is plainly evident in the better control secured over fruit-diseases, exports being almost entirely free of trouble caused through insect or fungus injury arising in the orchard. Among a very wide range of problems attacked in connection with transport and storage, interest centres on trials which have been conducted with various new systems of dunnage designed by the Cambridge Low-temperature Research Station.

SOIL SURVEY.

During the year the soil survey has been pushed ahead vigorously in two districts. The detailed survey of the Waipa County has been continued, so that most of the intensely farmed parts of the county have now been dealt with. While this work was in progress, sectional surveys have been completed in neighbouring areas, in respect to two definite problems, both associated with the quality of dairy-produce. This resulted in a much closer survey being undertaken of specified farms, where conditions having an apparent bearing upon dairy-produce quality were examined.

In view of the possibilities of an extensive system of irrigation being adopted in the Ashburton County, a reconnaissance soil survey of the flat land of this county was undertaken and completed. This will serve to indicate the main soil types which occur in this county, and help to indicate their suitability for the application of water by irrigation. The reconnaissance survey of Taranaki has been completed, while work has been carried out on a special area in Southland.

LEATHER AND PELTS.

The tanning industry in New Zealand has continued to make very full use of the scientific services provided by the Leather Research Association, and, in consequence, this industry has maintained itself in a satisfactory economic condition. The quality of the output has shown marked improvement, as exemplified by the fact that a small export trade has been established for certain classes of New Zealand manufactured leather. Most of the co-operating firms in the Leather Research Association have increased employment during the past year by 33 per cent.

Those participating in pelt research have had the advantage of new knowledge in relation to processing. The influence of new methods has been thoroughly tested out, consequent upon shipments being forwarded to England.

Some of the pelts processed by methods adopted in consequence of laboratory researches have found a demand in markets which were previously not available for the New Zealand article. Promising work has been carried out on calf-skins.

The progress which has been made in this field of research indicates the value of the steady utilization of scientific methods constantly reacting upon the processes of an industry, and assisting it in the exploration of new uses for its products. The results are discussed with fellmongers of co-operative companies in the works themselves and also at an annual round-table conference at the Head Office. Such conferences have proved particularly helpful in breaking down prejudices and creating a pride in the work.

DEVELOPMENT OF INDUSTRIES COMMITTEE.

The Development of Industries Committee met on a number of occasions during the year, and advice was given to the Government on several proposals and industries. With the appointment of the Chairman (Mr. G. A. Pascoe) to the Tariff Commission, meetings were suspended, with the view to formulation of definite policies when the report was published. Increasing use is being made of the Committee and of the Department's resources by the Unemployment Board.

MISCELLANEOUS.

During the year the Department has been called upon to a greatly increased extent to deal with a wide range of miscellaneous problems. Among these may be quoted the following:—

Chilled Beef.—In consequence of arrangements made between the Cambridge Low-temperature Research Station, Messrs. P. Borthwick and Co., and the New Zealand Meat Producers' Board, the Department supervised the scientific details of the first successful shipment of chilled beef aboard the s.s. "Port Fairy." This shipment was the first commercial consignment of chilled meat to be carried in "gas" storage, and the date of its arrival at Southampton, 18th July, 1933, may well prove historic. The success of the shipment led to the equipment of gas-tight compartments to the "Port Chalmers," the first vessel to be specially built with this feature. Mould counts were taken of the atmosphere in the freezing-works; records were kept of the flesh-temperatures from the time of slaughter until the meat arrived in England; details regarding CO_2 concentration and other matters of interest were also recorded with a view to keeping as close as possible to the specification laid down by the Cambridge Low-temperature Research Station, as being requisite for successful transport.

Further shipments are being watched and the optimum conditions investigated.

It would appear that carbon dioxide in 8 to 10 per cent. concentration is definitely helpful in transport of chilled meat to keep down mould and bacterial growth. Uniformity of temperature at about 29° F. is desirable. Information is still required as to the most desirable degree of humidity. The problem is to avoid moulds, preserve the bloom and surface colour, and to avoid undue loss of weight and oxidation of fat whereby a tallowy-linseed-oil taste is acquired. The whole chain of storage and transport needs careful control—chillers, railway-vans, and ships. Notable improvements in the latter are a pleasing feature of the past few years. It would appear that pasture-fed New Zealand beef has definite advantage in regard to flavour compared with that produced by certain competitors.

Cellulose.—Considerable attention has been given to the manufacture of cellulose from phormium and the possible utilization of this plant as a source of cellulose.

Fruit-juices.—Experiments have been in progress regarding the treatment of fruit-juices in such a manner as will allow them to be preserved and transported overseas without appreciable loss of flavour.

Irrigation.—In association with the Canterbury Progress League, Canterbury Agricultural College, the Lands and Survey Department, and the Public Works Department, attention has been devoted to irrigation experiments which have been in progress in Canterbury.

Wool.—Considerable negotiations and investigations have been carried out regarding wool-utilization overseas and the problem of wool research generally. It is hoped that a comprehensive scheme will be inaugurated shortly to provide for research and the collection and dissemination of information to wool-growers.

Reports have been prepared on numerous questions relative to industry, including passion-fruit preservation; asbestos-utilization; bentonite; diatomaceous earth; tung; pulping; kauri-gum refining; utilization of kauri peat; resources of tanning-material; oil resources; alcohol-production; coal-utilization problems, &c.

Overseas Co-ordination.—The value of maintaining a direct contact with overseas research developments, particularly those of Great Britain, has been exemplified during the year. The Department's Liaison Officer, Mr. Nevill Wright, who is attached to the High Commissioner's Office in London, has enabled the Dominion to have direct technical representation on the Executive Council of the Imperial Agricultural Research Bureau and on other bodies directly concerned with problems of moment to New Zealand. Through the Liaison Officer it has also been possible to secure advance information concerning industrial, scientific, or research tendencies which have proved of the utmost value.

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

DAIRY RESEARCH INSTITUTE.

Dairy Research Management Committee: Hon. Sir George Fowlds (Chairman), Mr. A. Morton, Mr. J. Murray, Mr. T. A. Winks, Mr. W. Iorns, Mr. Dynes Fulton, Mr. Quentin Donald, Professor H. G. Denham, Dr. C. J. Reakes, Mr. W. Singleton. Director of Research: Professor W. Riddett.

During the past year the following lines of work have been engaging the attention of those at the Dairy Research Institute. Some of these projects have been completed; work on the others still is in progress:—

(*a*) *Butter*:—

(1) The influence of the rate of cooling cream and churning temperature on the spreadability of butter.
(2) The relative advantages of making butter from fresh cream and from cream treated with starter.
(3) The possibility of avoiding wood taint from *Insignis*-pine timber by treating it with a casein preparation and formalin.
(4) The cause of primrose colour in butter, and factors giving rise to toppiness.
(5) The comparison of different parchment papers and the merits and demerits of using aluminium- and tin-foils backed with parchment, and the same foils backed with waxed paper, parchment papers sprayed with metal, and waxed papers of different kinds.
(6) Methods of determining quickly whether butter has been made from overneutralized or overacid cream.
(7) Methods of determining the acidity of cream more accurately than by titration.
(8) The devising of methods of determining in the laboratory whether butterfat is undergoing slight change before such a change is apparent to the senses.
(9) Reasons for butter deteriorating in storage.
(10) Comparison of the accuracy of different methods of estimating fat in skim-milk.

(*b*) *Cheese*:—

(1) Methods of preparing and maintaining cheese-starters, with a view to preserving their purity and vigour from day to day.
(2) The effect of starters and other factors concerned with the development of flavour in cheese.
(3) The identification of organisms and other biological conditions which injuriously affect milk for cheese-making.
(4) Chemistry of the changes affecting the acidity of milk and curd during the cheesemaking process.
(5) Changes at monthly intervals in the character of the curd from the milk of individual cows of the Massey Agricultural College herd.
(6) The effect on cheese quality of manufacturing cheese from—
    (i) High- and low-testing milk, respectively;
    (ii) Cooled and uncooled raw milk, and the same milk pasteurized at 150° F. and 160° F.;
    (iii) Milk produced on land that has been limed and not limed, respectively;
    (iv) Curd "dried" at different degrees of acidity;
    (v) Curd cooked at different temperatures, different rates, and in different ways;
    (vi) Curd stirred to varying extent;
    (vii) The same milk treated with different starters;
    (viii) Milk to which water has been added;
    (ix) Milk acidulated with hydrochloric acid before adding starter;
    (x) Curd hooped at low, medium, and high temperatures;
    (xi) Curd milled at varying degrees of acidity; and
    (xii) Curd treated with salt containing magnesium and calcium impurities.
(7) Comparison of bandage-cloths of different strengths.
(8) Study of the flow of moisture in cheese during pressing and curing.
(9) Correlation between changes in acidity of cheese between making, fourteen days old, and four months old, and their influence on cheese-quality.
(10) The reproduction of discoloration, the isolation and effects of organisms from discoloured cheeses, the chemistry of the changes occurring in discoloration, and the influence of curing temperatures on discoloration.
(11) Comparison of the accuracy of different methods of determining casein and the relation of casein and fat tests to cheese-yield, with a view to arriving at a rational and simple method of paying for cheese-milk.
(12) Comparison of different methods of grading milk.

The following account briefly summarizes the results obtained to date :—

Butter.

Flavour.—As in the past, flavour experiments have received most attention. Extremely favourable reports were received during last season on butter made from fresh cream which needed the addition of no neutralizer. It was daily-delivery cream of specially high quality. A long series of experiments has now been carried out on the use of starter. It is plainly evident that flavour demand varies with buyer and in all probability with district or trade. What suits one is not necessarily suitable to another. It would help the work enormously if we knew what flavours appealed to different sections of the trade, so that all might be satisfied. There is abundant evidence that it would be most unsafe for New Zealand to use starter on a lavish scale. In some cases, a slight addition of starter to cream has made butter more attractive ; in others, it is not wanted.

During the present season trials have been made of a new method of using starter, which involves the use of only a small amount, and which allows the starter to be neutralized. It entails the working-in of the serum of the starter which contains the flavouring-substances. Only part of the results have yet come to hand ; they are very encouraging.

Wrapping-materials.—During last season a number of different brands of parchment paper was compared with waxed papers, metal-sprayed parchment papers, and parchment papers backed with aluminium- and tin-foils. The parchment papers do not show wide differences, though those containing small amounts of soluble metals were slightly better than the others. The waxed papers and parchment papers sprayed with tin were not a success. The parchment papers, however, backed with aluminium- and tin-foils gave very good results—the surface colour of the butter was unchanged after storage, much superior to parchment in this respect, and free of "toppiness." The greatest defect was that the foils were liable to tear. In the present season the effect of protecting the foil with another layer of thin parchment is being tried. Foils attached to waxed paper—not parchment—gave poor results ; frequently the butter surfaces were toppy.

Timber-taint.—Experiments concerned with the treatment of *Insignis* pine with a casein preparation and formalin were not altogether satisfactory ; in the main a distinct advantage was obtained ; but there were a few exceptions to the rule ; and it is necessary to carry out an experiment on a commercial scale before deciding whether or not the treatment is wholly efficacious.

Spreadability.—In practical buttermaking experiments it has been shown that spreadability is improved by avoiding the adoption of excessively low temperatures in cooling cream and by avoiding what may be described as "shock cooling"—*i.e.*, excessively rapid freezing. This does not involve violent changes in manufacture ; it needs only the exercise of judgment. Great care is necessary because any extreme causes the butter to be greasy and lacking in keeping-quality.

Neutralization.—A rapid, accurate, and simple method of determining whether butter has been made from overneutralized or excessively acid cream is being investigated. Such a method would be most valuable in drawing the attention of makers to the practice of excessive neutralization, thereby avoiding "soda flavours," and in avoiding the export of butters acid enough to develop fishiness on storage. In connection with the development of fishiness, experiments are being carried out as time permits to determine the true mechanism involved.

Estimation of Fat in Skim-milk :—During the past season the whole subject of testing for fat in skim-milk has been investigated.

It was shown—

(i) That the ordinary Babcock and Gerber methods are quite useless for testing skim-milk, and that the results obtained (of the order of 0·01 to 0·02 per cent. fat in the skim-milk) are wholly false and misleading :

(ii) That the Butyl-alcohol-Babcock method gives results showing a fair agreement with the correct results as obtained by a laboratory method, if the test is carried out in a steam Babcock machine as regularly used at dairy factories in New Zealand. The results obtained with this test in an electric Babcock machine, without a subsidiary heating-device, are no more reliable than are those obtained by the Gerber or ordinary Babcock methods.

(iii) That any claims that a separator, working under ordinary commercial conditions, gives skim-milk testing lower than 0·06 to 0·07 per cent. fat, may be discounted as valueless.

Cheese.

Openness.—It has become quite evident that pure milk, pure active starters, careful manufacture, and careful curing play individual and collective parts in determining whether cheese will be close in texture. Given every one of these conditions, ideal so far as we know them, no one could guarantee to make close cheese, because still undefined variations from the normal appear to have greater effects than any one up to date in cheesemaking practice has determined. It is well to bear in mind that a cheese which bores close at normal grading-age, may not remain close, and that a cheese which bores close when judged by one plug or even several, may not be close when finally cut. All of our cheeses are judged by their closeness on cutting at an age when the grocer would cut them.

In spite of what has been said above, openness can be controlled within limits. The extremely open cheese can be avoided, though the ideally close cannot be made with continuous precision. All experience shows that the control of acidity is the keynote to the control of openness. If acid develops

too slowly or too quickly, no skill will avoid openness or equally great defects in quality. If, added to that, mistakes in judgment are made in manufacture or in the curing of cheese, openness will be accentuated.

There is abundant evidence that in the cheesemaking process a fairly definite schedule of operation might be defined for any individual milk; but it is difficult—at present impossible—to define a schedule applicable to all milk. The principal practical point emerging from our work is that acid must progress smoothly. The fundamental work on starters and on the chemistry of the cheesemaking process is most important in this direction.

Starters.—In previous work it had been observed that some starters were particularly sensitive to the conditions obtaining in the milk in which they were grown—that is to say, that, although the milk might be perfectly satisfactory from every point of view, it could on occasions be treated in such a way that a starter would not grow satisfactorily in it, and, in two or three days, would rapidly lose its vitality. It has been shown that trouble arising from this cause can be overcome to some extent if the milk in which the mother culture is prepared is pasteurized and cooled in closed vessels with as little disturbance as possible. The admixture of air with the milk after it has been pasteurized (such as would occur in pouring from vessel to vessel) is in some cases sufficient to cause the starter to fail entirely. This fact has now been proved beyond doubt by investigation of several cases. It certainly does not account for all cases of failure in starter cultures; but it is worth while to take precautions against failure from this cause. It was with this object, among others, that a piece of apparatus was devised which could be used in factories for the maintenance of mother cultures of starters under the best conditions possible in the present state of our knowledge. Arrangements with the National Dairy Association enabled this apparatus to be placed on the market. It has the following advantages over the more general method of keeping starter cultures:—

(1) The milk is pasteurized and cooled in suitable vessels.
(2) There is no necessity for pouring, and consequently aerating the milk. This minimizes the possibility of starter failure from the cause described above.
(3) Four mother cultures can be kept with the minimum of trouble. The factory-manager, therefore, has constantly several cultures on hand, and is not in extreme trouble should one culture fail for any reason.
(4) The cultures are much less liable to contamination than a bulk culture.
(5) The cultures are incubated at a constant temperature independent of the weather conditions. This ensures more regular running from day to day.

Some of these pieces of apparatus are known to have proved successful in eliminating starter trouble in factories.

Unfortunately, the starter problem still presents some unsolved mysteries. Even when starters are kept under the most suitable conditions known at present, they frequently exhibit a gradual fall in activity, which is distinct from the sudden "death" outlined above. This phase also is being investigated; but no solution is available yet.

"*Non-acid*" *Milk.*—With regard to factors in the milk in the vat which sometimes prevent an active starter from producing acid at the required rate, considerable advance has been made. At this time last year it had been proved in one instance that "non-acid" milk was due to the growth of a germ in the milk. This now has been confirmed in many cases; and the same type of germ has been found in every instance. Strangely enough, the germ responsible for the trouble is very similar to the germs present in a starter culture. It forms acid itself at a slow rate, and, quite often, if the contaminated milk were used in the raw state, no slowness would be noted in the vat. When, however, the germ has been killed by pasteurization, it leaves behind in the milk a substance which acts almost as a disinfectant and prevents the growth of the starter germs. Investigation during the past year has shown that the "non-acid" germ is widespread in milks. Usually, it is present in numbers too small to produce any marked effect during the early part of the cheesemaking process; but it may be responsible for difficulty in attaining a high enough acidity in the later stages. If, however, the milk on the farm is not cooled during warm weather or if the germ establishes itself and grows in the material present in a poorly cleaned milking-machine, it reaches numbers in the milk sufficient to produce the typical "non-acid" trouble in the vat.

Lately, evidence has been obtained that the germ is present in the udders of certain cows. It remains to be seen whether or not it is associated with disease in the cow.

Cheese-ripening.—The results of this work have tended to emphasize the part played by acid production in the manufacture of the finest-quality cheese. Evidence obtained so far indicates that the part played by starter bacteria in flavour-production and ripening is more in the direction of controlling events through their acid-production than through any other specific action—that is to say, the first essential property of a starter is its power to produce acid in the cheese-vat at a normal rate. The presence of specific types of starter organisms in the mixed starter is either of no importance or, at any rate, of considerably less importance. At the same time, it should be emphasized that the actual mechanism of flavour production in cheese is still not known. Attempts are being made to determine exactly where the flavour originates, and given this knowledge, it may still prove possible consciously to modify the flavour of cheese independently of the matter of acid-production.

Chemistry of the Cheesemaking-process.—It has become apparent that until we know more exactly what happens to each milk constituent during the cheesemaking-process, it is impossible to state the conditions under which close and open cheeses, respectively, may be produced. It has previously been shown that whereas the per-cent. acidity as determined in dairy factories by titration in the whey falls at salting, the content of lactic acid rises steadily and regularly, and that the fall in acidity during the later stages is due not to excess fat or to the presence of salt, as previously supposed, but to the

neutralization of the acid produced from lactose by the mineral substances present in the curd. The working-up of the results has been delayed by several anomalies for which explanation had to be sought before the results could be put forward with sufficient confidence. For reasons not easily explained in simple terms, a considerable amount of trouble has been experienced in providing this explanation; but results are now available which clarify the position and give a meaning to those results which previously were not in accord with the main body of the results. Further confirmatory work is now in progress. The previous work above cited, showing that there is an increase in the mineral content of the whey coincident with the increase in acidity, has been extended to show that the initial acidity of the milk at setting has a marked influence on the amount of lime retained by the curd. A study also has been made of the substances responsible for the acidity in whey collected at various stages of the cheesemaking process. It has been shown, too, that the cheese curd contains water in two forms—viz., water combined with the curd, and water enmeshed in the curd. These results are of considerable importance in providing a clearer understanding of the changes involved in Cheddar-cheese manufacture.

Payment of Milk for Cheesemaking.—Investigation of possible alternative methods for payment of milk for cheesemaking has been carried out during the year. The results are not finalized yet; but there is every reason to suppose that a satisfactory and practicable method will be evolved.

Discoloration in Cheese.—Work has been continued on the discoloration of cheese; but it now is certain that the problem is very complex, as no simple solution has been found which accounts for these defects. It has been conclusively established that the bleaching in cheese is due to bacterial action and not to the action of moulds. The bacteria responsible for the trouble evidently are widespread, for outbreaks of discoloration unexpectedly have occurred in cheeses made under strictly controlled conditions from good-quality milk, on several occasions. For this reason, cheese containing inoculations of bacteria (obtained from cultures of discoloured cheeses), and, therefore, suspected of giving rise to the trouble, are now made in a small experimental plant in the laboratory. It has been repeatedly shown that cheeses made from milk containing an inoculation of a perfectly normal cheese (either as an emulsion or as a culture of bacteria) will, in many cases, become discoloured. This further complicates the nature of the problem, and, therefore, work is being concentrated on the isolation of the particular organism, or organisms, responsible.

From the chemical point of view, it is clear that the local types of discoloration are not identical with those reported in other countries, and numerous analyses made on normal and discoloured cheeses, or portions of the same cheese, show no significant differences in composition. Investigations, therefore, have been made on the colour changes of annatto; and these indicate its easy bleaching by oxidation. Moreover, all the evidence collected so far confirms the view that the types of discoloration under consideration are due to oxidation by the admission of a certain small amount of air. It also has frequently been found that cheeses, which appear perfectly normal after three months or so in storage, develop discoloration after longer periods, which supports the view that all cheeses tend to discolour when kept long enough, while those which show the defect at an earlier stage differ in degree rather than in the nature of the biochemical changes. Possible oxidizing agents in cheese (such as enzymes, traces of metals, and oxidized fats), have been investigated, but have failed to produce the typical types of discoloration. As it has been noticed on numerous occasions that certain cheeses develop discoloration after exposure to the air (by cutting) for a few days, the presence of a powerful oxygen-carrier (catalyst) is indicated. Work is at present concentrated on attempting to determine the presence of this substance.

Cheese-bandages.—In connection with this work the usefulness of a large number of bandages was compared last year. Those that proved best were strong in fibre and relatively open in structure. They kept the cheeses erect on the shelves while the weak ones allowed the cheeses to bulge badly. The bandages exerted a greater influence on the shape of the cheese than on the texture.

Dissemination of Results.

The usual course for factory-managers was held during the first week in May, when fifty-seven managers were present at the Institute. A monthly bulletin was supplied to the principal dairy journals. The following separate publications were issued during the year:—

"Loss of Vitality in Starters." H. R. Whitehead and L. Wards.

"Two Surface Defects of Butter: 'Primrose' Colour and 'Toppiness'." C. R. Barnicoat.

"Deterioration of Dairy Produce by Moulds." T. R. Vernon.

"Observations on Some Factors in the Milk of Individual Cows which modify the Growth of Lactic Streptococci." H. R. Whitehead and G. A. Cox.

"A Substance Inhibiting Bacterial Growth produced by certain Strains of Lactic Streptococci." H. R. Whitehead.

"Further Observations on Slow Development of Acidity in Cheese-manufacture." H. R. Whitehead.

"Fat Losses in Skim-milk and Methods of Estimation of Fat in Skim-milk." F. H. McDowall.

"The Effect of Salt on the Growth of Lactic Streptococci in Milk." F. H. McDowall and L. A. Whelan.

"Chemistry of Cheddar Cheese-making." F. H. McDowall and R. M. Dolby.

PLANT RESEARCH STATION.

The Plant Research Station is an activity of the Department which is conducted in co-operation with the Department of Agriculture. The work of the station includes sections which deal specifically with regular routine matters, and other sections which are engaged purely on research investigations. The work at the Plant Research Station proceeds in close association with that of the Wheat Research Institute, and the fruit research programme of the Department of Scientific and Industrial Research.

The following report deals, in brief form, principally with those activities which receive financial assistance from the Department of Scientific and Industrial Research.

Mr. A. H. Cockayne is the Director of the Plant Research Station.

Botanical Section.

(1) *Identification of Specimens.*—Some four thousand specimens of plants have been received by the Systematic Botanist for identification and advice. This is particularly essential where the specimens are those of lately imported plants which are likely to constitute a weed menace.

During the year a large number of specimens of plants which have been suspected of being poisonous to live-stock have been received. The identification work carried out also serves very usefully where species figure as indicator plants of soil and habitat conditions.

(2) *Herbarium.*—Numerous additions were made to all sections of the herbarium during the year, so that it now contains close on twenty thousand sheets. Special attention has been devoted to grasses and to mosses of agricultural importance.

(3) *Systematics.*—The systematic investigation of the grasses and rushes of New Zealand have been carried a stage further, and additional work done on the whole alien flora of New Zealand, especially those possessing economic significance. Lucerne types established in New Zealand have also been receiving attention, and in this work co-operation is being effected with workers in other countries on a project entitled, "International Test of Types of Lucerne."

(4) *Fruit-trees.*—In association with the fruit research scheme, work dealing with root-stocks, propagation of fruit-trees, and strain differences is proceeding, and the progress in this connection is reported in the section dealing with fruit research.

Chemical Section.

(1) *Pasture Analysis.*—The Chemist has been engaged on the analysis of pasture and soil samples from the Marton mowing trials, determinations being made of the effect of fertilizers, grazing, and season upon the chemical composition of pastures from this area.

(2) *Manurial Investigations.*—The effect of applications of lime on the movement of phosphate or superphosphate, basic slag, and North African phosphates in the soil conditions of Marton are being continued.

(3) *Rape Analysis.*—An investigation of the chemical composition of the various types of rape was carried out in co-operation with the Agronomy Section, with the object of correlating chemical data with that received from feeding trials. This analytical work is associated with that which has already been done in connection with the different strains of rape which are being used for lamb-fattening purposes in the arable portions of the Dominion.

(4) *White Clover.*—With the object of determining type of white clover, using hydrocyanic acid content as a basis, analyses of the different strains established at the Station have been continued. The correlation between the HCN content and type has been well maintained, but, in general, the figures for the HCN content have been considerably lower during the present year.

FIELD EXPERIMENTAL SECTION.

(1) *Strain Tests with Perennial Rye-grass from the Hawke's Bay and Canterbury Districts.*—These trials, conducted in the Canterbury District over a period of four years, have been maintained. Those areas sown with certified perennial Hawke's Bay rye-grass have, up to the present time, given an average increase of up to 30 per cent. more grazing than those sown with the Canterbury strain of rye-grass, the margin of superiority being fairly constant during the past three seasons.

In the area sown with Hawke's Bay rye-grass, this grass is still dominant, whereas in the others cocksfoot and white clover have come in to such an extent as now to form the dominant constituents of the pastures.

(2) *Observational Top-dressing Trials.*—Two hundred and fifty observational top-dressing trials, arranged for the purpose of surveying the response of New Zealand grasslands to lime, phosphate, and potash, have been continued. From these the most prominent feature of the year is the marked responses to potash within two months of its application, which have appeared in North Taranaki. The results have been so consistent as to warrant a recommendation being made to farmers in this district that they should include potash in their manurial mixtures. In some districts it has been found that no response has been shown to superphosphate, and while there are cases where this may be attributed to a deficiency of lime, there are others where neither super nor super plus lime have produced visible results.

(3) *Trials with Strains of Rye-grass and Clover.*—Throughout New Zealand, trials of approved strains of rye-grass and white clover have been arranged in order to demonstrate their superiority over the types most commonly grown locally, and from these trials useful information is gained in regard to the behaviour of selected strains under a wide variety of strains.

(4) *Wheat Trials.*—(*a*) Manuring: As a result of manurial treatments carried out in Canterbury, the average increased yield in favour of super at 1 cwt. per acre was 2·4 bushels per acre, and was well below the average of 4·1 bushels, owing to the fact that the trials were laid down on soils known to possess a small response to phosphate application.

(*b*) Variety trials: These were carried out in collaboration with the Wheat Research Institute. Averaging the results secured, in a comparison between the yields secured with Solid-straw Tuscan and Cross 7, the former variety possessed a slight advantage of 0·7 bushel per acre.

Other trials were conducted with Jumbuck, Dreadnought, and College Hunters wheat.

(*c*) Rate of Seeding: In trials in which seedings of 60 lb., 90 lb., and 120 lb. of wheat were used per acre, the increase in yield was maintained as the rate of seeding was increased, so that the general conclusion would be in favour of heavier, rather than lighter seedings.

(*d*) Seed-treatment: In order to test the merits of Ceresan New, a mercuric seed-treating compound, a number of trials were laid down in the wheatgrowing areas to enable comparisons of this seed-treatment to be made with untreated copper carbonate dusting and wet "pickle" areas. The Ceresan-treated cereal germinated more thickly and more vigorously, and showed an efficacy equal to that of copper carbonate, formalin, and bluestone in its control of smut, and, in fact, was slightly superior in this respect.

(5) *Potatoes.*—In order to secure seed free from virus, potatoes are being grown in a number of selected districts, and it has been shown that there is a marked inverse relationship between the amount of virus and the yield of each line. That grown in four localities having milder or more humid climates has shown a progressive increase in the amount of virus and a relatively small yield. Seed grown at other centres, possessed of cooler climates, has shown no increase in the amount of virus.

(6) *Swedes and Turnips.*—Manurial trials conducted over a number of seasons indicate that in order to overcome the serious germination injury likely to result from the use of super alone, it is advisable to apply carbonate of lime when sowing this crop. Experiments have revealed the fact that the action of carbonate of lime from various sources is markedly different, and this matter is now being made the subject of further investigation.

Mycological Laboratory.

(1) *Brassica Diseases.*—Following upon the hot-water method devised by the Laboratory, it has now been possible to raise a small quantity of seed which is absolutely free from dry rot.

In a search for club-root-resistant types of rape, swedes, and turnips, a number of highly resistant lines have been selected. These include Herning swede, Bruce yellow-fleshed turnip, "Mai" white-fleshed turnip, and no less than five types of rape. The club-root organism has been isolated from soil not previously in brassicas for four years and a half, and found to be pathogenic.

Aqueous solutions of mercurous chloride and acidulated mercuric chloride proved, in a series of trials, effective soil disinfectants for the control of club-root, without causing appreciable injury to cabbage-plants.

(2) *Cereal Diseases.*—(*a*) Smut: Out of a number of commercial seed-dusts which were tested on several varieties of wheat, oats, and barley, certain organic mercury dusts gave the most effective control, especially when the spore load was relatively high.

Trials have shown that overdoses of copper carbonate appear to exert no influence on seed germination.

(*b*) Rusts: Pure lines of cereal rusts and their hosts are now being assembled, and a large number of these will be despatched overseas in order to ascertain the number of biotypes present in the Dominion. This work is being done with the object of securing rust-resistant strains of cereals.

(3) *Potato-diseases.*—Four varieties of virus-free potatoes have been grown, and approximately 16 cwt. of virus-free seed is now available. This represents the first successful attempt at bulk production of virus-free seed on a commercial scale.

(4) *Diseases of Lupins, Peas, Beans, &c.*—Sore-shin of lupins has been proved to be a virus disease, which is transmissible to other lupins and to garden peas. Work is being continued to ascertain the main vectors. Mosaic disease of peas, broad beans, and red clover has now been determined as not being carried by seed.

No methods of seed-treatment have proved effective in the control of bean-wilt, but seed selected from clean plants have yielded clean crops. The growing of a quantity of carefully selected seed on a Manawatu farm has shown this method of careful selection of seed to be the best means of combating this disease.

During the year cultures sufficient to inoculate 91,080 lb. of lucerne seed were forwarded to farmers throughout the Dominion. This is an increase of over 21,000 lb. more than last season. In addition, a considerable supply of cultures for inoculation of red and white clover, lupins, and garden peas, were also prepared and distributed.

(5) *Forest-tree Diseases.*—Three types of fungi—Phomopsis, Diplodia, and Fusarium—have now been determined as responsible for the losses occurring in tree nurseries. The fungi responsible for the Gummosis diseases of macrocarpa and lawsoniana have also been determined.

Needle fusion has been found to be present on *Pinus radiata* grown on the pipe-clay soils of North Auckland, and on the clay soils of the Moutere district. Investigations have been conducted to ascertain whether this is due entirely to soil conditions, or whether any pathogen is responsible for the trouble.

(6) *Small-fruit Diseases.*—(*a*) Tomatoes: The fungi responsible for "damping-off," and the virus disease responsible for narrow-leaf have been determined. It was found that mosaic was readily transmitted from diseased to healthy plants in the process of removing laterals. Tests have shown that fruit-yield may be decreased by as much as 36 per cent. through attacks from mild mosaic.

(*b*) Strawberries: Several strains of virus-free plants have been produced, and are available for bulking for commercial distribution.

(7) *Grass-diseases.*—Control of red-thread, a fungous disease troublesome on lawns, and brown-patch, both of which are due to *Corticium* sp., are under investigation. The fungous responsible for impairing the germination of rye-grass seed has been isolated, and is now being made the subject both of laboratory and field investigations.

(8) *Miscellaneous.*—The effects of molasses, bacterial cultures, and whey in the production of quality silage are being investigated. Preliminary work has indicated that silage production may be standardized and simplified by the use of certain of these agents.

Experiments dealing with the control of moulds on the woodwork of dairy factories and meat-works are partly completed. This work is being designed to check the spread or organisms responsible for the deterioration of meat and dairy-products. Associated with this has been an examination of sterilizing-compounds, suitable for treating woodwork. It has been shown that chlorine compounds, so generally used for the purpose, have little, if any, toxic effect upon the moulds present.

Agrostology Section.

The work of this Section has been largely concentrated upon the significance of strains in the main pasture grasses and clovers. This has involved a large amount of plot experimentation and hybridization.

(1) *Perennial Rye-grass.*—Comparative tests of New Zealand certified strain rye-grass against English, Irish, Australian, and South Island lines have again proved the superiority of the first-named. With the exception of one or two Australian lines, all of these are definitely inferior to the certified strains. This inferiority was particularly marked insofar as liability to rust attack was concerned. Many of the imported lines under test were up to mother seed standard when tested under the screened ultra-violet light.

The field experiments show the absolute necessity for plot tests when the history and origin of the line in question is not known.

For the first time it has been possible this year to commence work on the preparation of elite strains. This has been carried out in the newly erected glasshouse, where tillers of six selected plants of a high-producing perennial type were planted out, and self-pollinated. As a result, sufficient plants have been secured to plant out $\frac{3}{4}$ acre of this elite strain. This will enable the value of the strain to be subjected to preliminary test.

(2) *Italian Rye-grass.*—Studies are being made of Italian rye-grass and Western Wolths, in order to ascertain the differences between these two strains. It is apparent that the position of commercial Italian rye-grass in New Zealand is very unsatisfactory from a type point of view. The samples tested so far have revealed few which are wholly of a good Italian type, the majority being very mixed, and ranging from Italian through Western Wolths to lines comprised wholly of false perennials. The availability of glasshouses has now enabled elite strain work to be put in hand immediately in the case of Italian rye-grass.

(3) *Cocksfoot.*—For certification purposes some 280 lines of cocksfoot are under observation, and attempts are being made to select strains from Akaroa, Canterbury Plains, and Danish type, which are likely to be worthy of further propagation in New Zealand.

Aberystwyth pasture type cocksfoot was this year sown out for seed-production, and gave a very good yield of seed, but the type appears to be of very little value in New Zealand on account of its low total production, and slowness to start growth in the spring, and its almost complete winter dormancy.

Certification and strain work is also being carried out with brown top.

(4) *White Clover.*—Selection is still proceeding in connection with white clover, during the year some 6,200 plants being under observation. An elite strain, selected from varieties grown at the Station, has been propagated at Lincoln and trial plots have shown that it is superior to any commercial mother seed at present available.

Hydrocyanic-acid tests have shown that high acid content and high-quality strains correlate very closely, and that this test is likely to prove most useful in determining white clover types.

(5) *Red Clover.*—Strain-selection work with red clover is progressing, and over three thousand selected plants are now under examination. A large number of imported plants from the Welsh Plant Breeding Station are also under observation, and comparisons are being made with those secured in New Zealand.

Similar work is proceeding in regard to subterranean clover and *Lotus major*. An inspection of pasture swards established in newly developed areas of pumice land have shown that certified seeds are playing a particularly important part in the pasture development of this class of country, and that these types are giving an excellent response to top-dressing.

(6) *Green-keeping Research.*—Investigations made during the year indicate the great difficulty which is being experienced in maintaining the thriftiness of the sward on bowling and putting greens, resulting from close and continuous mowing even though artificial manures are liberally supplied. This practice results in starvation, due to overpruning, and it serves to emphasize the importance of endeavouring to arrange for pasture maintenance through a rational system of rotational grazing, rather than under a system of close and continuous cropping.

Arsenic pentoxide and sulphate of ammonia have shown themselves to be the best materials for the control of weeds and clovers on greens. The outstanding grasses for green development have shown to be brown top, Chewings fescue, and velvet bent. Of the latter grass, strain selections are now being made, with a view to still further improving the standard obtainable by the use of this grass.

WHEAT RESEARCH INSTITUTE.

(REPORT FOR YEAR ENDING 31ST MARCH, 1934.)

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

On the 31st December, 1933, the Institute completed the term for which it was constituted by the original Act of Parliament passed in 1927. In view of the expiry of the Act, the opinions of farmers, millers, and bakers were sought as to whether the work of the Institute should be continued and whether they were willing to continue to pay the levies of 1½d. per ton of wheat or flour. This was agreed to by every branch of the Farmer's Union in the wheatgrowing districts, by every miller except two, and by every Baker's Association, except two in one particular district. The position was, therefore, placed before the Hon. Minister, and an Act was passed authorizing the collection of the levies for a further five years. The amount of the levy was varied by giving authority to collect up to 2½d. per 50 bushels of wheat or ton of flour, on the understanding that the increase would not be made unless the interests involved agreed.

On renewal of the Act the various interests were invited to recommend to the Council persons to represent them on the Advisory Committee, for the ensuing five years. Only two changes were made in the Committee of fourteen.

WHEAT-BREEDING.

The programme of wheat-breeding to make wheats of high quality suited for New Zealand conditions has been continued according to plan. The high yielding New Zealand varieties crossed with high-quality Canadians, have, except in one case (White Fife × Tuscan) not proved satisfactory, and so a considerable number of back crosses have been made. Certain varieties from Iraq and China have shown high quality in small trials, and these have been used as parents for crosses. These crosses and their offspring accounted for some 13,000 plots in the experimental field.

The search for high-quality wheats that yield well under New Zealand conditions has met with a considerable amount of success in the cross-bred wheat that is called Cross 7. This cross was made nine years ago, and it has been thoroughly tested over several years. As the result of forty trials in three years, it can be stated that it will yield practically as well as Tuscan, will give 2 per cent. more flour and a 10 per cent. better loaf. About 200 bushels of the cross was produced in 1934, and next year the variety will be placed on the market for general distribution. It is expected that its introduction will largely obviate the importation of Canadian flour that has been common during the past few years.

About three thousand varieties from all over the world have been tested in the plots. Among these a series of varieties from Portugal have proved high yielders, early ripeners, and good loaf-makers. They appear specially suitable for Southland, and some trials of them have been established in that area.

These trials and those of Cross 7 above referred to were conducted by the Department of Agriculture, whose invaluable assistance the Institute gratefully acknowledges.

LORD BLEDISLOE'S PRIZES.

His Excellency the Governor-General inaugurated a competition at the Christchurch Summer Show for wheats of high quality and the loaves baked from them. The competition drew over forty entries, and elicited a great deal of interest. The Institute expresses its gratitude to His Excellency for his assistance in its work.

LABORATORY WORK.

The testing of wheats and flours so as to allow millers to make the best use of the wheats available in New Zealand has been continued on a large scale. Wheats milled totalled 2,314, the flours baked totalled (counting duplicates) 10,666. The effect of this work is to allow millers to make satisfactory blends of the wheats they buy, so as to give the bakers flour of constant quality, and the consumer a better loaf. The grower also benefits in that the best use of New Zealand wheats checks the tendency to import Canadian and Australian flours. This work may therefore be regarded as the central point of the laboratory work, and so it absorbs most of our time and effort.

Some 525 samples were tested for moisture in the 1933 harvest, chiefly for farmers wishing to know if their wheat was ready for the header harvester. In the 1934 season the number tested was about eight hundred, this being due partly to the increased number of headers, and partly to the rainy harvest season.

Jumbuck wheat, whose merit as a baking wheat was disclosed by the Institute's testing of individual lines in millers' stores, has been extensively grown in the past season, especially in the Manawatu and Rangitikei districts, and its inclusion in millers' blends should be reflected in improved flour-quality.

Samples of millers' grists of home-grown wheats were obtained from all the wheatgrowing countries of the world, from their harvests of 1933 or 1934. These have been milled and baked in comparison with New Zealand millers' grists, and the trial has proved that New Zealand wheat is as good as, or better than, that of most other lands. The only general exceptions are spring-grown Canadian wheat, and wheats from the drier parts of Australia.

Wheatgrowing Practice.

Investigations have been made into wheatgrowing practices, with the object of finding methods of cheapening production.

1. An experiment was conducted on the feeding-off of wheat by sheep. It was found that the fed-off plots had the same yield, were a week later in ripening, were one week shorter in the strains, and stood more upright. The extra sheep feed obtained was therefore nearly all grain.

2. By the courtesy of the Government Statistician returns were obtained of the yield per acre of all the varieties of wheats grown in each wheatgrowing district. Some striking results were obtained, from which definite conclusions could be drawn as to the best variety of wheat to grow in particular areas. A continuation of this work is likely to give valuable results.

3. Determinations of soil-moisture in wheat-fields were continued during the growing season of 1933–34. The great influence of sufficient soil-moisture during October and November was made obvious by the figures obtained. The observations will be continued from year to year.

Seed Wheat Certification.

The Fields Division of the Department of Agriculture has continued to carry out this work in all its details. The result is that there is no reasonably common variety of wheat of which the farmer is unable to obtain pure seed whenever he requires it.

F. W. Hilgendorf, Director.

PHORMIUM RESEARCH.

REPORT OF WORK AT THE MASSEY AGRICULTURAL COLLEGE.

(By Dr. J. S. Yeates.)

Phormium research at Massey College deals with the collection, growing, propagating, and testing of varieties and strains genetical work, and investigations into diseases. The work is financed partly by funds derived from grading charges imposed upon fibre and tow exported.

1. Field-work.

(*a*) *Collecting.*—Most of this work having ceased on account of lack of funds, very little collecting has been done during the past year. By good fortune, however, fifty fans have been procured of a really good variety (No. 273), which may prove to be identical with variety No. 56.

(*b*) *Growing and Testing.*—The plants of most varieties collected in earlier years have grown sufficiently well to give enough leaf for a good milling-test, where the variety appeared to warrant such test. Of the varieties tested, Nos. 56, 37, and 22 gave the most favourable results. No. 56, in particular, gives great promise of being a heavy-yielding strain with very strong fibre. Extensive culling-out of poorer-testing varieties has been done this year. A number of varieties collected in 1930 and 1931 promise well, but are not old enough for milling-tests.

(*c*) *Propagation.*—Of the good varieties being propagated vegetatively, the " Ngaro " is the main one. The acre of it planted in the autumn of 1929 is now fully matured, and after cutting should be broken up and set out in 15 to 20 acres of land for further increase. Until the land for this purpose is available, it would be unwise to cut and mill the leaf from this area. Growth of this variety has been excellent.

Sixty fans of the S.S. variety were planted in September, 1931, and will be ready for a milling-test and for division to plant about 1½ acres in the summer of 1934–35. The same applies to an equal number of plants of variety No. 22. Varieties Nos. 37 and 56 are being propagated as rapidly as possible. The latter is regarded as the best one yet found so far as fibre strength and yield are concerned. There are now 110 plants of it in the nursery.

2. Genetical Work.

(*a*) *Hybrids for Selection and Commercial Use.*—The hybrids raised in 1928 from the cross 13K × S.S. have been given a milling-test and the poorer ones destroyed. Some of them gave very good fibre, though none was so good as Variety No. 56. Of the crosses made in later years, that between Ngaro and S.S. is the main one. None of these is yet old enough to mill. Arrangements have been made to send most of the two-year-old hybrids (about fifteen thousand) this autumn to a millowner who will use them in his plantation. When they are grown to maturity, facilities will be afforded for the removal and propagation of the best plants.

Enough seed of the same cross (Ngaro × S.S.) was obtained by hand pollination this summer, to raise over a hundred thousand hybrids for an extension of this work.

(*b*) *Hybrids for Studies of Inheritance in Phormium.*—Certain of the characters which can be studied without awaiting full maturity of the seedlings (a matter of five years) are being given close attention. This work is particularly directed at finding an explanation for the great lack of uniformity amongst seedlings of Ngaro and similar varieties.

(*c*) *Inbreeding and Good Strains.*—Some of the best strains, such as Ngaro, S.S., and No. 22, are being inbred with a view to securing lines of plants which will all have the good fibre-qualities of their parents. Until such true-breeding lines can be isolated, work on fibre qualities similar to that on other characters as mentioned under (*b*) will be impracticable. The exact study of commercial qualities is also greatly slowed by the period of five years necessary before a seedling can be subjected to milling-tests.

3. Yellow Leaf Disease.

Observations on this disease are made whenever possible. Some indications noted recently as to a possible cause are being energetically followed up.

Admiralty Tests with Phormium Fibre.

A notable advance was made during the year when the results of the tests made with New Zealand phormium fibre by the British Admiralty in association with the Imperial Institute became available. These tests have been in progress since 1925 at the Imperial Institute, where the inaugural trials indicated that small-scale trials under service conditions were warranted. For this purpose, 30 tons of "high fair," "low fair," and "young leaf" grades were made into cordage of various dimensions and issued to the Royal Dockyards and to His Majesty's ships in different stations. The result of these large-scale trials is given concisely in the following extract from a circular letter written by the Director of the Imperial Institute:—

> "The breaking-loads of the cordage of all sizes immediately after manufacture equalled (and in most cases exceeded) the standard of the Government departmental specification for Manila cordage. The reports received from ships and shore services were, in the great majority of cases, definitely favourable, and no noticeable distinction was drawn between the cordage made from the three grades of fibre.
>
> "In view of the promising results of this investigation the Admiralty has decided that New Zealand hemp cordage may be used in the Navy for specified purposes so long as supplies can be obtained at satisfactory prices and the yarn and cordage give the breaking-strains demanded by the official specification. Subject to these conditions, and to the continued satisfactory behaviour of cordage made from New Zealand hemp, the question of its more general adoption will receive consideration."

Cellulose Pulp from Phormium (New Zealand Flax).

Cellulose pulp prepared from phormium has been frequently advocated in the past as a material for papermaking, and more recently its use for the manufacture of rayon (artificial silk) has been suggested. Two methods have been proposed for carrying out the pulping, one in which the green untreated flax is subjected direct to the action of chemicals in a digester, the other in which the flax is first treated mechanically to separate the fibre from the waste material of the leaf, and the fibre then subjected to digestion with chemicals. The advantage of the first is that there is practically no mechanical loss of cellulose. With the second, while some cellulose is lost in the mechanical pre-treatment, there is a much reduced bulk of material to be digested, and the pulp obtained is of a better colour and should require less bleaching.

In discussing yields of any product from flax the moisture present in the flax when treated must always be known. Moisture in the flax leaf while growing may be 70 per cent. or more. When cut, the leaf dries out considerably, and after some days may contain only 55 per cent. of moisture, or less. It is evident that a ton of green flax containing 70 per cent. of moisture—*i.e.*, only 30 per cent of dry matter, including fibre—would give a less yield of pulp than a ton of similar flax which had partly dried on standing to 55 per cent., moisture—*i.e.*, contained 45 per cent. of dry matter. It is important, therefore, in comparing yields of any product obtained by different methods or at different times to know the percentage of moisture, or, to put it in another way, the actual dry weight of the flax treated. Similarly, the moisture of the product must be determined. The results can then be brought to the same basis by calculation. A convenient basis is flax with 65 per cent. of moisture, which is probably not far from the average of cut flax delivered at a mill. For pulp it may be assumed that when air-dried it would contain 9 per cent. of moisture.

Laboratory pulping trials were carried out by Dr. J. S. Maclaurin by treating 1 lb. weight of green flax in a small digester for 3½ hours at 172° C. with 4 or 5 per cent. of its weight of caustic soda in solution, and in one case with the addition of 0·5 per cent. of sodium sulphite. The pulp, after washing, was bleached with bleaching-powder. The yields of bleached pulp with 4 per cent. soda, were 14·8 and 13·6 per cent. for two determinations, with 5 per cent. soda, 12·8 per cent.; with 5 per cent. soda and 0·5 per cent. sodium sulphite, 13·5 per cent. The average of these is 13·7 per cent. When only 4 per cent. of caustic soda was used for digestion the consumption of bleaching-powder was very high. A similar laboratory trial by Mr. W. Donovan, using 4·1 per cent., of soda and 0·08 per cent. sodium sulphite, gave a yield of 14·2 per cent. bleached pulp. A semi-commercial trial, using 200 lb. of green flax, with 8¼ lb. of caustic soda and 2½ oz. sodium sulphite (4·15 per cent. and 0·08 per cent. respectively) gave a yield equivalent to 13·3 per cent. bleached pulp. It is therefore evident that green flax of average moisture content, when digested direct, does not yield more than 14 per cent. of bleached pulp. Expressed in other words, at least 7 tons green flax are required to produce 1 ton of pulp.

For the second process, involving mechanical treatment of the flax prior to digestion, there are no direct figures available. Figures obtained at the Bureau of Standards, United States of America, and also by Dr. Maclaurin, indicate that the yield of good-quality pulp from ordinary scutched fibre is not more than 60 per cent. As 6 tons of green flax would, under very good conditions only, give 1 ton of scutched fibre, this is equivalent to 10 per cent. on the green leaf. Comparing with the 14 per cent. obtainable by direct digestion, it is evident that the mechanical pre-treatment may diminish the yield, and the advantages of better conditions of digestion and better appearance of pulp may be to an extent nullified.

The cost of chemicals for the processing is high, and even if flax could be delivered at the works for 10s. per ton, it seems improbable that bleached pulp could be produced for much less than £18 per ton at the works. (By installation of expensive machinery for the recovery of soda, this cost could be somewhat reduced.) The price of wood cellulose pulp landed in Great Britain, is from £11 to £15 per ton. It is essential, therefore, to know whether phormium pulp is superior to wood pulp for any purposes, and

whether it will command a higher price. These questions must be answered in the affirmative before the manufacture of pulp from flax can be profitably undertaken in New Zealand. It has been claimed that the pulp would have a special value—

(1) For the manufacture of special grades of paper, electrical-insulation paper, card index, &c.
(2) As a strengthening agent, mixed with short-fibred pulps, for paper-manufacture.
(3) For the manufacture of rayon or other similar material.

The only method by which these points can be determined is by preparing high-grade pulp on a semi-commercial scale, and submitting bulk samples to prospective users. This could be done by any group of men who desired to form a company for a moderate outlay, by utilizing the technical service of some reputable pulping laboratory in Great Britain or Sweden, with arrangements for supervision. If paper and other manufacturers agree that flax-pulp so prepared has special properties, as it quite possibly may have, and are prepared to pay a definite price considerably in advance of that of the best chemical wood-pulp, intending manufacturers of flax-pulp could be sure of their position. Without such authenticated knowledge, so-called estimates of profits obtainable by pulping are mere opinions or guesses.

MINERAL CONTENT OF PASTURES.

SIXTH ANNUAL REPORT OF THE MINERAL CONTENTS OF PASTURES INVESTIGATION AT THE CAWTHRON INSTITUTE.

During the past year investigations concerning the control of bush sickness have been continued at Glenhope. In addition, detailed studies have been made concerning the intake of iron by different plants grown in pots under controlled conditions. Samples of legumes and grasses have been collected from different soil types in the Nelson Province, and have been analysed for iron to ascertain what variation in iron content occurred in different species of pasture plants, and the effect of soil type on the iron intake of the plant. Some work has been done concerning the effect of fertilizers and lime on the iron intake of plants, but so far little noticeable effect has resulted from any treatment applied.

Another important investigation dealing with pastures has been the effect of lime and fertilizers on the production of an old-established pasture compared with that of a new pasture sown with pedigree lines of grasses and clovers.

Bush-sickness Investigations.

In the last annual report comment was made on the excellent results which had accompanied the drenching of sheep with Nelson soil, held on bush-sick pastures at Glenhope. Sheep receiving a drench of Nelson soil twice a week have continued in perfect condition, and now nearly two years since the commencement of the experiment, show not the slightest symptom of bush sickness, and could at any time during the last four months have been sold as prime fat sheep. The other sheep which received drench treatment of ferric ammonium citrate, Onekaka limonite, or which remained without drenches, went off quickly in the spring of last year, and by midsummer not one out of the nineteen which were started in these groups remained alive.

The drench experiments have been extended by the introduction of a new line of hoggets taken from healthy country. The sheep were divided into three groups and have received ignited Nelson soil, Whangarei limonite, and a new sample of Onekaka limonite. In each case the drench treatment appears to have proved beneficial, for even as late as the middle of April no symptom of bush sickness has appeared among these sheep. The average live weights of the sheep in these three groups on the 14th April were 97·8 lb. per head for ignited Nelson soil; 100·8 lb. per head for the sheep receiving Whangarei limonite; and 100·5 lb. per head for those receiving the fresh sample of Onekaka limonite.

These three groups will be carried through the winter and coming spring on their respective drench treatments in order to ascertain whether any alteration in health of stock occurs. The average live weight of the older sheep which have received unburnt Nelson soil for two seasons was 141 lb. per head on the 14th April.

Iron Content of Plants.

In previous reports comment has been made on the inaccuracy of many published figures in relation to the iron content of plants, owing to soil contamination. As a result of the much greater iron content of soil as compared with plants, a mere trace of soil contamination is sufficient to increase greatly the figures for iron in plants determined by chemists. Dr. H. O. Askew has made a survey of the iron content in pasture species and mixed samples of pasture taken from different locations in the Nelson Province. Although great care was taken in the collection of the samples, in a few cases the figures determined are under suspicion of being affected by soil contamination. Excluding cases where soil contamination was definitely known to occur, samples of mixed pasture collected from six locations in the Nelson District gave an average iron figure of 0·009 per cent. Fe on the dry basis. The average manganese content for the six samples was 0·104 per cent. The variation found in the iron content of the six pastures mentioned above was 0·0075 per cent. Fe, lowest, and 0·111 per cent. Fe, highest.

Further analyses have been made of the iron content of three pastures at Glenhope taken at intervals during the grazing season. The three pastures comprise typical unhealthy pasture subject to bush sickness, and two healthy pasture types in the vicinity. The average figures for iron in the case of these three pasture types has been found again to be very similar, the figures being 0·006 per cent. Fe for the unhealthy pasture, and 0·006 and 0·007 per cent. respectively for the other two pasture types. These figures for iron are very low in every case, and give no support to the theory that the sole cause of bush sickness is a low percentage of elaborated iron in pasture plants. The average figures for manganese on the three pasture types mentioned above were 0·031 per cent. for the unhealthy pasture, and 0·025 per cent. in the case of the other two types.

Seasonal determinations of iron and manganese have also been made on a typical Moutere Hills pasture at Pigeon Valley where xanthin calculi formation has occurred in the past. A seasonal average for an untreated pasture was found to be 0·009 per cent. Fe on the dry basis, and treatment with lime and super on an adjoining field made no difference to the iron figures which were determined.

A considerable number of samples of individual species of legumes and grasses collected from different pastures has been analysed, with the following results:—

Species.	Number of Samples.	Average Iron.	Average Manganese.
		Per Cent.	Per Cent.
White clover	6	0·012	0·008
Red clover	6	0·009	0·011
Alsike	3	0·009	0·014
Lotus major	3	0·009	0·009
Lucerne..	4	0·014	0·006
Perennial rye-grass	4	0·017	0·009
Cocksfoot	3	0·010	0·025
Yorkshire fog	4	0·009	0·025
Wheat	4	0·010	0·006
Oats	1	0·009	0·007

Results on dry basis.

It is noteworthy that the figures obtained in the above determinations of iron over a range of pasture plants show in every case comparatively low figures for iron, despite the fact that the samples have been obtained from a variety of soils, all of which are free from bush sickness. White clover and perennial rye appear to have a somewhat higher iron content than other pasture species, confirming earlier observations of the Institute on this point. The low figures for iron which have been obtained in this investigation again suggest that the percentage of iron elaborated by pasture plants on different soils does not vary greatly, and indicate the operation of other factors in the incidence of bush sickness. Some observations have been made concerning the effect of maturity of pasture growth on its iron content. The determinations which have been made show that growth cut at the ensilage stage has a slightly lower iron content than that of young leaf growth, and when the hay stage is reached a further considerable drop in the iron percentage occurs.

Effect of Fertilizers on Pasture Production.

Two trials mentioned in previous reports have been continued concerning the effect of fertilizer treatment on (*a*) an old-established pasture which had greatly deteriorated at the commencement of the experiment, and on (*b*) a new-sown pasture containing pedigree lines of cocksfoot and white clover.

In connection with the trials on the old-established pasture using the alternate mowing and grazing method as recommended by Mr. A. W. Hudson, pasture production has slightly exceeded that on the more recently established pasture under similar manurial treatment. Although white clover and a certain proportion of perennial rye is now making free growth on the treated areas of this old-established pasture, nevertheless agrostis species and other so-called inferior grasses are very prominent. The result of this experiment suggests that care should be taken, particularly at the present time, in ploughing up old pastures which by suitable manurial treatment can be so improved in pasture production. In one series of experiments the effect of superphosphate in small, as against large applications has been studied. The results show that under Nelson conditions the use of 1½ cwt. of superphosphate per acre gave on the soil in question, the remarkable increase of 1,200 lb. of dry matter per acre per annum. By increasing the application of super to 3 cwt. per acre an additional increase of approximately 300 lb. of dry matter was obtained. The soil in question is one which is known to be deficient in phosphate, and it is a matter of great interest that the use of 1½ cwt. of super per acre should result in such a large increase and that the effect of still further increasing the application of super should be relatively small.

Another point which is being studied is the effect of dividing the super application in two equal instalments applied in July and December. In the Waikato this procedure has been frequently recommended, and apparently has given satisfactory results. Under Nelson conditions little benefit has been obtained by the application of super in two instalments as compared with the use of the same total quantity in one application during July. Ammonium sulphate has continued to exert a marked influence on pasture growth during the early spring period when applied towards the end of July. An increase of 200 lb. of dry matter per acre has been obtained by the use of 1½ cwt. of ammonium sulphate, but it has been found that after the first season a slumping of production occurs in the mid-summer period, resulting in a slight reduction in total pasture production for the whole season when compared with that of plots treated solely with superphosphate.

The use of potash in these trials has not shown to advantage, and the improvement in yield has not been statistically significant.

Ammonium sulphate used at the rate of 1½ cwt. per acre with superphosphate in the case of the recently established pasture has given a marked increase over the control plots without fertilizers, but the yield so obtained is slightly inferior to that resulting from the application of 1½ cwt. of superphosphate, and the tendency is for rapid falling-off in production with the continued use of the ammonium-sulphate treatment.

General.

During the year under review the following papers have been published or have been prepared for publication :—

No. 20. "The Occurrence of Cyanogenetic Glucosides in Nelson Pasture Plants," by T. Rigg, H. O. Askew, and E. B. Kidson.
No. 21. "The Estimation of Hydrocyanic Acid in White Clover Samples," by H. O. Askew.
No. 22. "Sheep-Ailment in the Westhaven-Cape Farewell District, Collingwood County," by T. Rigg and H. O. Askew.
No. 23. "Sheep-Sickness in the Pakawau District of the Collingwood County, Nelson," by H. O. Askew and T. Rigg.
No. 24. "Soil and Mineral Supplements in the Treatment of Bush Sickness," by T. Rigg and H. O. Askew.
No. 25. "Effect of Sulphate of Ammonia on the Exchangeable Base Status of a Pasture Soil," by H. O. Askew.

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

PAKIHI SOILS RESEARCH.

SIXTH ANNUAL REPORT OF THE PAKIHI INVESTIGATIONS CONDUCTED BY THE CAWTHRON INSTITUTE.

(Period, April 1933, to March, 1934.)

During the past year, owing to reduction in the grant made for the Pakihi investigations, it was found necessary to restrict the experimental work at Sergeant's Hill, and as a result little fresh developmental work has occurred, but the experimental plots already established have been maintained and kept under observation.

Small-farm Trial.

In a previous report mention was made of the establishment of 24 acres of pasture at Sergeant's Hill. This area was sown down in two blocks of 10 and 14 acres respectively. During the first season the 10-acre block sown March, 1932, developed extremely well, and during midsummer provided good grazing for 10 heifers. From December, 1932, to the end of June, 1933, the block provided 118 heifer days of grazing per acre. At this stage stock was removed, the mower was run over the pasture, and it was top-dressed early in August with 2 cwt. of superphosphate per acre. Growth was slow in the spring and grazing did not commence until November, since when it has carried about a heifer to the acre. The 14-acre block sown in March, 1933, although good, was not so satisfactory as the initial block of 10 acres, but it has carried 1 heifer to the acre since January, 1934. Up till the end of May the two blocks, comprising 24 acres, have provided 151 heifer days of grazing per acre, and it is intended to hold 10 heifers throughout the winter. Certain areas on the 24-acre block have been shut up since March to provide winter grazing.

The stock which have been carried on this pasture have done extremely well and have put on satisfactory condition. No difficulty has so far been experienced in handling the stock on the pasture, but it will be interesting to see whether any difficulties are encountered during the bad winter and early spring months when growth on the pakihi pastures is very small.

Onekaka Farm.

At the request of Mr. F. G. Gibbs, observations have been maintained over the pakihi farm established by Mr. Gibbs at Onekaka. Some 72 acres was sown in March, 1932, and as mentioned in the last annual report, a fairly satisfactory take was secured over the whole area. During the first season the pasture was lightly grazed, the number of cattle being increased during the late summer and autumn until 25 head was being carried. During the winter months the carrying-capacity was maintained at this figure until growth commenced in the spring.

In the spring of the second season white clover made rapid development on all the drier areas of the farm, but in the damper situations *Lotus major* was more conspicuous. On certain areas of the farm manuka seedlings have caused considerable trouble and it was found necessary to mow with the horse mower.

In comparison with the growth on the Westport pastures, the Onekaka farm was very forward in grass and clover development, enabling stocking to be continued throughout the winter, and dairy cows to be run during the early spring months. During spring and early summer 16 head of dairy cows and 14 head of dry stock were maintained ; by midsummer the number of dairy cows was increased to 19. The cows have done well and have given nearly 1 lb. of butterfat per cow per day during the summer.

Review of Experimental Plots.

Effect of Lime.—The experiments continue to show the desirability of using not less than 1 ton of ground limestone per acre in the initial treatment of pakihi land for pasture establishment. Smaller quantities than 1 ton, though showing an initial good effect, have resulted in pasture deterioration after the second year. It is interesting to note that even after four years plots treated at the rate of 1 ton of ground limestone per acre still show satisfactory growth of grasses and clovers.

Effect of Phosphate.—The experiments continue to confirm our early observations that the use of 5 cwt. of phosphatic manure per acre in the initial treatment of the land is essential for the best results. Top-dressing established pastures at the rate of 2 cwt. of superphosphate per acre has again demonstrated its value, and where top-dressing treatment has been omitted a marked falling-off in growth has occurred.

Species Trials.—Trials of individual grasses and clovers sown on land treated with 1 ton of ground limestone and 5 cwt. of superphosphate per acre showed in the first year good growth of *Lotus major*, white clover, red clover, alsike and crested dogstail. In the second year there has been a great falling-off in alsike, and improvement in the case of *Lotus major*, white clover, and crested dogstail. Perennial rye, cocksfoot, Timothy, and paspalum when sown separately have done rather poorly. In the case of comparison plots sown with a standard mixture of grasses and clovers there is a noticeable improvement in the growth of grasses over that obtained when the individual species are sown separately.

Shelter-trees.—A large scale trial of different trees and shrubs which might prove valuable for shelter on the pakihi land was commenced at the beginning of the season. Various species of gums, pines, and hedge plants such as privet, barberry, wattle, willow, and escalonia are being tested. So far, the gums, *Pinus pinaster*, *Pinus Banksiana*, and *Pinus Mariana* have done relatively well, but it is too early to express any opinion of their value for shelter under pakihi conditions. In the early plantings made some four years ago, *Pinus densiflora* continues to give the best results, but even in this case it must be admitted that the result is far from satisfactory.

Tobacco Trials.—The light sandy soils of the Onekaka pakihis suggested that tobacco might possibly be grown to advantage in sheltered locations where surface drainage was good. A piece of ground which had been dug over in the previous year was selected for trial with several varieties of tobacco grown in the Nelson District. The land was limed and manured with a suitable fertilizer mixture containing superphosphate, sulphate of potash, dried blood, and ammonium sulphate. Three varieties of tobacco—viz., Hester, Warnes, and Burley—were planted out in November, and made satisfactory growth during the summer. The Warnes and Burley varieties in particular made excellent growth, and the size of leaf compared favourably with good plants grown on the tobacco soils of the Riwaka district. The texture of the leaves of these two varieties was good, and the leaves were remarkably free from physiological spotting and fungus disease. The leaves matured extremely well and gave every indication of high quality if subjected to kiln curing. This result with tobacco is of interest, as it indicates that if shelter was provided selected areas of the Onekaka pakihis might be used for the culture of high-quality tobacco. In the United States of America it has been found that poor sandy soils, almost useless for ordinary farm crops, give high-quality tobacco under suitable manurial treatment.

T. Rigg, May, 1934.

FRUIT RESEARCH.

Advisory Committee: Messrs. H. Vickerman (Chairman), F. Firth, A. M. Robertson, F. S. Pope, H. E. Napier, W. Benzies, T. C. Brash, W. J. Rodger, A. H. Cockayne, J. A. Campbell, Professor T. H. Easterfield, and T. Rigg. F. R. Callaghan, Secretary.

During the year Mr. H. E. Napier and Professor T. H. Easterfield resigned, being replaced by Messrs. A. Robertson and W. J. Moffatt.

General.

The Fruit Research programme has continued as a co-ordinated research activity in which the following organizations participated: Plant Research Station, Cawthron Institute, Horticulture Division of the Department of Agriculture, and the Department of Scientific and Industrial Research. In addition, overseas co-operation in effort has been effected through the Imperial Bureau of Fruit Production, Cambridge Low-temperature Research Station, and East Malling.

Two subcommittees (1) The Fruit Cold Storage Committee, which dealt with all problems connected with the handling, transport, and storage, and (2) the Fruit Research Workers' Committee, which concerned itself with the details of all experimental work. The Fruit Research Workers' Committee has met periodically to discuss these details and to examine the progress attending the various investigations.

The field-work connected with fruit research is conducted at (1) the research orchard of 72 acres, at Appleby, Nelson, 29 acres of which is planted in full-bearing trees; (2) the Tiritea area attached to the Plant Research Station at Palmerston North; (3) the Cawthron Institute orchards, Nelson; and (4) in a series of selected orchards located in the different fruit districts of the Dominion.

1. Orchard.

The trees on the 29 acres planted in orchard are in full use for manurial trials, spray investigations, and are available for propagation, entomological, mycological, and cold-storage investigations by any of the research workers.

Each tree carries a record of the treatment it has received, is subjected to regular measurements and other inspections, its yield of fruit is each season recorded, and data relative to pruning, blossoming, leafage, &c., assembled.

The yield of fruit has been as follows: 1931, 4,600 cases; 1932, 7,620 cases; 1933, 4,233 cases; 1934, 10,300. These figures reveal the biennial bearing characteristic of many of the fruitgrowing areas of the world. Variations in fruit-quality are also almost as marked as the yield itself, the 1933 crop being badly affected with eye-rot, and also inferior, insofar as keeping-quality was concerned. That of the present season is generally of smaller size, and, with the exception of a small amount of

drought core, is free of disease and has the appearance of being of good keeping-quality. The whole of the available trees are now in use for manurial trials, while some 109 spraying trials have been conducted in the orchard. Both the Plant Research Station and Cawthron Institute have made use of the orchard for field trials, and have drawn upon it for materials for laboratory investigations. In the nursery some 600 East Malling selected and 100 Northern Spy stocks have been established, and have now been budded with buds selected from special-type trees of the leading varieties of commercial apples.

Improvements have been effected in the packing and storage sheds during the year. Meteorological records of a type particularly required in orchard research, have been kept, a fully equipped station having been established. Particular interest attaches to the evaporimeter installed by which it will be possible to have some information regarding evaporation in the conditions of the Nelson climate. In view of the investigations to be undertaken shortly upon drought diseases of apples and pears, this information will prove of much assistance.

2. Botanical Investigations.

Stocks.—Girth measurements of some 200 trees of the varieties Statesman, Sturmer, Delicious, Cox's Orange Pippin, and Jonathan, worked on Northern Spy and East Malling Stocks Nos. I, XII, XIII, XV, and XVI, representing thirty stock-scion combinations, have shown to date that those propagated on East Malling stocks are slightly more vigorous. This work is designed to indicate whether improvements can be effected by the more general use in New Zealand of these selected East Malling stocks.

Strains of Apples.—Varietal studies of apples, peaches, and apricots have been commenced. Attention is being focused on the Delicious apple in an attempt to overcome the trouble caused by mouldy core, which is due to fungus growth gaining entry to the core of the apple through the calyx remaining open. Various strains selected throughout the Dominion are now being propagated on the early bearing Jaune de Metz Paradise stock, with a view to ascertaining those which are free from this defect.

Northern Spy Rootstocks.—Five hundred stocks selected throughout New Zealand from very vigorous, normal, and stunted apple-trees have been grown in the nursery, and it has been found that 90 per cent. of these are Northern Spy stocks of a single botanical type. It appears, therefore, that there is no correlation between the three classes of trees and the rootstock upon which they are established.

Experiments have demonstrated that Northern Spy stocks grown from root cuttings, possess a markedly different root system and greater vigour of growth than those secured from layering, which appear weaker and generally shallower. It is obvious that with some of the weaker growing varieties of apples, care should be taken to ensure that these are propagated on vigorous stocks secured from root cuttings.

Standardization of Pear Stocks.—Types of pear stocks are being collected from different parts of the Dominion, with a view to testing for an ultimate system of standard stocks.

Filberts.—With a view to ascertaining the possibilities of commercial growing of filberts, trees developed in the nursery have been sent to different parts of the Dominion for trial.

3. Entomology.

Red Mite: Control by Oil Sprays.—Trials were conducted with twenty-six specially prepared oils on the winter eggs of the two varieties of red mite. *Bryobia praetiosa* eggs were much more readily destroyed than were those of *Paratetranychus pilosus.* Quick-breaking unstable emulsions were found to be much more effective than were stable permanent emulsions made with the same oils. The killing-power of stable emulsions was found to increase with viscosity, but with unstable emulsions a 100 per cent. kill was secured with considerably lower viscosity. Field trials showed that winter oils were most effective against red mite, when applied as close as possible to bud movement in the spring.

Bronze Beetle: Control by Sprays.—Investigations on the control of bronze beetle by sprays has now been concluded. The results show that maximum efficiency is secured by the use of 4 lb. acid arsenate of lead dissolved in 100 gallons of water, the mixture being applied so that a good even "spot" cover is secured. This can be done by applying the spray in a very fine mist. Spreaders and fish-oil detracted from the efficacy of the arsenate, because they induced an undue amount of run-off. Paris Green, while superior in its killing effect, was liable to cause fruit injury. Barium fluosilicate gave the same control as lead arsenate, but caused severe burning of the fruit.

Apple Leaf-roller.—The results of the bait trap experiments during the previous two seasons were incorporated in a graph showing the flight period of the moth in Nelson. Copies of this graph were distributed to Orchard Instructors.

Some further observations have been made on the existing parasites of the leaf-roller and a paper on the most important parasite (*Apanteles*) has been prepared for publication.

Codling Moth.—Graphs showing the flight period of the moth in Nelson during the previous two seasons were prepared and made available to interested persons.

In January, 1934, a second consignment of the codling moth parasite (*Phanerotoma tibialis*) was received from the United States of America. This material consisted of codling-moth larvæ said to be parasitized by *Phanerotoma.* The parasitism must have been very low, as only two parasites emerged from the material. Both the parasites were females and as the product of their unfertilized eggs will probably be exclusively males the prospects for successful breeding of the parasites from this material are slight.

Leaf-hopper.—During the year an effort was made to ascertain the country of origin of the leaf-hopper in order to facilitate the search for parasites. It has been found that this leaf-hopper also occurs in the United States of America and in France. Previously the species was known only from Australia and New Zealand.

Some work has been done on the seasonal history and biology of the leaf-hopper under New Zealand conditions. It was found that a parasite of the eggs of leaf-hopper was already present in New Zealand. Some work has been done on the biology of this parasite, and field investigations show that it exercises a valuable control on the increase of the leaf-hopper.

Arrangements have been made with the Imperial Institute of Entomology for the introduction of other parasites to supplement the work of the egg parasite already present.

A report on the above work has been submitted for publication.

Pear Midge.—During the year an investigation was made of the efficacy of the pear midge parasite in the field at Nelson. The parasite was found to be successfully established and doing good work in the control of pear midge. A short note on this subject has been submitted for publication.

Woolly Aphis.—An investigation of the behaviour of the woolly aphis of apple was commenced during the year. In connection with this work it was desirable to clear up the identity of another species of woolly aphis which is present in New Zealand. This was found to be *Eriosoma lanuginosum*, a European insect which migrates between elm and the roots of pears. The species had not previously been recorded from New Zealand, and a note on its occurrence has been submitted for publication.

4. Mycology.

Fungous Diseases in Cold Storage.—A comprehensive survey of the fungi responsible for fruit-wastage in cold storage has been completed. The fungus responsible for the black discoloration in deep scald has proved to be *Dematium pullulans*. The following fungi constitute those chiefly responsible for storage losses: *Botrytis cinerea* (17 per cent.), *Gloeosporum perennans* (14 per cent.), *Polyopeus purpureus* (15 per cent.), *Glomerella cingulata* (7 per cent.), *Penicillium expansum* (6 per cent.), and *Neofabraea malicorticis* (5 per cent.).

Black Spot investigations have been continued, with the object of reducing the amount of ascospore infection arising from affected dead leaves. In the present season it was found that spore discharge commenced a fortnight earlier than usual, and it is therefore evident that spray schedules will require to be sufficiently elastic to cope with unusual spore discharges, such as occurred in this season, if black spot injury is to be reduced to a minimum.

The infectivity power of spores from different varieties of apples has been tested, and it was shown that considerable variation occurred in this respect. For example, black spot from the Washington apple infected eight of the varieties on which it was tested, while that taken from Granny Smith or Lord Wolseley had a range of not more than four varieties.

Botrytis.—Investigation of the secondary fungi occurring in the calyx region of apples affected with eye-rot have revealed that some twenty different species are found there.

Strawberry Leaf-spot.—Comparative trials of the leaf-spot resistance-power of New Zealand and English varieties of strawberries have shown that local varieties, especially Perfection, resist this disease better than any imported types.

5. Spray Investigations.

(1) *Nicotine Production in New Zealand.*—A number of varieties of tobacco have been grown and harvested with a view to ascertaining their nicotine content suitable for insecticide purposes, and to ascertain whether this quality is affected by topping or by infection with mosaic. Samples will be submitted to chemical analysis.

(2) Analyses of the commercial sprays at present on the New Zealand market have been completed, and cover sulphurs, lime-sulphurs, arsenates, nicotines, and petroleum oils. This work has been written up in a series of reports, which have appeared in the *New Zealand Journal of Agriculture*. This work has brought to light a great deal of new knowledge of the actual behaviour of spray specifics, much of which has been dependent upon their physical and chemical nature, and their reaction to vegetation, insects, and fungi. Adoption of modifications which the present researches have suggested has resulted in improved control of a number of serious orchard-pests.

(3) Over one hundred plots were set aside at the Research Orchard for field trials of sprays designed to deal with black-spot, red mite, leaf-roller, and codling moth. On these, various sulphur compounds, copper-sulphate mixtures, summer and winter oils, and other specifics are under test. The results of these field trials are the subject of separate reports which have been or will be issued. The objects of these trials has been the improvement of standard sprays, reduction in concentrations, and alterations in periods of application, following on the chemical tests carried out in the laboratory.

6. Manurial Trials.

In the trials conducted at the orchard where replicated plots have been treated with nitrogenous, phosphatic, and potassic manures, the first year's definite trials have yielded no differences in the weight of fruit produced. The following summarizes the results secured in the different varieties of apples included in the trials:—

Cox's Orange.—Nitrogen improved foliage growth and colour; exerted no influence upon eye-rot or field-pit, and in storage did not modify susceptibility to breakdown or true storage bitter-pit. Phosphates and potash, in conjunction, effected a slight reduction in internal breakdown and fungous diseases in cold storage.

Dunn's Favourite.—Nitrogen improved foliage colour and growth, 4 lb. ammonium sulphate per tree giving greater response than 2 lb., but former amount appeared excessive, because it induced more breakdown and fungous disease in storage; no increase in skin cracking was caused, this disorder being most prevalent on the fruit of trees growing in clay situations. Phosphates, potash, and lime (2½ tons per acre) gave no response.

Jonathan.—Nitrogen improved foliage growth and colour, but reduced red coloration on fruit; breakdown and fungous disease in storage was intensified, and the fruit seemed also more susceptible to deep scald. Concentration of nitrogen in a circle of diameter 6 ft. round the trees gave best results, while spring dressings (August, September) appeared to give slightly better results than autumn (April) applications.

Delicious.—Nitrogen improved foliage growth, and colour especially on poorer soils; no adverse effects were produced in so far as incidence of disease or storage behaviour were apparent. Phosphates and potash gave no visible effects on the fruit of this variety.

Sturmer.—Nitrogen improved foliage colour, increased lateral growth, and did not affect leader growth. It also delayed leaf fall by about a fortnight. No difference upon disease or storage behaviour was apparent. Phosphates and potash did not appear to exert any visible influence upon either trees or fruit.

Girth and pruning-weight measurements have also been made of all varieties receiving different manurial treatments. These have shown distinct varietal differences. For example, Cox's Orange responded best to a complete manurial treatment, Dunn's to nitrogen applications, and Sturmers to phosphate.

In various fruitgrowing areas throughout the Dominion some sixty-three manurial trials are being conducted. The following are some of the results which have been secured:—

Apples.

Auckland: In two experiments the influence of applications of lime is being shown in increasing the growth of lotus angustissimus between the trees and in another improvements in the colour and density of foliage have appeared where nitrogen has been included.

Hawke's Bay: Manures appear to have exerted no appreciable effect beyond an improvement in association with complete manuring.

Mapua: The response to manures has been small, except where nitrogen applied to Dunn's Favourite has improved foliage colour and density and has changed the sequence of the "on" and "off" bearing years.

Canterbury: No fertilizers appeared to give significant results in this district.

Otago: Nitrogen was the only fertilizer to yield any difference which was noticeable in the improved vigour and growth of the trees. In one instance lime also appeared to effect improvements.

Peaches and Apricots.

Nitrogen dressings gave consistently improved vigour and better foliage colour. It appeared also to improve slightly the frost-resistant power of these trees. Potash also gave good results in one Otago district.

Lemons.

Have responded to dressings of nitrogen, phosphates, and potash applied individually, and have given most response to dressings of complete manures. Applications of lime have consistently increased the yield per acre, and reduced the amount of fruit rejected because of poor quality.

A general review of the present position of the fruit-tree manurial trials reveals—(1) The almost universal response to nitrogen by way of improved tree vigour and foliage colour, especially marked in soils of low fertility; (2) the absence of response to phosphates; (3) a small and irregular response to potash; (4) some slight advantages arising from use of lime; (5) a tendency on the part of nitrogen to detract from fruit appearance, resistance to disease, and storage quality.

Chemical analyses of leaves and fruit are being undertaken to ascertain what influence manurial applications have upon their composition.

FRUIT COLD-STORAGE RESEARCH.

Advisory Committee: Messrs. J. A. Campbell (Chairman), R. Sutherland, W. Benzies, F. W. Grainger, T. Rigg, H. G. Apsey, L. W. Tiller, A. M. Robertson, Dr. M. A. F. Barnett, and F. R. Callaghan.

The fruit cold-storage investigations during the past year were carried out on lines similar to those of previous years, but with this difference, that the scope of the work was extended. This was possible through the establishment and functioning of a consultative group in London, which comprised representatives of shipping, research, and trade interests, and aims at facilitating overseas transport experiments. In consequence of the activities of this committee it has been possible to arrange for special dunnage experiments, which constituted a new feature of cold-storage research activities during the year.

A large-scale trial with the tower system of dunnage was therefore conducted aboard the s.s. "Nebraska," the hold carrying the fruit in which the tower system of dunnage was used, being equipped with twenty-four distance recording thermometers, which will enable a complete picture of the temperature distribution throughout the cargo to be obtained. The fruit carried in this consignment will be subjected to critical examination by both commercial and research authorities in Great Britain.

Contact has still been maintained with the Cambridge Low-temperature Research Station, which has rendered invaluable service in the examination of experimental cargoes of fruit, and by furnishing reports to New Zealand upon the out-turn of the experimental lines, so that there is being accumulated a store of most useful information which will enable improved transport of fruit to be made possible.

The co-operation between the Fruit Cold Storage Committee, the Cambridge authorities, and the consultative group, has demonstrated the value of such an organization, as a means of following through fruit right from the orchard to the English consumer.

During the year the following cold-storage factors were studied in connection with apples of the Cox's, Jonathans, Sturmer, Granny Smith, Delicious, and Dunns varieties :—

(1) The influence of locality and soil type upon keeping-quality.
(2) Maturity at the time of picking in relation to quality and to such diseases as bitter-pit, scald, and breakdown.
(3) Packing, in relation to bruising and fungal rotting.
(4) Handling.
(5) Wraps and pads, in regard to bruising, general keeping-quality, and scald.
(6) Delayed storage, transport, temperature, and irrigation, in their relation to general keeping-quality, and to the occurrence of pear mould.

The pear investigations cover the varieties Winter Nelis, Winter Cole, and Louis Bon de Jersey.

With passion-fruit, the influence of wraps, packing-material, surface treatments, and storage conditions, were under investigation. With peaches, investigations were carried out with Pullar's Cling, Goodman's Cling, Wiggins, Million Dollar, and Akarana varieties, in regard to their respective factors influencing keeping-qualities.

Plums.—Doris and Grand Duke plums were stored at specified temperatures, and subjected to a transport test to ascertain the possibility of the export of these varieties to British markets. Both varieties showed that they were able to maintain condition well throughout the voyage to London.

Lemons.—Lemons were stored under different conditions, with a view to ascertaining the most suitable conditions for this purpose.

The nature of the season was such as to reduce all storage troubles to a minimum, with the exception of those associated with physiological conditions. In consequence of a period of dry weather, during maturation, a fair amount of drought spot, an internal browning of the flesh, was found in those varieties of apples susceptible to these troubles. In addition in the Cox's variety, bitter-pit appeared in some of the early season's pickings.

The raising of the transport temperatures overseas, which was last year recommended to be raised to 36-37° F., in the case of Cox's and Jonathans, again has shown up to advantage, even though this season's fruit was remarkably free from storage troubles.

The fruit cold-storage work is conducted in cold stores at Auckland, Wellington, and Nelson. In the Nelson cool stores the investigations are largely concerned with the influence of manures and storage temperatures upon the keeping-qualities of the main export varieties of New Zealand apples.

Reports have been issued and published in the *Journal of Science and Technology*, *Journal of Agriculture*, and the *Orchardist*, relating to a number of the cold-storage investigations upon which progress reports were desirable.

LEATHER RESEARCH.

Advisory Committee : Messrs. J. E. Astley, A. E. Lawry, J. Garton, W. Donovan, F. Johnson. Director of Research : Mr. P. White. Assistant : Mr. F. G. Caughley.

During the year under review, at the request of the manufacturers, much closer contact has been maintained between the laboratory and the factories. The Director of Research has visited the tanneries much more frequently than in previous years. This has curtailed the amount of research work carried out on specific problems. On the other hand, it has increased the number of actual works problems investigated. From the industrial point of view, this alteration of the programme of work has been immediately beneficial, and may ultimately prove of greater value than if a regular programme of research work had been carried out.

One very gratifying result is the increased interest which is being shown by the workers in the tanneries in the scientific aspect of leather-manufacture.

Chrome Leather.

Continuing investigations of the processes used in the manufacture of chrome leather, this year particular attention was devoted to fat liquoring. In order to set a standard of what good fat liquoring could do, and what defects incorrect methods might produce, a large number of commercial samples were examined. This examination included analyses for penetration of fat, total amount of fat present, and amount of fat fixed in the leather. The results obtained from this work showed quite definitely that some of the qualities associated with good upper leather are directly related to the fat liquoring, thus emphasizing the importance of this process. The conditions necessary to obtain the best results in this process were determined both as regards penetration of fat, and the total amount of fat present in the leather.

A brief survey of the different fat liquors used was carried out in their relation to water-proofing qualities, size of the break of the grain, and the degree of fixation of the fat. A result of this work has been a modification of the fat liquors used by the firms which are associated with the Research Association.

Mechanical Effects.

It was stated in the last annual report that "fibre structure is probably more closely allied to the qualities of the finished leather than is the chemical composition as revealed by the present system of analysis." It has been shown in pelt research that the fibre structure of leather can be definitely altered by the mechanical methods used in the various processes. In chrome-leather manufacture, the tanning process is usually carried out in drums. The speed of the drums was found to be a very important factor not only as regards the speed of tanning, but also in the fibre structure of the tanned leather. More important than the speed of the drums is the effect of tacking or stretching on fibre structure. Unless proper care is exercised, it is quite possible, by this process, to turn a good fibre weave into one of a very poor weave. Other processes, such as setting and slaking were found to be of much less importance than those just mentioned.

Sole-leather.

An extensive investigation was carried out to determine the action of acids present in sole-leather on the threads used in the manufacture of boots and shoes. Certainty in the estimation of acid in leather is a very debatable point, and in spite of the large amount of work given to the subject, international agreement on this subject has not yet been reached. It is a recognized fact that acids will destroy vegetable fibres under definite conditions, and the presence of very highly ionizable acids in leather was found to be deleterious as far as sewing-threads were concerned.

During the year several complaints were received about the wearing-quality of New Zealand sole-leather. Some of these were obviously in connection with leather which had been deleteriously affected by heat. The usual analytical tests—viz., those of hide substance, water solubles, tanning ratio, fixed tan were shown to be of no value in determining with a fair degree of certainty whether the deterioration of sole-leather was due to inferior leather or due to maltreatment.

The amount of soluble nitrogen in the leather was found to be a fairly reliable method of showing whether a worn sole had been damaged by heat. The investigation carried out showed that the acidity of the original leather determined to a great extent the amount of heat which it would stand without being burned or soluble nitrogen liberated.

Investigations of other complaints revealed the fact that many users of leather know little of the basic qualities which make leather the valuable material that it is. Sometimes one good quality seems to be a drawback because its presence seems to impair another good quality. For example, the porosity of leather reduces its resistance to the absorption of water. It is the aggregate and balance of qualities which should be the determining factor not only in assessing the value of the material, but also in the method of treating it. Leather is a very complex material of biological origin, and because of this complexity it can be used for so many different purposes.

More attention has been given during the year to control of the different processes used in the manufacture of leather.

The measurement of pH or the effective acidity of the various liquors used in tanning is very necessary, and the installation of the glass electrode for measuring pH has been of great use in extending this important method of works control.

Tanning-barks.

During the year a 4 ton bulk sample of the bark of the Kamahi tree (*Weinmannia racemosa*) was obtained from Southland. The tannin content from an average sample was found to be 25·0 per cent. with a non-tannin content of 5·1 per cent. The colour of the tannin solution was reds, 8·2; yellows, 18·0. The intensity of the colour was very readily reduced by slight bleaching with sulphur dioxide, and then became reds, 3·8; yellows, 7·0. The colour of the leather produced by the unbleached solutions was slightly darker than that given by mimosa-bark, and the bleached solution gave a pale pinkish leather. Provided economic conditions do not operate unfavourably against the production, it should be possible to use the bark of this tree in the manufacture of tanning extracts.

Monthly circular letters and the usual activities with routine work have been maintained during the year.

PELT RESEARCH.

The manufacture of leather is a series of processes which often may appear to have no relation to each other. For example, a skin is limed, and the next process is to remove the lime. However contradictory the processes may seem, they are all part of a balanced whole, and if at any stage the balance is upset, the result will be seen in the finished leather.

The processing of sheep-skins in the preparation of pickled pelts is but a stage in the manufacture of leather. Hence it will be seen that the processes used should be of such a nature as to fit in suitably with the subsequent tanning operations. If this does not happen, then inferior grades of leather will be produced from the pickled pelts.

Some of the causes affecting the quality of the skin are (1) feeding under different climatic conditions, (2) different types of food, (3) length of the wool when the animal is slaughtered, (4) the age of the animal, (5) the general health of the animal, (6) more especially the breed of sheep. Skins of all types and conditions pass hurriedly through the fellmongery, and, of necessity, get practically the same treatment.

Other conditions affecting the processing of the skins, over which the fellmongery has little or no control, are those due to the atmosphere, and the irregular supply of the raw material. The peak load is sometimes much greater than the capacity of the works. The necessity of preventing accumulations of pelts which are easily damaged by putrefaction or by chemical means demands that the skins shall be preserved or pickled as soon as possible.

The object of the fellmonger should be to place the pickled skins in the casks with the fibre structure in as near the original condition as possible. During the year some of the conditions which may affect the fibre structure of the skin during its process through the fellmongery have been investigated. Of these, the following were found to be the most important:—

(1) Strength of paint used.
(2) Composition of the lime liquors.
(3) Speed of the paddles.
(4) Temperature.

The essential factors to be considered are: (1) Orderly progress in the liming process, and (2) reduce as much as possible the rate of swelling.

An interesting feature has been to watch the effect of the growth of wool on the fat content of the skin. As the wool grows the fat content drops. After shearing the fat content rapidly increases, probably to a maximum, and then gradually decreases. These variations may be expected to exert some influence upon pelt quality.

During the year a conference of fellmongers and works chemists was held to discuss the problems which are familiar to all pelt-producers. This was probably the first meeting of this nature held in New Zealand, and proved to be a great success. The value of practical men meeting and openly discussing their own particular difficulties and the methods adopted to cope with the day-to-day problems cannot be overestimated. Many problems were discussed which may have been somewhat outside the scope of the purely scientific side of pelt research. On the other hand, practical difficulties are always present and practical solutions of them are necessary. It is the broadening of outlook, the interchange of ideas and experiences, rather than the discussion of any specific problem.

The reports from the London Committee on the trial shipments of pelts were very full and comprehensive. It is very fortunate that there is an organization in England who will give so readily of their time and work to the consideration of the problems under investigation. One of the main points of these reports is that attention must be given to every detail in the different processes. A slight alteration in a process, which should not have taken place, may alter the value of the trial, no matter how carefully the test is carried out.

The trial shipments sent to England this season have been very carefully supervised. As far as possible all the conditions have been standardized in the directions required. Unfortunately, as mentioned previously, economic and other conditions will not allow of complete standardization. To illustrate this point, shorn and unshorn animals were being killed at the same time. Shearing affects the quality of the skin to a very great extent, and so the inherent quality of the skins in some of the trials was not strictly comparable. It is hoped that by careful tabulation of such discordant factors some further information may be obtained from what might have appeared to be contradictory results.

Considering the year's work from the commercial aspect, progress has been made, for it was the considered opinion of the tanner members of the London Committee "that the trial shipments under consideration showed definite improvement in quality on those of the previous year." Evidence has again been obtained that better processed pelts are commanding better prices and more ready sales than those of inferior quality. As soon as this fact is more thoroughly realized, then will there be a greater support and desire for information not only of the processing of pelts, but of factors such as the effect of nutrition and seasonable variations on the quality of the skin.

It is desired once again to record the fact that the grant from the old Empire Marketing Board has made it possible to conduct the work on a larger scale than otherwise would have been possible.

SOIL SURVEY.—FOURTH ANNUAL REPORT.

During the year the chief activities of the soil survey were (1) the continuation of the detailed soil mapping in the Waipa County, and (2) a reconnaissance survey of the plains of the Ashburton County.

The field-work in the Waipa County has been carried out by Messrs. N. H. Taylor and L. I. Grange (in the field for only a short period), assisted by field hands, the majority of whom drew part of their wages from the Unemployment Board. Mr. L. I. Grange carried out the survey of the Ashburton County, where he was assisted by Mr. K. G. Manchester and by several field hands, a portion of whose wages were paid by the Unemployment Board and the Ashburton County Council.

At the commencement of the field season, Messrs. Grange and Taylor mapped the soil types in the area lying between Opunake and Kaponga, thus completing the reconnaissance survey of Western Taranaki.

Messrs. Grange and Taylor made preliminary investigations for one of the dairy companies on flavour in butter in relation to soil types in the Hauraki district.

Mr. Taylor prepared a report on the soils of the suppliers to the Rukuhia Cheese-factory (Waipa County) at the request of the Director of the Dairy Division of the Department of Agriculture.

FIELD WORK ON SOILS OF ASHBURTON DISTRICT.

(By L. I. Grange.)

From the beginning of February to early in May the writer was engaged in making a soil survey of the plains of Ashburton County, an area of 1,080 square miles.

The plains of Ashburton County are part of the Canterbury Plains. The Rakaia River forms the northern boundary and the Rangitata the southern boundary of the area described. Midway between these rivers is the Ashburton River, and between the Ashburton and the Rangitata is the Hinds, the courses of all these rivers being roughly parallel.

In classifying the soils consideration had to be given to (1) climate, (2) the origin and mode of deposition of parent material, and (3) vegetation. As is well known, the climate of the plains is not uniform. South of Lauriston, Westerfield, and Carew the rainfall averages between 25 in. and 28 in., whereas in the belt lying between these settlements and the foot of the Southern Alps the rainfall is between 33 in. and 45 in. A line through the towns mentioned form an arbitrary boundary of the two rainfall belts—no doubt the change to the higher rainfall is gradual. Ashburton County, like other portions of the Canterbury Plains, is subject to warm dry winds of high evaporating-power. Again, the plain rises gradually from the seacliffs to the foothills. At the seacliffs at the mouth of the Ashburton River the plains are 65 ft. above sea-level and gradually rise inland till at the foothills they reach, in places, a height of 1,500 ft. With lower temperatures on account of height above sea-level, the soils of the higher portions of the plain suffer less from evaporation than the coastal belt, and consequently in the former area there must be a higher percentage of the rainfall available for leaching. Thus the Ashburton lowland can be divided on climate into two main belts, one with a low rainfall and high evaporation, and the other with a moderate rainfall and high evaporation, which, however, is less than that of the low rainfall belt. From the moderate rainfall belt is separated the belt lying close to the foothills of the Southern Alps, where temperatures are fairly low.

The soils of the plains are derived practically entirely from greywacke. The plains consist of a series of coalescing fans of greywacke gravel formed by the Rakaia, Rangitata, and Ashburton Rivers. They were mainly built up during the Pleistocene glaciation. The gravels consist of tightly packed subangular pebbles with coarse sand filling the interspaces. While the gravels were being deposited, the winds carried rock flour from abandoned channels of the braided rivers, and deposited it on the neighbouring hills and upland surfaces. Such deposits, which are called loess, mantle the mature surfaces standing 150 ft. or more above the plain at the back of Mount Somers. Probably towards the close of the glacial period the rivers started to entrench themselves on their fans. Although entrenched, the rivers remained in braided channels and the north-westers which swept down the mountain gorges carried dust from the river-beds on to the wide areas lying between the rivers. The building-up of loess deposits on the interfluves continues to the present day. As is to be expected, the loess is thickest and coarsest in texture near the banks of the rivers. Several miles north of Rakaia Township the loess is 15 ft. thick, and thins to 12 in. at eight miles away from the river. While the loess was being deposited the Ashburton and Hinds Rivers overflowed their banks, and deposited alluvial sediments mainly of a loamy texture.

With these data it is possible to consider further the classification of the soils. The soils are all of the same geological origin, so that factor does not enter into the classification, though important in considering the soil process operating in the Ashburton County. The age factor comes in; the old loess at the back of Mount Somers must be classed differently from the young loess deposits, as it has been subjected to more leaching. The mode of formation allows of two broad divisions within the climatic belts: (1) The loess deposits, and (2) the alluvial deposits. The recognition of loess deposits aids in the mapping of soil-textures, for it is to be expected that such deposits will maintain a uniform texture over fairly wide belts, trending parallel to the rivers.

Vegetation is a simple consideration, for the native vegetation was low tussock, matagauri, scrub, &c., except for small areas of forest at Alford Forest and Starcly, near the foothills. The soils under the forest, which occupied about 10 square miles, are much lighter in colour than those under tussock vegetation, and hence have to be classed separately. There are differences in humus content of the soils of the tussock area, due to the density of the vegetation. Where shallow loess rests on gravel, the soils are lighter coloured than where the loess is thick.

Further factors in classification are depth of loess, or alluvial material, on the gravel, and the texture of soil and subsoil. The gravel having a coarse sand matrix, is very porous. Shallow soils on the gravels dry out more readily than do the deeper soils. The minimum depth of loess on the gravel is about 9 in. Depth to the gravel is, of course, more important in the low rainfall belt, where the moisture even under optimum soil conditions is low for crops other than grain. Texture plays an important part; for one thing the moisture-holding capacity largely depends on it.

The soils have been divided into fifty-five types. The alluvial soil types occupy about a quarter of the total area.

The finer-textured alluvial soils in the low rainfall belt are loams and clay loams, which, in places, have a total depth of as much as 6 ft. A profile at Wakanui is—

9 in. to 15 in. dark-grey clay loam;
12 in. creamy-yellow clay loam;
3 ft. (+) sandy loam.

At Eiffelton the clay loams are low lying, and were originally badly drained. The subsoil is lighter in colour, and there is, in places, iron-staining. A hard iron pan has formed in the clay loam to the east of Eiffelton. Small areas of peat and peaty loam ranging in depth up to 3 ft., occur at Willowby, Blackbridge, and Lowcliffe. Occupying a little less area than the loams are silts and stony silts, which are in general shallow. The stony silts to the south of Tinwald average about 13 in. thick. Silts near the coast southward of the Ashburton River are a little thicker than the Tinwald silts, but are bleached owing to the former presence of a high ground-water level. The sands which occur close to the rivers are mainly more than 3 ft. thick.

The loess in the low-rainfall belt ranges between 9 in. and 15 ft. in thickness. The profiles show some similarity; the top 6 in. to 9 in. is darkened by humus, the colour ranging from light brown to nearly black, the subsoil being yellowish brown. The subsoil is usually compact. A wide area of loess, 9 in. thick, lies between the Ashburton and Hinds Rivers, extending from Winslow to near Valetta. The profile is—

6 in. brown stony silt loam or silt;
3 in. yellowish-brown stony silt loam or silt;
On gravel.

Between the Rangitata and Hinds Rivers, below Hinds Township, the loess is about 10 in. thick, and its texture is that of a silt loam. Towards the foothills from Hinds, the loess contains more clay, and ranges in thickness from 12 in. to 18 in.

From the Rakaia River, below Rakaia Township, across to Wakanui and Ashburton Township, the loess ranges in thickness from 10 in. to about 20 in. and is divided into four types, which run in strips parallel to the rivers. The widest strip extending from Wakanui to Pendarves embraces the loess of an average depth of 10 in. The soil is a silt loam, and contains more clay than that near Winslow or below Hinds. Nearer the Rakaia is a strip in which the loess is 18 in. thick and of similar texture to that of the preceeding area. This is followed by a narrow strip with loess 20 in. deep and of a silt loam texture, somewhat coarser than that of the two former areas. Close to the river the loess is about 18 in. thick and is a sandy loam. Towards the foothills from the above areas, but still in the low-rainfall belt the loess ranging in thickness from 13 in. up to 15 ft., is divided into several types.

In the moderate rainfall belt (excluding the area close to the foothills) the most important alluvial deposits are those extending from above Methven south to the Ashburton River. The general profile is—

11 in. dark-brown clay loam;
4 in. yellowish-brown clay loam;
On clay loam.

The alluvial deposits bordering the Ashburton and Hinds Rivers cover a much smaller area than those in the low-rainfall area, and they are chiefly sands.

The loess deposits are, in general, thicker than in the low-rainfall belt, ranging from 17 in. to more than 6 ft., the bulk being between 17 in. and 24 in. Their texture is that of a silt loam, except close to the Rakaia River, where the texture is that of a silt. As judged from the feel, the silt loams contain more of the clay fraction than do their representatives nearer the coast.

The soils in the narrow belt against the foothills are practically entirely derived from loess, which is from 18 in. to more than 3 ft. in thickness. All the loess deposits on the plain in this belt, except those originally under forest, give rise to one type of soil. The forest soils on the plains are devided into two series, depending on drainage. The soils of the old loess deposits on the mature uplands against the foothills are divided into two series, one originally supporting low tussock and the other forest. The soils of both these series are more weathered than those of the plain, and contain more clay, the subsoil being a clay loam.

A check on the mapping of soil types was provided by (1) compiling a map showing unimproved values* of each farm in the area surveyed, and (2) obtaining from farmers their views on the variation in yield of crops and in stock-carrying capacity on their farms. The valuation map records the relative production of each farm. It is of most use where the soil types cover a fairly large area. From both these checks it was found that the soil types are fairly closely related to production. It must be emphasized that production is used as a check and not as a method of mapping soil types.

Most of the farming on the plain of Ashburton County is mixed, being of the wheat-sheep type. The highest yields of wheat—40 to 45 bushels—are obtained on the deep alluvial clay loams and loams of the low-rainfall belt, on the alluvium strip running through Methven in the moderate rainfall belt, and on the thick loess deposits bordering the Rakaia. The thin loess deposits give small yields, and in some cases are unsuitable for this crop. Where the loess averages about 10 in.—between Pendarves and Wakanui—wheat yields average from 22 to 24 bushels. On the loess extending from Winslow towards Valetta, and south of Hinds, no wheat is grown. In the moderate rainfall belt wheatgrowing is chiefly confined to the thick loess deposits between the Ashburton and Rakaia Rivers.

Sheep are carried on all farms, except those devoted to dairying. The carrying-capacity corresponds roughly with the wheat yields. The alluvial clay loams of Wakanui carry about three ewes to the acre. The thick loess above Rakaia Township carries two to three ewes; loess 20 in. thick near Rakaia, one and a half ewes; the loess 18 in. thick nearer the Ashburton River, one ewe or slightly more; the loess 10 in. thick between Pendarves and Wakanui, three-quarters ewe; and the loess 9 in. thick between Winslow and Valetta, one-half to three-fifths ewe.

Dairying is carried on to a small extent on the clay loams of Eiffelton and Flemington, which were originally badly drained, and most of the originally forested area at Starcly is used for dairying.

The differences in yield and carrying-capacity are due to several factors, the main one in the low-rainfall belt no doubt being the moisture factor. The shallow loess deposits appear to be the most deficient in moisture in the dry weather. They have no reserves of moisture in the subsoil.

Tests made by Mr. F. T. Seelye, of the Dominion Laboratory, show that the subsoil of the low-rainfall area contains a negligible amount of soluble salts, the quantity being only slightly in excess of that in the subsoil at Methven in the moderate rainfall area.

* This check was suggested by Dr. I. W. Weston, Farm Economist, Lincoln College.

The soil-samples collected during the progress of the survey have not been analysed for plant-foods. Samples analysed by Aston* indicate that the soils of the Ashburton district are fairly well supplied with phosphoric acid. Nevertheless, there is a general response by the pastures over the whole district to dressings of lime and superphosphate.†

The soil map will form a basis for (1) irrigation investigations, and (2) a farm-practice survey.

The irrigation of the low-rainfall area is now being considered. Information is already being obtained by other workers on the cost of bringing the water to the farms, and on the probably increase in yield and carrying-capacity on an irrigated farm located at Seafield, which is on the thin loess strip between Pendarves and Wakanui. The soil-type map allows of a definite plan being laid down for determining the moisture-holding capacity—field capacity—and duty of water. Field-capacity and duty-of-water figures obtained in a couple of localities on a soil type will apply over the whole type. The writer laid down some irrigation experiments on the shallow loess deposits at Seafield and Fairfield, between Pendarves and Wakanui, near Winslow, and on the thick loess deposits north-west of Rakaia Township. At Seafield small plots were irrigated with 2 in., 4 in., and 6 in. of water, and at the other localities 6 in. The weather was unfavourable as rain sometimes fell within a few days after the plots were irrigated. Tentative conclusions are that field capacity is reached—*i.e.*, the gravity water has drained away three days after irrigation. At field capacity the silt loam at Seafield and Fairfield contains about 21 per cent. of moisture, whereas the silt loam at Rakaia contains about 20 per cent. of moisture. The minimum irrigation to attain field capacity in the Seafield soil is between 2 in. and 4 in.

The soil survey is of use to the investigators on irrigation farms for it is a means of telling over what areas their results are applicable.

Some investigations on farm practice on the main soil types is being undertaken by Dr. I. W. Weston, Lincoln College.

FIELD-WORK ON SOILS OF THE WAIPA COUNTY.

(By N. H. Taylor.)

During part of this field season a further 33,000 acres of the soils of the Waipa County have been mapped. Approximately all that part of the county lying north of a line from Ngahinepouri to Kaipake has now been examined.

Geology.

The geology of the county was outlined in last year's annual report. The following additional data gathered this season are of assistance in the understanding and the mapping of the soil types.

Six miles south of Hamilton the rolling hills are covered with a volcanic ash which overlies the ash that forms the soil on the hills in the northern part of the county. This ash is very similar to the Mairoa ash which covers the rolling hills near Otorohanga and is tentatively correlated with it. Near Rukuhia Settlement the ash is thin and patchy, but south of Ohaupo it is 2 ft. to 3 ft. deep, and covers all but the steepest slopes.

Stretching from Frankton to Ohaupo is the Rukuhia Swamp, an area of partly drained peat land, covering more than 15,000 acres. The swamp appears to be very flatly dome-shaped, being higher in the centre than near the edges. The higher central part of the swamp which is formed of peat, more than 30 ft. deep, supports a dense growth of manuka. Nearer to the margin are lower-lying areas supporting a carpet of rushes. Around the margin of the swamp where the peat has shrunk after being drained or where it has been burned, stumps and logs of a former rimu forest are exposed. The average width of this border of stumps is about 30 chains.

Before it was invaded by the Waikato River, the site of the Rukuhia Swamp was an area of low relief lying between two higher northerly trending ridges. The presence of beds of sand and gravel show that the river entered the area from the east near Rukuhia Settlement, and flowed to the south and south-west, building its fan across to the Waipa River at Ngahinepouri. Later the river turned north along its present course, and built-up beds of gravel near Hamilton, across the north end of the low-lying area. In the basin thus formed the peats of the Rukuhia Swamp accumulated.

Soils.

The soil types mapped this season are mainly those described in the last annual report. Four additional soil types have been recognized:—

Ohaupo Silt Loam.—The Ohaupo silt loam, which covers the rolling hills to the south and west of Rukuhia Settlement, is derived from the volcanic ash of the Mairoa Shower (?). The topsoil is dark brown and has a free very fine crumbly structure; the subsoil is light brown and has the same free fine structure as the topsoil. This soil is well drained and friable, but it appears to be very retentive of moisture, for pastures on it do not dry out in the summer months.

Rotokauri Loam.—The Rotokauri loam is the soil in many of the swampy arms that extend into the rolling hills. It is derived from sediment washed from the ash-covered Ohaupo Hills. It is very similar to the Rotokauri clay loam which occurs in similar positions in the northern part of the country, but is much lighter in texture.

Whatawhata Clay Loam.—The Whatawhata clay loam is best developed near the banks of the Waipa River at Whatawhata and in the Ohote Valley.

* B. C. Aston: "Phosphates," Bull. No. 48, N.Z. Dept. Agric., p. 18; 1914.

† A. W. Hudson and A. Y. Montgomery: "Pasture Top-dressing experiments in Canterbury," *N.Z. Jour. Agric.*, Vol. 41, No. 5, pp. 343–49; 1930.

A typical profile is—

6 in. dark-grey crumbly clay loam;
12 in. compact light-brown clay loam;
On whitish clay loam—speckled light brown.

In the lower-lying areas the light-brown subsoil is absent, and the whitish layer underlies the grey topsoil. This soil is derived from debris deposited by the Waipa River, as that river built up its bed, keeping pace with the fan-building of the Waikato. As the Waipa River flowed more slowly than the Waikato and gathered its debris from a greater variety of geological formations, the Whatawhata soils are finer in texture and have greater natural fertility than the Horotiu and Te Kowhai soils.

(?) *Kahikatea Peat.*—A mile east of Ngahinepouri more than 1,200 acres of flat land is covered with about 2 ft. of a dark-brown powdery peat. This peat has probably accumulated under kahikatea forest. It is very friable throughout its whole depth, and does not dry out in summer as do the peats of the Rukuhia Series. In all localities examined it supports much better pastures than are generally seen on other types of peat.

An attempt is being made to subdivide the peats of the Rukuhia Swamp, and with this object a vegetation map of the swamp is being prepared. An analysis of the peat from near Rukuhia Railway-station shows it to be more decomposed than many of the peats now farmed in Europe.

Relation of Farm Practice to Soil Type.

Every soil type has some quality which causes the farmer to modify his methods, if he wishes to obtain the best results. In the Waipa County, where the country is for the most part flat to gently rolling, the rainfall plentiful and well distributed, and the temperatures mild, dairy-farming is an established practice on every soil type, and thus the relationship between farm practice and soil type is not so striking as it is in districts where the farming activities are more diverse. The following brief account of conditions on the main soils indicates the type of relationship that exists at present.

The *Hamilton* soil is a heavy well drained, warm soil but little affected by frost. It provides a large amount of early spring and late autumn feed, but dries out in the summer or early autumn months. Most farmers on it make ample provision for supplementary feed for use in summer as well as winter. Where, however, the soil has been heavily top-dressed with phosphate, the pasture withstands the dry weather much better. In its virgin state the soil can be cultivated at certain times of the year only, for in wet weather it becomes extremely tenacious and in summer it bakes hard. Under careful cultivation, however, it breaks down to a fine tilth. It grows good root crops and many stands of lucerne are situated on it.

The *Horotiu* soils are light and well drained. The pastures come away early in spring, but they become parched in spells of dry weather. During November the pasture grows rapidly and from this excess growth ensilage and hay are made to provide feed for the dry summer months, and for winter. The soil is friable, and easily cultivated, but the large numbers of weeds that thrive on this soil in the spring have deterred many farms from cropping it. It grows lucerne well; in fact, all the lucerne seen was either on the Hamilton or the Horotiu soils. On account of the spring weeds, some farmers prefer to sow lucerne in the early autumn.

This soil, because it is well drained and light, does not pug up in wet weather, and the sand and gravel that lie below the soil provide a ready supply of metal for yards and gateways. Thus farms on this type are clean and free from mud and are the most suitable for winter dairying.

The *Te Kowhai* soils must be drained before they are suitable for dairying. Open drains are generally maintained close to the fences and tile drains or their substitutes are laid down in some of the fields. The drainage practice, however, seems to be largely a matter of guesswork, and probably more could be produced from these soils if the drains were scientifically planned along the lines followed on many meadow soils in Europe. As the soils are damp the pastures do not commence to grow in spring until about three weeks later than those on the Horotiu soils, and the flush is also later, and not so pronounced. The pastures do not dry out during summer, and consequently farmers on these soils do not generally give supplementary feed during the summer period. It may be said that during periods of dry weather cows pastured on the Te Kowhai soils are producing butterfat from grass while those on Horotiu soils are producing it from ensilage.

In Autumn, the Te Kowhai soils, being charged with moisture, cool slowly and the pasture often continues to grow after the pastures on the Horotiu soils have ceased. Excellent crops of swedes are grown on this soil.

It will be readily seen how well suited for dairying are farms which enclose areas of both the Te Kowhai and the Horotiu soils.

The *Whatawhata* soil is similar in many ways to the Te Kowhai soils, but although it has a greater natural fertility, it has some undesirable qualities which they do not possess. Owing to its compact and heavy nature, it is more difficult to drain. The spring growth is earlier than on the Te Kowhai soils, but there is a tendency to dry out somewhat during the summer months. During winter this soil pugs up under heavy stocking, and on this account some farmers have ceased dairying on this soil, and are now fattening sheep.

The *Rukuhia* peats, where they are farmed at all, are usually poorly farmed. On most farms the peat is so deeply drained that during summer it suffers from drought. In winter the frost lies heaviest on the peat lands and pasture growth during the colder months is extremely small. Under these conditions farming is difficult. Some few farmers have established fairly good rye and clover pastures. The main essentials seem to be careful levelling of the field, fairly liberal initial dressings of lime and fertilizer, control of the water-table, and trampling by stock to consolidate the surface.

The drying of peaty colloids is in part an irreversible process, and once peat is allowed to dry thoroughly it does not readily rewet, but forms a light dry porous mass known to farmers as "puffy top." If some practicable method of controlling the water-table could be adopted, many of the difficulties attending the farming of these peats would probably disappear.

Several farms in the area mapped are used solely for the fattening of sheep, and the rearing of fat lambs. These farms are situated mainly on the Hamilton, Horotiu, and Whatawhata soils. Stud sheep are bred on the Horotiu and Hamilton soils, but the hoggets are difficult to rear on the Te Kowhai soils.

The urgent need of all the soil types for phosphates has led to the belief in some quarters that superphosphate is the only top-dressing that it is economic to apply. Working in co-operation with officers of the Soil Survey, the Department of Agriculture is laying down trial manurial plots on typical areas in order to investigate the effect of lime, phosphate, and potash top-dressing on each soil type mapped.

RESEARCH SCHOLARSHIPS.

Two national Research Scholarships, with an annual value of £100, were awarded during the past year. The holders of these scholarships, and the researches upon which they have been engaged, are as follows:—

K. M. Rudall, Massey Agricultural College: "Zoology of the fleece of Romney sheep."
M. S. Carrie, Otago University: "Karakin."

"NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY."

The *New Zealand Journal of Science and Technology* has been issued at two-monthly intervals. The journal has published reports from different branches of the Department, and from researches carried out during the year by the staff of the Department, and by others engaged in research work in other institutions in the Dominion, reprints from the *Journal* have been used on an extensive scale to disseminate the knowledge of the results of investigations, and have also been made particular use of by industrialists.

IMPERIAL AGRICULTURAL RESEARCH BUREAUX.

The Department has continued to act as the co-operating link between the eight Imperial Agricultural Research Bureaux, whose headquarters are centred in Great Britain, and each of which has its own local representative in New Zealand. The value of these Bureaux has been demonstrated amply in New Zealand by the regular issue of important reports, and by digests of research work done in every country of the world. Workers in New Zealand are thereby kept in touch with researches in progress overseas, and this information has, in a large number of cases, proved of the greatest use.

PIG-RECORDING, PORK, AND BACON.

The Department has continued to facilitate the tests arranged with experimental shipments of pork carcasses overseas. During the season some half-a-dozen lines of experimental carcasses have been shipped, and these have been critically examined and scored by Dr. Hammond, and Messrs. Davidson and Swain. Details of the marks allotted to each carcass have been forwarded to the Waikato Pig-recording Club and to the Manawatu-Oroua Recording Club. The scores have been illustrated by photographs, showing both the characteristics of the carcasses and of the cut joints, so that a very complete idea of the actual nature of the carcasses has been conveyed to the producers in New Zealand.

PUBLICATIONS.

During the year five new bulletins were published apart from publications elsewhere, as follows:—

No. 40: "Gold-bearing Conglomerates of Central Otago," by E. O. Macpherson.
No. 41: "The Relation of Storage Temperature to the Overseas Carriage of Some Further Varieties of New Zealand Export Apples," by L. W. Tiller.
No. 42: "Third Annual Report, Wheat Research Institute, 1932–33," by Dr. F. W. Hilgendorf.
No. 43: "Hawke's Bay Earthquake of 3rd February, 1931," by F. R. Callaghan, M. A. F. Barnett, Dr. C. E. Adams, Dr. J. Henderson, Dr. P. Marshall, and others.
No. 44: "The Commercial Ripening of Bananas in New Zealand," by J. B. Hyatt and C. W. O. Turner.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

I. Plant Breeding.

(*a*) *Cereals.*

1. *Wheat.*—Variety trials carried out in co-operation with the Wheat Research Insitute have now been brought to a conclusion, and the following recommendations were made regarding the principal varieties at present grown in Canterbury :—

Victor yields 3 to 4 bushels better than Tuscan, but its baking score is seven points lower, and therefore it should not be grown except for fowl-wheat.

Solid-straw Velvet yields ½ bushel better than Tuscan, but its baking score is a little lower. It is perhaps therefore just equal to Tuscan in value, but it has no outstanding merits ; its use would confuse the seed position, it is viewed with disfavour by millers, and therefore it should not be grown.

Major yields very slightly better than Tuscan and its baking score is nearly the lowest of all wheats tested. It therefore should not be grown.

Tuscan is the standard. Its yield is satisfactory over a wide range of conditions and its baking score, although not high, is fair. It should be retained as the standard wheat especially for windy districts.

Hunters yields practically the same as Tuscan and its baking-quality is consistently higher. It should therefore be grown somewhat more widely, especially where shaking by wind is not the limiting factor.

Dreadnought is poorer than Hunters both in yield and milling-quality and has nothing to recommend it, at least from Waimate northward.

Yeoman, Velvet, Marquis, and Garnet : Although their baking-quality is satisfactory or very good, yield 5 to 10 bushels less than Tuscan, and therefore can only be grown profitably in special localities.

Further investigations of Cross 7 and Jumbuck varieties have been conducted, and it has been made clear that Cross 7 is a distinct improvement on any variety now grown in New Zealand. 32 acres of this variety will be grown this year, and the seed made available for commercial distribution during the 1935 year. Jumbuck has given a low bushel yield per acre, but its other qualities render it a desirable variety for further investigation.

Soil-moisture investigations are being continued, and the records correlated with wheat yields, it being anticipated that in a few years time sufficient data will be available to enable yields to be forecasted earlier and more accurately than is the case at present.

The trial of the effect of the practice of "feeding-off" wheat with sheep gave the following results :—

(1) No rudimentary heads were destroyed by the feeding, as they were discovered on the main shoot still an inch below ground-level.
(2) A fortnight after feeding the number of tillers was equal on the fed and non-fed plots.
(3) The fed-off plots ripened about a week later.
(4) They were about an inch shorter.
(5) They were slightly more erect.
(6) At harvest there were fewer plants per foot of coulter row on the fed-off plots, this showing that there was some damage due to feeding.
(7) Probably, as a result of 6, there were more heads per plant, and a greater yield per head in the fed plots.
(8) The yield of the two series of plots was the same, whether this was deduced from the analyses of yield constituents, or from the actual threshing returns.

2. *Oats.*—An investigation on the rate of seeding of Algerian and Garton oats, where the seed was carefully spaced at different distances in rows, gave the following results :—

(1) Different varieties, owing to their different growth habits, have different optimum spacings which may be low as in Algerians or high as in Gartons. Therefore, in yield trials the sowing of an equal number of seeds of each variety does not necessarily place all the varieties on an equal footing.
(2) Once the optimum spacing is reached the yield does not increase or decrease with thicker sowings up to the ½ in. spacing used in this trial.

Pickling of Algerian and Garton oats with Ceresan, bluestone, and formalin for the control of smut, showed that bluestone significantly lowered the yields of both varieties, formalin had little effect on yields, and Ceresan, while not affecting Algerians, materially increased the yield of Gartons.

A pickling trial to ascertain the influence of Corona copper carbonate, Tepapapa copper carbonate, Smutol, Uspulin, Ceresan, and formalin, upon the yield of wheat, and the control of ball smut, indicated that all were completely effective as controllants of this smut, while untreated seed was affected to the extent of 16 per cent. of the heads.

The copper carbonates Smutol and Uspulin gave a significant increased yield of about 10 per cent. while formalin and Ceresan, depressing the germination, lowered the yield slightly. As the ground was very dry when the seed was sown, this had an influence on depressing the germination on formalin-treated seed.

(b) Herbage Plants.

Rye-grass.—Seed from sixty crossings of perennial rye-grass has been harvested and sown for the establishment of progeny tests. Some of the families in progeny tests from the 1931 crop, which showed strong immunity to rust attack, have apparently subsequently lost this characteristic.

Cocksfoot.—A poor yield of seed from the area devoted to strain C 23 was obtained, this being due to unfavourable weather conditions.

II. Animal Nutrition.

Experimental work on pig-feeding on selected diets has been continued, and the trials have shown that the 100 lb. live-weight increase was most readily secured by a daily diet of 3½ lb. of barley, ½ lb. meat-meal, and a small amount of minerals. A comparison between the standard English diet, comprised of 60 per cent. barley, 30 per cent. pollard, 7½ per cent. meat meal, 2½ per cent. minerals for the first six months, followed by one of 70 per cent. barley, 20 per cent. pollard, 7½ per cent. meat-meal, and 2½ per cent. minerals for the last period of feeding, compared with the New Zealand mixture of barley and meat-meal, indicated that almost similar results were secured from these two diets.

When pork is 5d. a pound, barley about 4s. a bushel, and pollard £6 10s. a ton, milk shows a gross return of 1¾d. to 2d. a gallon.

Sheep-feeding Trials.—Small flocks of sheep have been grazed on plots, which for the past six years have been top-dressed with different fertilizers alone and in combination with lime. The most significant increases have been obtained from the use of animal manure. Liming has also given significant increases, and also has combination of lime and potash.

The trials are not on a scale to be conclusive, but the results show that a comparison of lime versus no lime on a larger area, is certainly worth while, particularly if it can be possible to carry the stock for two or three generations on this treatment.

Trials with flocks of well-fed ewes and lambs, compared with rather poorly fed flocks, have shown that the former treatment gives a yield of 12 lb. more lamb per ewe than did the latter. While this involves doubling the cost of winter feed, the annual returns per ewe under either method are almost identical, but the well-fed flock was in much better condition at the end of the trial, and the manurial residues from this flock, being of superior value, constitute two further factors to which consideration must be given.

III. Veterinary Research.

(*a*) *Pulpy Kidney.*—Large-scale experiments have shown that pulpy kidney of lambs may be attributable to deficiencies in the diet of the ewe before lambing, which have rendered the offspring more susceptible to digestive troubles and to pulpy kidney.

(*b*) *Teeth-defects.*—Microscopic and chemical examinations of the defective teeth of a large number of ewes have been made, with a view to ascertaining what part this plays in stock health.

(*c*) *Wheat and Sorrel Poisoning of Sheep.*—An examination of the contents of the alimentary system of horses and sheep affected by wheat poisoning, have shown that these are toxic to healthy animals, and ways and means have been devised for detecting the difference in symptoms produced by milk-fever and sorrel poisoning in ewes.

(*d*) *Blindness in Sheep.*—A number of the causes of blindness have been examined, and it has been shown that some forms of this trouble are infectious, and in this class is road blindness, which is popularly associated as being caused by dust.

Treatment of affected animals with cod-liver oil, rich in vitamin A, gave rapid cures. It is now suspected that the diet may be responsible for precipitating large outbreaks, and causing delays in recovery.

(*e*) *Lung-worm Disease.*—The incidence of this disease has been particularly serious, some farmers losing thereby 50 per cent. of their hoggets. Results from treatments recommended have been variable, and it is felt that a survey of the different types of worms is urgently needed.

IV. Entomology.

Entomological investigations comprised continuation of the Codlin-moth research, work on parasites of sheep, and weevil damage to wheat.

V. Farm Economic Research.

Header-harvester costs in Canterbury for the 1933–34 season have been compiled, and costs of production for the main farm-products over a large number of farms are being regularly assembled.

Work is proceeding in connection with methods of keeping farm accounts, and information gathered for the purpose of forming associations to facilitate this work being more generally done among farmers.

A survey of farm management in the Springs County has been completed, and is now being published.

VI. Manurial Experiments.

Plots to which super, super and sulphate of ammonia, Leunophos, Nitrophoska, and lime respectively have been applied, have been subjected to regular monthly mowing treatments, and the mowings carefully weighed. All the manures were applied at the rate of 1 cwt. per acre, with the exception of lime, which was used at the rate of 5 cwt. per acre.

Conclusions from the present figures indicated that the time of application of super does not appear to have affected very much either the total increase over control or the seasonal increase during the year.

October applications of manures gave unexpectedly poor results in January and March, where the anticipated response should have been marked.

January applications showed a good response in late autumn and winter to all treatments, while April applications gave easily the best winter growth; especially where super and sulphate of ammonia were used the result continued over a fairly long period.

The use of nitrogenous manure for quick response was supported by the figures, while lime produced an excellent growth during late summer and autumn.

VII. Engineering.

Irrigation.—Experimental areas designed to show the influence of irrigation, are in operation in a number of localities throughout Canterbury, while special attention has been devoted to the Seafield trial area under the control of the Lands and Survey Department.

Work has proceeded at Canterbury College in regard to a simpler method of expressing the mechanical analysis of soils.

VIII. Wool Research.

The weighing of fleeces has continued, designed to reveal what influence breeding can exert upon the yield of wool.

Consideration is being given to methods of determination of which fleece should be taken for comparison, indicative of any change following upon the results of breeding and selection methods adopted.

Owing to the adverse season, quite a fair percentage of all the wool in the experimental flock showed some signs of tenderness. In the well-fed flock nearly 10 per cent. were cotted, and about 50 per cent. were tender.

Further work has proceeded with branding-fluids, tests being carried out with new fluids prepared by the Wool Industries Research Association, Leeds. A locally prepared fluid, containing casein, ammonia, lamp-black, and oil gave almost as satisfactory results, but the scouring tests were not on a sufficiently complete scale to justify any conclusive opinion being reached.

IX. Farm Advisory Service.

For the year ending 31st March, 1934, the work of the Farm Advisory Service has been continued along the lines adopted in previous years. The service provides for (1) the complete control, (2) the partial control, (3) special advice, and (4) occasional reports on farm-management of farms located within the Canterbury district. The object of the Service is to extend to farmers new knowledge which has been gained as the result of investigation and research, and to apply this new knoweldge in a way which will enable the whole farm to be run as an economic unit. It therefore involves the building-in of new knowledge into farm management and practice. The Service is arranged in such a way as to enable research work on farm-management to be undertaken, and in this respect has proved a valuable source of information in regard to farm costings and actual returns.

During the year twelve farms have been under complete control, sixteen under partial control, and thirty-eight farms have received special advice on particular problems. In addition, complete management and financial reports have been prepared for eight farms. In the farms under complete control there is a variety of types covering almost all classes of farming and types of soil in Canterbury. In all, these farms cover over 5,000 acres.

Detailed management and financial returns in each farm have been prepared, and in every case where there has been a full measure of co-operation with the advisory officer, the financial returns have been improved, so that on most of the farms it has been possible to resume interest payments which, in many cases, had ceased for a number of years past. It is therefore evident that a combination of improved farm-management, together with the utilization of all recently acquired knowledge in regard to pastures, stock-feeding, &c., will go a long way towards improving the financial return from farms, and even during the present economic depression, enable partial, if not complete, interest payments to be made.

The demand for the Advisory Service is increasing year by year, and the information gained by past experience is being assembled and will be utilized for providing guidance in all instances where difficulties are being experienced in the conduct of farming.

DOMINION LABORATORY.

The work of the Laboratory consists mainly of chemical analyses and investigations carried out for various Government Departments. The numbers of samples received in Wellington from Departments and their branches are as follow: Customs, 231; Police, 98; Geological Survey, 129; Main Highways Board, 172; Mines, 639; Health, 3,279; Post and Telegraph, 55; Research, 87; Public Works, 81; Railways, 46; Stores Control, 18; Agriculture, 45; Defence, 17; Prisons, 20; Government Printer, 65; External Affairs, 39; other Departments, 47. In addition to these, 43 samples were received from municipal and other public bodies and 234 from miscellaneous sources, making a total of 5,345.

The totals for the branch laboratories are: Auckland, 2,647; Christchurch, 2,568; Dunedin, 1,663.

Customs.—The majority of the analyses made for this Department were for use for tariff purposes. Several samples, such as cream of tartar, flour, malt-extract, malt and cod-liver oil, and iodized salt were examined to ascertain if they complied with the regulations under the Sale of Food and Drugs Act.

Police Department.—A large number of samples, 651 in all, were examined at the main laboratory and the three branches during the year.

Numerous beers were analysed in connection with sly-grog charges and samples of liquor, &c., in cases concerning the illegal manufacture of whisky.

Many exhibits were examined in connection with cases of suspected poisoning. The following poisons were found in various instances: Strychnine, zinc, veronal, aconite, luminal, prussic acid, mercuric chloride, carbolic acid, carbon monoxide, arsenic, and lysol.

The proportion of alcohol in urine was determined in a case of death through alcoholism and blood was examined for alcohol in connection with cases of intoxication.

Several analyses were made of counterfeit coins and of materials for their manufacture.

A number of medicinal preparations used for illegal purposes were examined and also suspected opium.

Department of Health.—Milk: 7,587 samples were examined and, with some exceptions, were of satisfactory quality. The statement in the previous year's report to the effect that the quality of the milk supplied is in marked contrast to the state of affairs which existed prior to the enforcing of the provisions of the Sale of Food and Drugs Act, applies also to the year under review.

Water: 264 samples from existing and projected town supplies were examined. In view of the increased possibility of pollution of streams, this work is becoming of greater importance from year to year.

In addition to the above, numerous foodstuffs and many drugs were examined. In the majority of cases they were found to be of good quality. A number of samples of lime-water examined were, however, defective.

A special investigation was made of enamelware. It was found that with several brands dangerous amounts of antimony could be dissolved from the enamel by acid foodstuffs, and that they were therefore unsafe for culinary use.

Mines Department.—The work carried out for the Mines Department has consisted chiefly of the testing of prospectors' samples from all parts of the Dominion, analyses of coal from the State Coal-mines, and examination of mine-air from numerous collieries for noxious and inflammable gases, on behalf of the Chief Inspector of Coal-mines and his staff.

Work having as its object the rendering of concrete impervious to sulphide and sulphated mine-waters underground has been continued, with a fair amount of success. Ready means for the detection and estimation of sulphuretted hydrogen in mine-atmospheres have been further investigated. Regular and systematic work on special properties of New Zealand coals has not been possible since the disbandment of the Coal Research Association two years ago. It is gratifying, however, to note, as a result of the briquetting investigation carried out by the association, that a commercial plant has been erected near Christchurch for the briquetting of slack coal.

Government Stores.—Many samples were analysed in connection with the purchase of Government stores by the Public Works, Post and Telegraph, Stores Control, and other Government Departments. These include paints, galvanized iron, lubricating and fuel oils, soap, shellac, rope, bronze, special materials for use in hydro-electric plants and numerous other supplies.

Several investigations were made of cases of corrosion.

Gas-inspection.

The gas-supplies of the four main centres and principal towns were regularly examined for calorific value, purity, and pressure, and almost without exception were of satisfactory quality.

Research.

Incidence of Goitre.—The medical and chemical work in connection with this research has been completed, and the report is in the hands of the printer.

Fuel.—An investigation is in progress with the object of ascertaining the chemical composition and possible commercial uses of the low-temperature tar produced at the Waikato Carbonization Co.'s works at Rotowaro.

Spray Research.—The chemical work required by the Plant Research Station for this research has been continued. Special attention was devoted to an investigation of the amount of nicotine in tobacco-leaves, the methods for determining nicotine being carefully examined. Seed disinfectants were also analysed.

Pyrethrum Flowers.—Samples of flowers from pyrethrum, *Pyrethrum cinerariæfolium*, grown in the North Auckland District, were examined for pyrethrin content, which is a measure of their insecticidal value. Flower-heads grown from the Dalmatian variety of pyrethrum were found to contain 0·33 per cent. of total pyrethrins, and a specimen of flowers from the Japanese variety contained 0·74 per cent. total pyrethrins. The Japanese variety has been introduced into America, where it is growing successfully and could no doubt be grown similarly in New Zealand.

Ragwort.—Preliminary work has been undertaken with a view to isolating and characterizing the chemical nature of the poisonous principle present in ragwort (*Senecio jacoboea*). This has shown that an alkaloid in the crude state can be isolated to the extent of some 0·15 per cent. from the air-dried plant. The work is being continued in order to obtain larger supplies of the pure alkaloid to enable the carrying-out of physiological tests and an exact study of its chemical nature and properties. It is not definitely known whether the alkaloid is actually responsible for the poisoning of stock by ragwort.

Kauri-gum.—The standardized resin obtained by the solvent process worked out in this Laboratory is in the form of a dry granular powder, entirely free from foreign material. Reports received from European manufacturing firms who were supplied with bulk samples, indicate that a ready market awaits the purified gum. Specimens of various grades of crude kauri-gum have been investigated as to their solubility and behaviour when put through the purifying process. Experiments on the esterification of the pure material are proceeding. Samples of resin associated with lignitious coal from Otago and Southland were on examination found to be kauri-resin of high melting-point. The extent of the resin-bearing beds should undoubtedly be determined.

Sodium Chlorate.—In view of the increasing importance of sodium chlorate as a weed-killer, especially against ragwort, a report was prepared on the manufacture of this chemical with reference to the possibility of producing it locally. There would be some saving in freight by importing sodium chloride, and converting it to chlorate by the electrolytic process, but a further saving, especially for a small plant, seemed possible by distributing the substance in the form of a concentrated solution. An estimate of the cost of production indicated that at present prices chlorate might be made economically in this country. A method was outlined for preparing a concentrated solution suitable for transport. It would also be possible to use the solution to slake quick-lime producing a dry powder, which mixed with a further amount of ground limestone, or fertilizer, would be suitable for dry dusting, a method that has been found to give good results, and has certain advantages over spraying. These processes are the subject of an application for a patent.

Soil Research.—The work carried out in the Laboratory has again proved of great assistance to the members of the Geological Survey Staff in classifying soils in areas under examination.

Advisory and Consulting Work.

The Director of the Laboratory and other members of the staff have been frequently requested to advise regarding chemical subjects or to report on industrial processes of which they were considered to have special knowledge.

W. Donovan, Dominion Analyst.

GEOLOGICAL SURVEY BRANCH.

REPORT OF DIRECTOR (DR. J. HENDERSON).

During the year ended 31st May, 1934, the Director was some three weeks in Otago Central examining gold workings at Hamilton's, St. Bathan's, Cromwell, and Waikaia. He also visited Waihi, Hamilton, and Mahakipawa.

Mr. M. Ongley continued his examination of the Eketahuna Subdivision, where he mapped about 350 square miles; some 50 square miles of this district still remain to be examined.

Mr. H. E. Fyfe from June to December, 1933, examined most of the old gold diggings along the west coast of the South Island between Westport and Okarito. He also visited several alluvial mining centres in the Grey and Teramakau Valleys, and, to assist in the interpretation of magnetometer data, spent several days at the Baton Goldfield, near Nelson, and in the Upper Matakitaki Valley, south from Murchison. During 1934 Mr. Fyfe was in the Amuri district where, assisted by Dr. Marwick, he mapped in detail about 175 square miles.

Mr. J. H. Williamson continued the systematic examination of the Naseby Subdivision, mapping 510 square miles, chiefly in the southern part of the Maniototo depression. A map of the subdivision is included with Mr. Williamson's report.

Mr. E. O. Macpherson devoted his whole time to the study of alluvial deposits in Otago Central and Southland, visiting St. Bathan's, Cromwell, Arrowtown, Skipper's, Shotover, Round Hill, Orepuki, Waikaia, and Lawrence. At several localities his investigations were made chiefly in order to direct the geophysical party in selecting the most suitable sites for their tests and to help in the interpretation of the data.

Mr. L. I. Grange, the officer in charge of the Soil Survey, and Mr. N. H. Taylor continued the detailed mapping of the soils of Waipa County. For several months, however, Mr. Grange was engaged on reconnaissance work in the Ashburton district. The reports on the investigations of these areas are contained in another section of the report of the Department of Scientific and Industrial Research.

During the year the annual report and Bulletin No. 34, "The Geology of the Dargaville-Rodney Subdivision," by the late Dr. H. T. Ferrar, were issued. Other reports, articles, and reviews written by officers of the Geological Survey appeared in the *New Zealand Journal of Science and Technology*, as follows: "The Geological Aspects of the Hawke's Bay Earthquakes," by J. Henderson; "Manganese Deposits, Bombay," and "Bentonite and its Occurrence in New Zealand," by H. E. Fyfe; and "The Gum-land Soils of North Auckland," "Visit of Dr. H. T. Stearns, of Hawaii, to New Zealand" (review), and "The Soils of Australia in Relation to Vegetation and Climate" (review), by L. I. Grange.

Last year Mr. G. E. Harris drew seven maps and twelve blocks for photographic reproduction as well as a number of graphs, sections, &c. He prepared twenty-two field sheets for different officers and coloured many prints, &c.

A heavy correspondence on matters more or less closely connected with the work of the Geological Survey was attended to, and many specimens of rocks, minerals, and ores were examined and identified.

Little except periodicals and exchanges was added to the library.

EKETAHUNA SUBDIVISION.

(By M. ONGLEY.)

Eketahuna Subdivision lies on the east coast of the North Island between 40° and 41° south, extending 45 miles along the coast approximately from Cape Turnagain to Castle Point and 50 miles inland to the Tararua Mountains. It includes 1,700 square miles. In 1930 J. H. Williamson and M. Ongley began work in the north-east, in 1931–32 H. E. Fyfe, J. Marwick, and M. Ongley carried on, in 1932–33 J. Marwick and M. Ongley, and in 1933–34 M. Ongley.

The East Coast, of which the subdivision is a part, contains some places that yield traces of oil, and many that yield gas, facts which have induced investigators to drill in search of the oil that was judged to lie below. The bores did not strike oil. Hence before any more attempts are made, it is desirable to find out as much as possible about the underground structure and the general geology of the district. It is safe to say that the information already gained shows that the holes at Waipatiki, Tane, and Tawataia (six miles east of Eketahuna) were bored in unfavourable places.

During the past season the writer working alone mapped 350 square miles in the south-west of the subdivision—that is, the country near Alfredton, Eketahuna, Mauriceville, Bideford, &c., and nearly to Masterton.

TOPOGRAPHY.

The west of the subdivision includes part of the Tararua Range, 2,500 ft. to 3,000 ft., rising by several steep steps from the low alluvial flats of the upper Wairarapa Plain that lies 500 ft. above sea-level. The mountains and ridges trend east of north parallel with the main faults and folds. The foothills east of the Tararua Range are carved from a series of narrow northward-trending blocks tilted gently westward. The angles of the blocks make two acute re-entrants into the range at upper Mangatainoka Stream and Bruce Stream. Another greywacke ridge diverges off through Mount Bruce (c. 1800) and Mount Munro (1,500 ft.), and is continued under a thin cover through Mount Hansen (1,300 ft.). The depression east of this block is conspicuous below the mountains mentioned,

and extends northward up Mangaone Valley and along the Tiraumea across the subdivision. Another parallel fault depression runs along the railway at Kopuaranga and Mauriceville. East of this is the limestone capped ridge through Snowden (1,800 ft.) and Rioux (1,600 ft.) which, after a break of eight miles, continues through Tane and Makahikatea (1,100 ft.), Waikuku (1,700 ft.), and the west flank of the Waewaepa Range. Three miles east of this another limestone ridge runs through Rangitumau (2,000 ft.) and Perry (1,000 ft.); and three miles farther east is the sandstone ridge through Dodgshun (1,300 ft.) and Cap (1,300 ft.), which joins up at the north-east with Tintock (1,600 ft.), Gibson (1,700 ft.), &c. East of this another greywacke ridge extends twenty miles across the subdivision and forms the west flank of Tinui syncline described last year.

The position of the Ruamahanga River deserves study. It has previously flowed through Masterton and will tend to do so again.

Structure.

In the part examined this season the exposures of the undermass of greywacke reveal that the country consists of long narrow blocks of greywacke with a cover of Tertiary elongated north and south, gently tilted towards the west and broken off at steep escarpments on the east. This structure is easily seen by looking north or south over the country when the asymmetrical ridges appear with a steep and high escarpment on the east and a long gentle back slope declining gradually away westward. On looking east one sees the gentle slopes; and on looking west, the escarpments. In the Tararua Range the blocks are of greywacke, in the foothills of the range they have a thin cover of high Tertiary beds, and farther east the cover is thicker and includes lower Tertiary and Cretaceous beds.

Economic Geology.

During the season three more samples of gas were obtained from Tertiary beds, and on analysis by the Dominion Analyst they were found to be methane, and therefore not indicative of the presence of oil. In fact, it may be said that the season's work confirms the general conclusion that away from the Cretaceous rocks traces of oil are lacking.

Soils.—The geological formations mapped are too big to give the detail required on a soil map, but they give the broad outlines. For example, on the maps all the alluvial soils are shown as one formation as distinct from the residual soils. Similarly it is easy to pick out on the maps what districts carry greywacke-derived soils, seeing that these, though of several types, are grouped in one formation.

Water.—In parts of the subdivision, particularly on the thin soils of the upper Cretaceous white rocks and of the low Tertiary sandstone and on the gravel plains, the small streams and lagoons dry up in the summer, and the soils parch. Low clay embankments across the heads of the streams would generally trap good supplies of water, and in the gravel plains and along the valley bottoms water nearly always flows at the rock surface under the gravel.

Road-metal.—The west and especially the south-west of the subdivision have abundant supplies of gravel derived from hard greywacke. Many of the other patches of greywacke supply metal nearby, but in many places no good rock is known. Near Pongaroa the white argillite in the upper Cretaceous is found satisfactory. In several places a Lithothamnium limestone that occurs low in the Tertiary is used, as at Cook's Nose in Tautane, and near Ti Tree Point, Pongaroa, and Tinui. Mudstone has been burnt in several places for road-metal. Gravel from the present river-beds and the old fluvial gravels near Pahiatua have been used. Coarse Tertiary conglomerate of greywacke boulders is quarried in two places along the Mangaone Valley. No good gravel has been found on the coast.

Limestone.—The subdivision has huge deposits of limestone, some fairly remote, some beside the railway. Thick limestones form the crest and west slopes of the Puketoi Range for twenty-one miles south from the north boundary, and, after a gap of eight miles, run on again for twelve miles to the Wairarapa Plain.

Limestone also forms the west slopes of Waewaepa Range, trending west of south for sixteen miles to Tane Trig. This bed is sharply bent and broken west of the Tiraumea River, and farther south-west is turned up into a syncline at Pahiatua Trig. Beds of limestone occur on the low hills west of the railway at Pahiatua, Konini, Kaipararo, Ngarara Trig., Matahiwi, &c. On the east coast Castle Point and Cape Turnagain are both formed of limestone. Limestone forms outliers on the hilltops at Cook's Nose, Ti Tree Point, Pongaroa, Tinui, and Langdale.

Beside these Tertiary limestones poor argillaceous limestone bands are common in the Mangatu formation.

Limestone is being quarried and ground for agriculture at Mauriceville on the railway-line, also to a small extent at Makuri and Tinui.

Coal.—Many beds of coaly matter less than an inch thick streak the sandstone on the coast south of Castle Point. Poor carbonaceous shale occurs at the contact of the greywacke and the Tertiary sandstone at Waitawhiti in Puketoi Survey District, near the contact west of the railway at Mauriceville, and at several other places. None has any value.

Clay.—Bricks have been made from the local clay at Tinui and Rangitumau, and clay suitable for bricks can be got throughout the subdivision; but, as fuel is wanting, it is not used. Bentonitic clay occurs in the Mangatu formation north of Cape Turnagain and along Tinui Stream, but has not been sampled.

AMURI SUBDIVISION.

(By H. E. Fyfe.)

Field work was resumed in the Amuri Subdivision in mid-January and continued till the end of May. From March to the end of the season Dr. Marwick collected from several fossiliferous localities and assisted with the field-work. The 175 square miles mapped are within a strip north of the Hurunui from its mouth to the Kaiwara junction, and east of a line from this point to the Oaro Mouth.

Structure.

The main highland mass within the area is the Hawkswood Range of which Mount Wilson (3,725 ft.) is the highest point. A fault extends along the greater part of the west side of this elongated rectangular greywacke block. This fault, which has been traced from the Oaro Mouth to a point east of Parnassus, is well exposed in the Te Kahika and Hundalee Streams and in the Conway Valley. A few chains along the road to Kaikoura from the Okarahia Bridge the greywacke is thrust eastward over Pliocene conglomerates and sandstones. The block pitches northward between the Oaro and Amuri Bluff, where the greywacke forms the core of an anticlinal fold in Cretaceous and Tertiary rocks.

Cretaceous and Tertiary rocks flank the western base of the Hawkswood block from a point east of Parnassus, and are exposed along the valley of the Jed where they wrap round the greywacke core in a south-west plunging anticlinal fold. South-east of this anticline lies the Gore Bay syncline. The rocks forming the south-east limb of the syncline rest on the greywacke block of Mount Seddon as shown in the sections upstream from the lower Hurunui Bridge, but to what amount faulting has determined their boundary to the north-east is not clear.

The fault along the west side of the Pendle Hill block enters the subdivision two and a quarter miles east of Tormore, but it has not been located within the Cheviot basin. It may be continuous with the fault west of the Hawkswood Range.

The majority of the fractures in the highly brecciated greywacke along the coast between the Jed and the Waiau River are oblique to the coast-line. Pliocene rocks are involved in this fault-zone immediately south of Waiau Mouth and to the north of Hawkswood Bluff where the faulting is also oblique to the coast-line.

Geology.

Pre-Cretaceous Rocks.—Greywacke and argillite are the oldest rocks of the district. In a few isolated boulders from a stream-bed a mile and a half south of Waiau mouth Dr. Marwick identified numerous specimens of *Buchia* and *Inoceramus* fragments. An igneous conglomerate apparently identical with those noted in earlier annual reports crops out in the Hawkswood Range south of the Waiau where pillow lavas, in one locality associated with marble, are not uncommon. Pillow lavas and tuffaceous beds occur at many places between Waiau Mouth and the Jed, and in the hills west of Tormore.

Cretaceous Rocks.—These consist of conglomerate, calcareous sandstone, glauconitic sandstone, quartz sand, and purplish carbonaceous mudstone that at many outcrops show a "sulphur" efflorescence. Hugh concretions up to 15 ft. diameter occur in the sandstones and some contain saurian and cetacean bone fragments. The basal calcareous sandstone is fossiliferous at Amuri Bluff, and about 100 ft. from the base is a conglomerate consisting of well rounded pebbles apparently of Cretaceous sandstone. These rocks, which belong to the Piripauan stage, include the Lower Greensand and the Waipara groups of McKay's classification, to the base of the Teredo limestone.*

The break between the Cretaceous and Tertiary rocks appears to be at the base of the glauconitic sandstone or greensand which at many localities grades upward into the shaly or marly beds that underlie and merge into the Amuri Limestone. On the south bank of the Hurunui 10 chains upstream from the bridge, near the mouth, this glauconitic sandstone rests on the greywacke. A phosphatic band crops out at several localities at this horizon and contains derived pebbles and a few fossils including some resembling *Tancredia*, apparently identical with one from the glauconitic greensand overlying the Brighton limestone, Otago. Below this phosphatic band which at Amuri Bluff underlies McKay's Lower Teredo limestone are the sandstone and carbonaceous mudstone usually considered typical of the Cretaceous. Belemnites occur 3 ft. below the phosphatic band in a sandstone at the mouth of the Pariwhakatau Stream where there is a thickness of about 30 ft. of glauconitic calcareous sandstone between the definitely Cretaceous sandstone and the Amuri limestone.

Tertiary Rocks.—These include the Teredo limestone and the younger rocks of the Waipara group and the succeeding Tertiary rocks of McKay's classification. The Teredo limestone is a calcareous slightly glauconitic sandstone that contains nests of worm tubes at Amuri Bluff and the Conway River.†

The glauconitic sandstone that at places grades downward into the marls and shaly limestone usually grouped with the typical Amuri limestone are possibly the equivalent of the Teredo limestone horizon of the Amuri Bluff section where the contact with the limestone is sharp. The marl and shaly limestone are at many localities intruded with sandstone dykes and sills, which range from 1 in.

* McKay, A., 1890: "On the Geology of Marlborough and the Amuri District of Nelson," Rep. Geol. Explor. during 1888–89, pp. 85–185.

† McKay, A., *Id.* 1890.

to about 10 ft. in thickness. At many points brecciation of the shale and calcareous bands accompanied the intrusion, and the dyke material at places is a breccia with many marl and limestone fragments cemented in a sandy matrix. The limestone and shale blocks in the dykes range from a fraction of an inch up to about 2 ft. through, and they may be abundant in or entirely absent from the dykes and sills.

These dykes are best exposed at Hurunui Mouth, where the marl in the section along the south bank at the river mouth is invaded by sandstone dykes and sills and is unconformably overlain by sandstone containing a band of phosphatic nodules at the base, or a coarse basal conglomerate with a few phosphatic nodules. The conglomerate consists mainly of fragments of Amuri limestone or the marly beds underlying it, and boulders of the sandstone breccia dykes intruding the marly beds.

The mapping shows that the marl intruded by sandstone dykes at the Hurunui Mouth is the equivalent of the chalk marl of other areas, and is the bed that underlies and grades into the Amuri limestone rock type. Dr. Finlay examined a specimen from this marl at the Hurunui Mouth and identified a micro-fauna identical with that of the marly limestone beneath the typical Amuri stone at Port Robinson and characteristic of the Hampden beds, Otago.

The typical cuboidal jointed Amuri limestone ranges from a few feet to 50 ft. thick in the area so far mapped, and it is succeeded by a nodular phosphatic band with a glauconitic sandy matrix.

Cookson Beds.—Localized volcanicity followed the deposition of the chalk marl in the Waiau Survey District, where tuff, breccia, basaltic flows, and pillow lavas crop out close to the fault zone that extends from the Upper Waiau to Kaikoura. These volcanic rocks suggest instability along this zone in early Oamaruian time.

Weka Pass Stone.—The equivalent of the Weka Pass stone within the subdivision grades from a calcareous sandstone or glauconitic sandstone to a massive crystalline limestone. The Isolated Hill limestone of the annual report for 1931 is correlated with the Weka Pass stone. At Isolated Hill and Mount Cookson tuffaceous bands are interbedded with it, indicating that volcanicity continued to the Ototaran. South of Amuri Bluff the Weka Pass stone is a banded sandy limestone with thin interbedded glauconitic sandstone bands, and north of the Bluff it resembles somewhat the Amuri limestone.

Grey Marl.—Calcareous mudstone with abundant fucoids is the equivalent of beds known as Grey Marl beyond the subdivision. It is apparently conformable with the Weka Pass stone at Amuri Bluff. Elsewhere in the subdivision sandstone and glauconitic sandstone interbedded with argillaceous sandstone represent the grey marl. No rocks corresponding with the Grey Marl were recognized in the Waiau Survey District, but should they be present, they are included in the Sugar-loaf beds of the 1931 annual report. The Sugar-loaf beds are disconformable to the Isolated Hill limestone.

The age of the sandstone that unconformably overlies the marl at the Hurunui Mouth is debatable. It truncates the Weka Pass glauconitic calcareous sandstone along the lagoon front; and its equivalent in the south limb of the Gore Bay syncline is probably the sandstone that disconformably overlies the Weka Pass glauconitic calcareous sandstone about 12 ft. above the contact of that rock with the Amuri limestone. The sandstone overlying this disconformity is associated with fucoid-rich mudstones, a rock-type considered by Speight and Jobberns characteristic of the Grey Marl. But these writers considered the sandstone above the unconformity at Hurunui Mouth the equivalent of the Mount Brown Beds.

Mount Brown Beds.—Mount Brown Beds, consisting of shelly conglomerate bands and sandstones, unconformably overlie the grey marl in the Cheviot basin, and at the Trig. two and a half miles west of Domett they rest on the Amuri limestone.

The Sugar-loaf beds which yielded faunas that place them in the Awamoan and Hutchinsonian stages, are the equivalent of the Mount Brown Beds.

Bourne Conglomerate and Sandstones.—Since 1931 the Bourne conglomerate and interbedded mudstones and sandstones have been mapped over an extensive area, and the suggestion in the annual report for that year, that the huge rocks of the coarser facies were derived from newly formed fault scarps is inadequate to account for its distribution. The coarse conglomerates represent the shallow-water beds of an extensive Pliocene transgression. These conglomerates, sandstones, and mudstones truncate all the older rocks. Their equivalents are the Greta Beds of the Waipara and Weka Pass district,* the Great Hundalee Conglomerate of Jobberns,† and in all probability the Great Post-Miocene Conglomerate which McKay has described,‡ and the Great Marlborough Conglomerate of Thomson.§

Highfield and Lyndon Beds.—Tilted gravels occupy a considerable area east of the Hawkswood Range between Hawkswood Bluff and the Conway. Both the Highfield and Lyndon gravels appear to be represented in this area. The conglomerate in the Gore Bay syncline is tentatively correlated with the Bourne beds, but it may possibly be younger.

Late Pleistocene and Recent.—High-level terrace gravels, loess, and raised beach gravels and sands constitute these deposits.

* Thomson, J. A.: "The Notocene Geology of the Middle Waipara and Weka Pass District, North Canterbury, New Zealand," Trans. N.Z. Inst., Vol. LII, pp. 322–415.

† Jobberns, G.: "The Raised Beaches of the North-east Coast of the South Island of New Zealand," Trans. N.Z. Inst., Vol. 59, 1928, pp. 508–570.

‡ McKay, A.: *Id.* 1890.

§ Thomson, J. A.: "The Great Marlborough Conglomerate," Seventh Ann. Rep. N.Z. Geol. Survey, 1913, p. 123.

NASEBY SUBDIVISION.

(By J. H. Williamson.)

Part of the area shown on the accompanying map was described in last year's annual report (1933). During the past field season a further area of 510 square miles was mapped in detail, embracing Highlay, Budle, Rock and Pillar, Maniototo, Upper Taieri, and Upper Taieriside Survey Districts, and including Macraes Flat, Nenthorn, Hyde, Hamiltons, and Patearoa mining districts. Gimmerburn Survey District has not yet been examined, and the geological boundaries sketched are subject to alteration.

Physiography and Structure.

It has already been pointed out that the rocks of Central Otago fall into two divisions, older metamorphic and semi-metamorphic rocks that form the undermass, and younger unaltered sediments, the overmass, that was deposited on the planed surface of the older rocks. This deposition was followed by a period of deformation, involving block movements on a large scale, which resulted in a chain of broad tectonic depressions separated by elevated blocks. Large areas of the planed undermass were exposed by the stripping of the cover during a subsequent period of erosion.

The largest of these depressions forms the Maniototo Plain. It is bounded on the north by the Ida Range, on the east by the Kakanui Range, on the west by Rough Ridge, and on the south-east by the Rock and Pillar Range, a fault in each case separating the elevated block from the depression.

The structure of the Ida and Kakanui Ranges is briefly described in last year's annual report.

The Rock and Pillar Range is a fault-block, bounded on the east by a fault striking north 15° east and on the west by one striking north 50° east, so that the part within the subdivision forms a subtriangular mass eleven miles long and eleven miles wide at the south end. The top of the range is flattish, with a pitch to the north, where it is 2,500 ft. high, as against 4,000 ft. at the south end, and consequently the major streams that drain it flow northwards.

On the east side of the range the dip of the schistosity planes of the schist becomes noticeably steeper, indicating that considerable folding preceded faulting.

On the west side of the range there is a series of thrust faults, the schist overlying the Tertiary beds along the fault angles. The greatest movement is along the fault that passes east of Hamiltons Diggings, thence southward by way of the Upper Pigburn gorge to the Taieri River at Paerau (Styx), and along the east side of the Styx Valley. These faults are important, because the alluvial mining areas to be described later are in the auriferous conglomerate that is preserved in the fault angles.

West of the Rock and Pillar Range lies the Maniototo basin, a structural depression drained by the Taieri River and its tributaries. On the west side of the basin Rough Ridge trends north-east, extending from Idaburn southward beyond the area examined. The scarp of Rough Ridge, a westerly tilted block that rises to a height of 3,500 ft. at the south end, bounds the depression on the west. The scarp is splintered, the splinters pitching to the north, in which direction they disappear under the cover of the Maniototo basin.

East of the Rock and Pillar Range a series of tilted fault-blocks, each having a gentle westerly slope with a pronounced fault scarp on its eastern edge, extends to the east boundary of the subdivision. The largest block abuts against the Rock and Pillar Range, being slightly upturned on this its western margin, and is delimited on the east by a fault, which extends north-east to Waihemo Valley from beyond the south boundary of the subdivision. High points along the top of the fault scarp are Brother Peaks, Station Hill, and Mount Highlay. In the fault-angle between this and the next block are Moonlight Valley and Horse Flat, whence the surface rises to Billy's Ridge and its northward extension, Stag Hill, on the eastern fault-edge of this second block. Nenthorn Creek flows in the fault-angle at the foot of this scarp, and the third block rises to a poorly defined ridge through which Deighton Creek, carrying the drainage of the fourth block, has eroded its channel.

General Geology.

The following table, which was published in last year's annual report, shows the sequence of formations developed in the area examined.

Series.	Strata.	Approximate Age.
..	Alluvial (auriferous)	Recent.
..	Terrace gravels (non-auriferous)	Pleistocene.
Surface Hill ..	Gravels (auriferous)	Pleistocene.
Maori Bottom	Cemented quartz-greywacke gravels, clay (auriferous)	Pliocene.
Waipiata ..	Basalt flows	Pliocene or Upper Miocene.
Wedderburn ..	Clay, sand, grit, conglomerate, coal	Miocene ?
Naseby ..	Greensand	Oligocene (Ototoran).
Hogburn ..	Quartz conglomerate, quartz grit (auriferous) ..	Eocene (? Ngaparan).
Kyeburn ..	Indurated quartz conglomerate, sandstone, claystone, schist, conglomerate	Cretaceous.
Ida	Greywacke, argillite, conglomerate	Triassic.
Waihemo ..	Greywacke	Palæozoic.
Kakanui ..	Greyish argillaceous schist	Palæozoic.
Wanaka ..	Foliated quartz mica schist (auriferous quartz veins, scheelite)	Palæozoic.

Wanaka Series.—The schist outcropping in the southern part of the subdivision is micaceous and foliated with quartz, and constitutes the bulk of the rock in this area. The schistosity planes dip at a uniformly low angle, usually less than 20°; generally they strike north-west to north-north-west and dip east, but in Budle S.D. and in the south-east part of Rock and Pillar S.D. they strike east and dip north. On the Rough Ridge block (Upper Taieriside S.D.) they strike north-north-west and dip south-west in the northern part of the survey district and north-east in the southern part. Local variations of dip and strike occur at many points.

Kakanui Series.—The subschistose rocks that form the main mass of the Kakanui Range continue on the north-west side of the Waihemo Fault as far as Pigroot Creek. The series is chiefly developed in the area described in last year's report.

Waihemo Series.—Between the east branch of Pigroot Creek and the head of Shingly Creek the rocks outcropping change from subschists of the Kakanui Series to greywacke. The actual passage from one to the other is obscured; but the change is along the strike, and the scanty evidence suggests a fault between the two series rather than a gradual change from metamorphosed to unmetamorphosed rocks. The beds where seen were unfossiliferous greywacke; but they are probably the oldest of the unmetamorphosed rocks of this district, corresponding to Cox's Te Anau series of Upper Devonian age.*

Their age cannot be determined until the adjoining district to the east has been examined, and they are accordingly referred to a separate series, and tentatively classed as Palæozoic.

Ida Series.—The unaltered argillite, greywacke, and conglomerate beds of this series outcrop only in the northern part of the district, where they form the Ida Range between Mount Ida and Mount Buster.

Kyeburn Series.—The beds of the Kyeburn Series represent the beginning of the new cycle initiated by the Hokonuian orogeny. They grade from a coarse, indurated, schist conglomerate to claystone and sandstone, and then to bluish-coloured beds in which the quartz content may rise to 80 per cent. The series is not represented in the area examined during the past season.

Hogburn Series.—The Tertiary beds older than the glauconitic greensand outcropping in Kyeburn Valley are difficult to distinguish from those of the Wedderburn Series, for the greensand has not been found in many places and fossils are absent from both the Hogburn and Wedderburn series. The silicified beds of sandstone and conglomerate from which the "chinamen" stones and wetherstones are derived, and also the patches of conglomerate involved along many of the fault-angles, are placed in this older series. In many of these patches of conglomerate the pebbles are 3 in. or more in greatest diameter, whereas in the beds that are definitely younger the tendency is for the pebbles to be generally smaller and for the beds to show current bedding and sandy patches. If this distinction is valid, it follows that the auriferous conglomerate in this area belongs to the older series, and that the conglomerate beds of the Wedderburn Series are not here auriferous.

Naseby Series.—Fossiliferous greensand containing a well-preserved marine fauna of Ototaran age outcrops near the Government Dam west of Naseby and at Upper Kyeburn. No greensand definitely referable to this series was found in the southern part of the subdivision, none of the outcrops containing a molluscan fauna. A bed of glauconitic greensand 50 ft. thick is exposed in the small creek flowing north-west to join the Mareburn 10 chains above its junction with the Taieri River, near Hyde, and similar beds outcrop near the road bridge across Pigroot Creek, and eastward therefrom. Though some of these outcrops are foraminiferous, the absence of the molluscan fauna found at Kyeburn makes correlation difficult.

Wedderburn Series.—The best section of these beds so far seen is that along the Pigburn, between the bridge on the Waipiata–Patearoa Road and the ford on the Hamiltons–Patearoa Road, where mainly sands and clays outcrop. Beds of medium-textured conglomerate, showing current bedding, outcrop near Hyde, and generally the beds immediately underlying the basalt flows belong here.

Because the separation of the beds of the Hogburn and Wedderburn series depends on their lithological character, which is not sufficiently distinctive to give a certain division between them, there are a number of outcrops of beds that cannot be definitely assigned to one or other of these series. On the accompanying map these beds of doubtful age are included with the Wedderburn Series. One such area is that near Patearoa, between the Swinburn and the Pigburn, where the lower conglomerates and clays are probably of Hogburn age, and the upper beds of Wedderburn age. There are, however, no data from which to draw a boundary, and all the beds are tentatively shown as Wedderburn.

Likewise if the glauconitic greensand outcropping on the Mareburn tributary is rightly assigned to the Naseby Series, the beds above and below it, which on the map are included with the Wedderburn beds, must belong respectively to the Wedderburn and the Hogburn series. There is doubt, too, of the age of the beds near Hyde that are involved in the faulting along the front of the Rock and Pillar Range—the so-called "Deep Lead," and also the beds near Fullartons and north-east therefrom.

Waipiata Series.—Basalt flows near Waipiata are thin, and disappear westward under the gravels of the Maniototo Plain. They reappear at one other point, Haughton Hill, on the west side of the plain. No definite vents were found, though the hill at the north end of the Rock and Pillar Range on which is St. Paul's Trig. may be an old plug.

Maori Bottom Series.—The Maniototo Plain is a structural depression that was formerly in part, and apparently in large part, a lake. After the deposition of the Wedderburn beds there was strong deformation which raised the country round the depression into the highlands from which the mountains of the present day have been carved. The typical Maori Bottom beds exposed at Naseby,

* Cox, S. H.: "On the Shag Valley," Rep. Geol. Explor. 15, p. 55, 1883.

Kyeburn, and Patearoa consist of rusty greywacke and schist conglomerate that local streams built out into the depression. Fine conglomerates, sands, and clays near Waipiata are thought to represent the purely lacustrine phase of this group.

Near Patearoa the conglomerate is yellowish-brown and loosely compacted, with clay bands up to 10 ft. thick, and rests partly on schist and partly on Tertiary conglomerate. Though the beds otherwise resemble the typical Maori Bottom beds near Naseby, there is a difference in the nature of the schist pebbles, due no doubt to initial differences in the hills supplying the pebbles. The beds at Patearoa, as at Naseby, are auriferous, and are being profitably sluiced. They do not exceed 100 ft. in thickness.

Surface Hill Gravels.—Near Naseby, between Hogburn and No. 1 Spec Gully, auriferous reddish-brown gravels containing decomposed greywacke boulders overlie the Maori Bottom beds. No similar beds have been found in the southern part of the district.

Pleistocene and Recent Deposits.—Economically the gravels of these two periods are not very important. On Horse Flat, near Macraes Flat, there is an auriferous gravel deposit, consisting largely of quartz pebbles that have been derived by denudation from the Golden Point lode, and in the Mareburn older terrace gravels carry both gold and scheelite. Good rough gold occurs in gravels deposited by the Scrub Burn or Three Mile Creek, south of Hyde; but elsewhere the gravels of these periods are either of limited extent or not payably auriferous.

Economic Geology.

In the years following the discovery of gold in 1861 at Gabriel's Gully, Otago owed its strong financial position to the development of its gold resources, but with the depletion of the easily worked areas the industry languished. As a result of recent conditions, attention has once more been turned to gold-mining, and the public has been asked to support ventures, some of which have a reasonable chance of success, others of which are foredoomed to failure. The major object of this investigation is to review the prospects of the known fields and the possibility of finding new ones, or new minerals or deposits of economic value.

The alluvial deposits at Naseby, Mount Buster, Kyeburn, and Hyde and the quartz-lodes at Oturehua were described in last year's annual report, and mention was made of lignite deposits at Oturehua, Idaburn, and Wedderburn. No good-grade lignite or coal occurs in the part of the district examined during the past field-season; but there are alluvial areas that are being profitably worked, and also two groups of quartz-lodes, one at Nenthorn and the other near Macraes Flat. The latter carries scheelite, a tungsten mineral of rather limited occurrence but of especial value in the manufacture of high-grade steel. Until recently China has been one of the largest producers of tungsten minerals, and, in view of the decrease of supplies from that country and the consequent rise of price, local deposits are increasingly important.

Gold.—Nenthorn field, now wholly abandoned, was discovered in 1888, and was actively developed for two or three years. High working-costs, inefficient management, and extravagant finance brought about the downfall of most of the companies. The veins have a general north-west strike, and dip north-east at from 65° to 85°. They form a subparallel series, the most southerly one being the Eureka lode. Half a mile north is the Zelandia; a quarter of a mile farther north is the Break of Day-Victoria line, which is the longest one; 10 chains north is the Croesus-Blue Slate line; then come the Prospectors and Consolidated lines, one and a quarter miles north-east of the Eureka. The Surprise claim lies about a mile west of Nenthorn Township, and away from the main field.

The veins cut across the bedding-planes of the schist that form the country. Their average width is about 2 ft., though in places the reefs are up to 4 ft. wide. Both the hanging and foot walls are well defined; and the reefs have every appearance of true fissure veins. Occasional rolls in the walls cause them to pinch and make.

No mine plans are available, and no definite information can be obtained about the extent of the workings in the various mines. The Consolidated Mine seems to have been worked for about 1,500 ft. The Surprise reef was stoped for 1,000 ft., to a point where the vein was cut off by a fault. As it was then less than 12 in. wide, the faulted portion was not prospected for. Of the other mines, both the Croesus and the Victoria gave good results. In the former the reef at a depth of 100 ft. yielded little or no gold, and pinched in places. The Eureka Mine was worked to 200 ft., at which depth the ore was still payable, work being abandoned when the main winze collapsed.

No production records of the field are available; but so far as can be ascertained the ore yielded from 1 oz. to 2 oz. per ton, on a recovery which is unlikely to have been more than 50 per cent. The field should be worth careful prospecting by a financially strong company.

Macraes Flat field extends from Mareburn, a tributary of the Taieri River, south-east to Stoneburn, a tributary of the Waikouaiti River, in all a distance of some twelve miles. The outcrops of the main lode are not continuous, being broken by a series of north-east-trending faults, some of which have a displacement of several hundred feet. On this main lode some twelve mines have been worked from time to time, although the only ones recently open are Golden Point, Round Hill, Ounce, and Golden Bar.

North-east of this line is Tate's Reef, which may be either a faulted portion of the main lode or a parallel lode; and intermediate between the two lies the Duke of Edinburgh reef, first worked about 1869.

The veins of this field, unlike those of Nenthorn and Oturehua, lie parallel to the lamination planes of the enclosing schist. Their gold content is low; but scheelite, absent at Nenthorn and Oturehua, is present in payable quantities.

— Legend —

- RECENT — Alluvium (auriferous), tailings, and low terraces
- PLEISTOCENE — Medium & high terrace gravels (non-auriferous)
- PLEISTOCENE — *Surface Hill Series* Gravels (auriferous)
- PLIOCENE — *Maori Bottom* Quartz gravels, clay (auriferous)
- PLIOCENE OR UPPER MIOCENE — *Waipiata Series* Basalt flows
- MIOCENE (?) — *Wedderburn Series* Clays, sand, grit, conglomerate, coal
- OLIGOCENE (OTOTARAN) — *Naseby Series* Greensand
- EOCENE (NGAPARAN?) — *Hogburn Series* Quartz conglomerate, quartz grit (auriferous)
- CRETACEOUS — *Kyeburn Series* Indurated quartz conglomerate, sandstone, claystone, schist conglomerate
- TRIASSIC — *Ida Series* Greywacke, argillite, conglomerate
- PALÆOZOIC — *Waihemo Series* Greywacke, argillite
- PALÆOZOIC — *Kakanui Series* Greyish argillaceous schist, sub-schist
- PALÆOZOIC — *Wanaka Series* Foliated quartz mica schist (auriferous quartz veins), scheelite

Quartz lodes 12
Faults
Workings
Water races
Trig. stations F ⊙ 3138'
Railway
Roads
Survey dist. bdries

— Quartz Lodes —

1. Homeward Bound
2. Lloyds
3. Perseverance
4. West of England
5. Queen of Isles
6. Great Eastern
7. Otago Central
8. Bruhns
9. Mt. Highlay
10. Nunns
11. N.Z. Gold & Tungsten
12. Coronation
13. Deep Dell
14. Maritana
15. Golden Point
16. Round Hill
17. Innes
18. Golden Ridge
19. Duke of Edinburgh
20. Tates
21. Surprise
22. Consolidated
23. Prospectors
24. Crœsus
25. Victoria
26. Zealandia
27. Eureka
28. Bonanza

GEOLOGICAL MAP OF
NASEBY SUBDIVISION
CENTRAL OTAGO

SCALE

CHAINS 80 40 0 1 2 3 4 5 6 7 MILES
KM 1 ½ 0 5 10 KILOMETRES

Geology by J. H. Williamson, 1934.

J. HENDERSON
DIRECTOR.

N.Z. GEOLOGICAL SURVEY

KEY TO SURVEY DISTRICTS

MOUNT BUSTER · IDABURN · BLACKSTONE · NASEBY · KYEBURN · GIMMERBURN · MANIOTOTO · SWINBURN · UPPER TAIERI SIDE · UPPER TAIERI · ROCK AND PILLAR · HIGHLAY · BUDLE

MILES 10 5 0 10 20 MILES

G.E.H. 1934

Golden Point Mine was first opened in 1889, and was in active production till 1921, when the low price of scheelite rendered operations unprofitable. In 1929 a new company was formed to reopen the mine, but large ore reserves have not yet been developed. Two veins have been worked in Golden Point Mine, the upper known as the Home Reef, and the lower as the Dip Reef. Near the entrance to the mine these reefs are 45 ft. apart; at a point 1,000 ft. from the entrance to the Low Level Adit the distance between them is 90 ft. In the mines adjoining Golden Point along the strike of the lode the distance between these two reefs decreases, and eventually only one reef is present. It may therefore well be that the two reefs are really only bifurcated parts of a single lode.

The lodes dip north 70° east at an angle of 15° to 20°, though in parts the dip is steeper than this, and in parts less steep. The hanging-wall of the upper lode and the footwall of the lower are generally well defined, but the other two walls are rather ill-defined. The thickness of the lodes ranges from less than 2 ft. to 7 ft. or 8 ft., a fair average being 4 ft. The formation consists of quartz and heavily mineralized mullock bands. In places the quartz extends over the whole width of the fissure, elsewhere it is narrow with a mullock band on one or both sides. Both the quartz and the mullock bands carry gold, and scheelite veins are found in places running through the quartz and in places in the mullock bands near the quartz.

The mine has been developed by several adit levels, the most important being the Home, Intermediate, Engine Dip, and Low Levels. The Home Level was driven on an outcrop of the Home or Upper Reef, which was followed to a point where a fault displaced the lode. The lode was again found and followed for a considerable distance. It is up to 6 ft. wide where last developed, and carries payable gold and scheelite.

The Engine Dip Level, now closed, was driven to cut the Dip Reef, after which it was continued as a dip to a fault, then turned to the north-east and continued along the reef. A fault zone, encountered in the Water Tank Rise, downthrows the vein to the east. The vein is somewhat broken eastward from this rise, but is present in the Low Level Adit on the downthrow side of another fault.

The Low Level was driven to explore the east part of the mine. The Dip Reef is exposed in cross-cuts from this level at three points, at each carrying both gold and scheelite. It has not yet been developed eastward.

In Round Hill Mine, which lies half a mile south-east of Golden Point Mine, the same two reefs are exposed; but here the greatest distance between them is 20 ft., at the north end of the mine. At the south end, which is not fully opened out, the two reefs apparently join, and from there southwards only one line of outcrop has been exposed by prospecting.

A lode which outcrops a mile north-east of Macraes Flat has recently been driven on from a winze 35 ft. deep. This is Tate's Mine. The recovery from 70 tons was 22 dwt. per ton. The lode has an average width of about 12 in. It strikes north-west and dips 85° east near the winze, but southwards along the strike the dip flattens to 45°. Northward the lode is much disturbed, and more work is required, both in depth and along the strike, before any estimate of its possibilities can be given.

At Fullartons or Four Mile Diggings, east from Hyde, a small infaulted patch of quartz conglomerate of the Hogburn Series is being worked by driving. When the field was visited in November, 1933, the deposit had been partly tested from a shaft, and an old adit was being cleaned out. It was proposed to continue this drive towards the bottom of the shaft. There is only a small area of quartz conglomerate here; but similar conglomerate occurs north-eastward in the area known as the Deep-sinking, where much sinking and driving, with payable results, was done some thirty or forty years ago. No subsurface examination of this field could be made, and it is not possible to state whether it is worked out or not.

At Patearoa a small amount of driving is being done by unemployed miners, and near Mount Highlay, an adit is being put in to prospect the quartz conglomerate in that area.

During 1933 it was reported that a diviner had discovered a rich lead in the fine-grained Maori Bottom beds near Ranfurly, and much prominence was given to some high assay results that were obtained. Two drives were put in to pick up the so-called lead, but all that was exposed was a bed of fine sand, from which the supposedly rich assay was taken. Samples taken from the bed which were assayed by the Dominion Analyst gave no trace of gold, a result that is not surprising, for a more unlikely place to look for gold could scarcely be found.

Sluicing operations in the part of the subdivision examined during the past season are hampered from lack of water just as they are at Naseby. At Macraes Flat this is overcome by using electrical power for pumping the water to the nozzle, elevating by an electrically driven gravel-pump, trapping the water used in sluicing, and, after settling, using it again. By this method a considerable area that contained too much clay to be treated by dredging can now be profitably worked.

The Hamiltons field is now almost deserted, and the water once available for mining has been alienated, so that there is little chance of further development here.

At Patearoa Carr Bros. are sluicing Maori Bottom gravels and quartz conglomerate resting on a soft schist bottom. There is a considerable area of similar but much deeper ground still unworked. An area in the Sowburn has recently been pegged off as a dredging claim.

Scheelite.—To 1920, 2,300 tons of scheelite, valued at £300,000, had been produced from the Macraes Flat field, but since that year, owing to the low price of scheelite, production has been negligible. The price, which has risen owing to short supply and increased demand, is now high enough to make scheelite mining profitable. In the Golden Point Mine, and in the adjacent mines on the same lode the mineral occurs with gold.

Coal.—The coal outcropping in the southern part of the subdivision is a poor-quality lignite, and none of it is now mined. On Horse Flat, near Macraes Flat, two pits were once worked, and the coal was used to generate power for the quartz-mines, and another outcrop in Trimble Gully was worked for

the same purpose. All have been abandoned because this market no longer exists, and the coal was not suitable for domestic use. There are several outcrops near Hyde, which indicates a field of about 300 acres. It was worked for a time many years ago by an open-cast pit on the river-bank, which is now filled with tailings. At this point the coal, a low-grade lignite, is reported to be 15 ft. thick and lying at a low angle.

Near Waipiata on the south side of the Taieri River an outcrop at least 6 ft. thick has been driven on, but only small quantities for private use have been taken out.

Building-stones.—Many buildings and bridge abutments in Central Otago have been constructed of schist rock, which makes an easily worked building-stone. Basalt from near Hyde was used for the Dunedin Railway-station, and is available in large quantity.

Limestone.—A calcareous deposit near Patearoa is being examined to determine its suitability for agricultural purposes.

ALLUVIAL GOLDFIELDS, OTAGO AND SOUTHLAND.

(By E. O. Macpherson.)

During the 1933–34 field-season gold-mining areas were geologically examined in the following fields: Surface Hill, Rise and Shine Creek, The Branches, Soho Creek, Campbell's Creek, Cambrian, all in Otago Central, as well as King Solomon mining field, Grindstone Creek, Upper Whakaea, Pebbly Hills, Wetherstone Flat, Wendon Valley, Waimumu, and Round Hill in the Southland district.

This geological work, in the main, was done for private companies which required geophysical surveys of their properties. In a few areas geophysical prospecting was recommended, in some these methods would probably not add to the geological information. Interpretation of geophysical results required close collaboration with the geophysicist, Mr. N. Modriniak, and occupied a good deal of time.

Wakaia Goldfield, Southland.

The Wakaia district consists of a number of sub-parallel north-east-trending ranges separated by wide valleys. The upper Whakaea flows between the Garvie Range on the west and the White Umbrella Range on the east. The Argyle, a large branch, flows between the White and Black Umbrellas which northward form the Umbrella Range, an offshoot of the Old Man or Obelisk Mountains. The lower Round Downs continue the White Umbrella south of Winding Creek though offset a little to the west. The Argyle after joining Winding Creek turns abruptly westward and crosses the gorge between the White Umbrella and Round Downs to the Whakaea Valley. The valley between the ranges continues south-west from Winding Creek east of Round Downs for another twelve miles, being drained by Stony Creek flowing north to Winding Creek and Wendon Creek flowing south to the Whakaea. The Otama, a small branch of the Mataura, also has its head in part of the same broad valley. These three last-mentioned streams are obviously much too small to have carved the wide valley which, as will be shown later, is of structural origin. There is evidence that the ancient Whakaea crossed the range by way of the gap, that Winding Creek occupies and flowed south-west between the ranges. Rich deposits of auriferous wash, thought to have been despoited by this ancient river, are worked in the King Solomon Mine. Other areas of the old bed of this river, preserved from erosion by coverings of younger gravels, probably occur along the Stony-Wendon Valley south of the King Solomon, and also in the valley of the present Whakaea upstream from the Winding Creek junction.

Stratigraphy.

The formations recognized in the Wakaia district consist of—

(1) Alluvium and tailings.
(2) Angular gravels, in part fanglomerates and slope-deposits, silts, and clays.
(3) Rusty brown gravels with clay and silt bands.
(4) Gravel and sand with boulders of quartzite, jaspilite, and "chinamen" (wash of the King Solomon Mine).
(5) Clays and sandstone, in parts fossiliferous.
(6) White and brown sandstone, carbonaceous mudstone (in places with bands of lignite), quartz, conglomerate.
(7) Semi-schist, greywacke, argillite, quartzite, &c.

The semi-schists and greywackes form the mass of the mountains. These basement rocks are separated by a strong unconformity from the white sandstones and carbonaceous mudstone. The fossiliferous marine clays and sands, which are of Ototaran age, probably overlie the white sandstone group concordantly though the relation of the beds has not been observed. The Ototaran and underlying strata lie on a gently undulating surface of the old rock and their texture shows that land was not then as mountainous as it now is. They are in places strongly tilted and lie in fault-involved strips, and were clearly laid down before the faulting occurred.

The gold-bearing wash of the King Solomon Mine rests in places on an eroded surface of the white sandstones and in places on the semi-schist. Distinct channels occur, and the wash, which is obviously of fluviatile origin, varies from 2 ft. to 8 ft. in thickness. Most of the boulders in the wash are of greywacke and semi-schist, though angular masses of these rocks and of the white sandstone also occur; but some of the most prominent boulders in the wash—the jaspilites and "chinamen" are not known in place in the region and do not occur in the gravels of the present streams. Rusty

gravels, decidedly of less coarse texture and containing clay and silt bands, overlie the wash, but the contact is not well defined. Toward their base they contain many quartz pebbles. They are well exposed at Murphy Hill, a little east of the King Solomon shaft. These gravels, which are at least 180 ft. thick, are derived from the semi-schist and greywackes of the adjacent highlands and are correlated with the Maori Bottom gravels of Otago Central which they in general resemble in texture and consolidation. Like them they contain detrital gold usually in small amount.

The wash and rusty gravels are in places tilted and faulted, but the amount of deformation is not great compared with that which the Ototaran beds have suffered. They are considered the deposits of a stream or streams that drained the land after the faulting had taken place; they accumulated in the fault-angles and the narrow structural depressions where, in spite of the great subsequent erosion, they still occur in thick masses and occupy considerable areas.

Silts and clays 50 ft. or more thick, possibly lake-beds, but more probably river deposits, overlie the rusty gravels. These again in places are covered with angular talus from the adjacent hills or by terrace gravels. The gravels of the existing streams and the tailings of the miners bring the geological record to the present day.

Faults.

A major upthrust fault can be traced along the eastern side of the Whakaea Valley from above the Argyle Station southward to Winding Creek, a distance of seven miles; this fault probably extends north from Argyle Station, but was not traced owing to the obscuring alluvium on the flood-plain of the Whakaea River. Southward from the Winding Creek junction, this fault apparently dies out, but it may continue southward as a warp or monoclinal flexure along the east side of the Round Downs.

Rusty gravels occur along this upthrust fault, and along their east boundary are involved in the movement; schist forms their western boundary for three miles in the southern part and the contact with the schist is depositional and not faulted.

Geophysical prospecting was recommended in this area, the work revealing a concealed fault which trended sub-parallel to the eastern upthrust. The structure in this locality is therefore a long narrow depressed area bounded east and west by faults which enclose younger sediments. The major fault on the east is a high angle upthrust, but from the geophysical data the fault on the west appears to be a normal fault with downthrow to the east. The classification of this type of fault structure is difficult, it is not a rift block or graben, and is apparently a hybrid.

Rusty gravels identical with those overlying the King Solomon lead occur along this fault-bounded depression; and the King Solomon lead may be present in this area also, underlying the rusty gravel, and overlying the infaulted pre-deformational white sands and lignite clay, or the fossiliferous marine beds, or the basement rocks.

The rusty gravels were traced southward down the Whakaea Valley from Winding Creek; schist gravels occur in this direction, but rusty gravels are present in the re-entrant along the range where Winding Creek crosses the western block, and small disconnected patches occur on the sides of the low part that leads through the western block into the next valley. They occur in the old Break-em-All claim on Winding Creek, and as already stated overlie the wash worked at King Solomon Mine.

A fault was traced south-west from Winding Creek along the eastern side of the Wendon Valley and continues in this direction for twelve miles into Otama Valley. The evidence for this fault is mainly physiographic, but the actual fault-plane can be seen at the mouth of a small creek where the King Solomon pipe-line rises from the tailings; at this point rusty semi-schist and greywacke gravel are downthrown to the westward against the basement rock; the fault-plane here is almost vertical. This fault was not directly observed elsewhere, but a bold scarp continues to the south-west and defines the south-east boundary of the depressed area.

The western boundary of this depression or rift is also defined by a fault. At its northern end this western fault was not seen on the surface, but was revealed by geophysical work. Two miles south-west down to the depressed area, beyond the saddle which divides Wendon Creek from Stony Creek, this western-bounding fault is clearly seen; along this stretch of the depression it shows as a low, conspicuous scarp easily traceable into the Otama Valley.

Clays and silts which overlie the rusty gravels at the King Solomon end of the depression or rift occupy the area between the bounding fault-walls, but minor patches of marine (Ototoran) beds and white sands with lignites outcrop at several places.

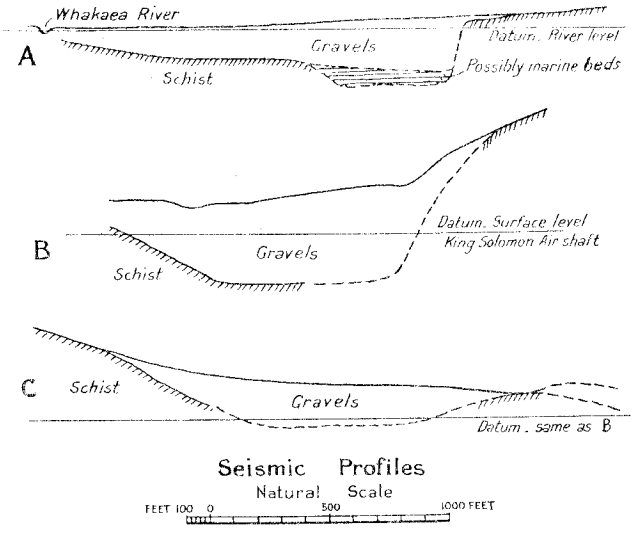
Observations in the King Solomon Mine workings show that the east-bounding fault dips about 55° eastwards; it is an upthrust fault, and this attitude probably persists southward.

The west-bounding fault for the greater part of its length presents an almost undissected scarp (except where breached by streams consequent on the eastern fault scarp) which dips 50° to 60° to the east, suggesting a normal fault with downthrow to the east. Other minor faults occur in the area. The fault-bounded rift or graben along the east side of the Whakaea Valley is structurally similar to that which extends southward from King Solomon Mine.

Pre-Whakaea River.

The interpretation from these observations and other data not discussed here is that a pre-Whakaea River flowed southward down a fault-angle depression a little east of the present bed of the Whakaea River. This depression is floored with infaulted pre-deformational sand, lignite, clay, and marine beds. The river swung eastward at the low notch or sag in the ridge now occupied by Winding Creek. It crossed the western fault-block (which has since been uplifted) and flowed southward down the Stony-Wendon depression. The rusty gravel along the east side of the Whakaea Valley, the patches of gold-bearing gravel containing "chinamen" boulders which occur along the notch or sag connecting the Whakaea with the Stony Creek – Wendon Valley, the gold-bearing gravel at the Break-em-All claim and the King Solomon Mine are deposits of this ancient river.

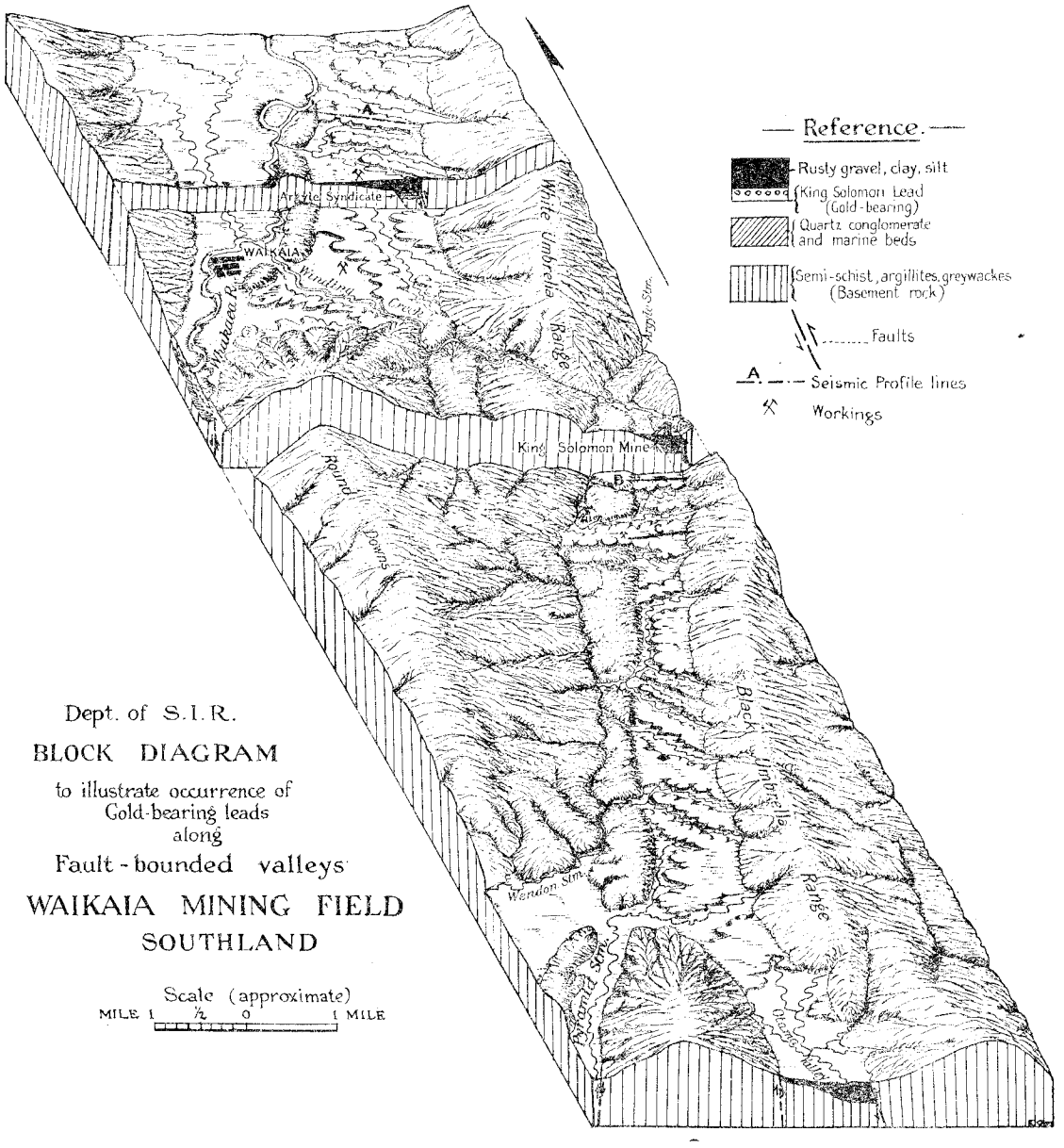
The fault structure that appears to control the distribution of the gold-bearing gravel in the King Solomon Mine persists southward into the Otama Valley and it is considered that the pre-Whakaea River was adjusted to this fault structure and flowed southward along it and deposited gold-bearing gravel now concealed beneath the younger silt, sand, and gravel.



Seismic Profiles

Natural Scale

FEET 100 0 500 1000 FEET



PALÆONTOLOGICAL REPORT.

(By J. Marwick.)

During the year 1933–34 the description and figuring of the fossil mollusca of Kaitangata district was almost completed, so that only a small amount of work is now necessary to prepare the paper for printing. Many difficulties were met in evaluating the age of the Wangaloan fauna not only from the lack of proper library facilities, but also because so many of the mollusca belong to new groups. Evidently New Zealand at that time was isolated in a similar degree to the present. The age is somewhere about Danian, but no direct comparison can be made with European faunas and a possible Paleocene age has not been disproved.

An exchange of New Zealand molluscan genotypes was carried out with the Academy of Natural Sciences, Philadelphia, in return for a copy of their Special Publication No. 3. This important book, a recent revision of Californian Cretaceous and Tertiary genotype mollusca, was not available for ordinary exchange and so was lacking in New Zealand libraries. The United States National Museum has recently asked for an exchange of Triassic brachiopods, and this is now being put through.

As the lake formed by the closing of the Waitaki dam will cover the richly fossiliferous Wharekuri greensands, a fortnight last February was spent in collecting as thoroughly as possible from this district. Part of the time was spent in preparing a detailed geological map of the Wharekuri basin, about twenty square miles being covered.

The rest of the field season was spent with Mr. Fyfe in the Amuri Subdivision. Here, good fossils were collected from the Bourne conglomerates, showing clearly a Waitotaran age. This links the Bourne series with the widespread marine transgression which invaded much of the eastern and southern parts of the North Island in Lower Pliocene times. The Cretaceous sandstones of Amuri Bluff proved disappointingly poor in fossils. Several specimens from rather soft glauconitic sandstones, both above and below the "Black Grit" of this section, were kindly examined by Dr. H. J. Finlay for foraminifera, but without success.

An important link between the Amuri and Kaitangata districts was found in a bed of phosphatic pebbles and concretions about 20 ft. below the base of the Amuri limestone. At this horizon phosphatized casts of a shell resembling *Tancredia* were found near the Conway mouth, and near the Cheviot Lime Co.'s quarry, fifteen miles to the south-west. As far as can be seen, these agree with casts in the Geological Survey Collection No. 22 from greensand overlying the Brighton limestone at Green Island near Dunedin. In the Green Island collection occurs also *Lahillia*, suggesting correlation with the Wangaloan. At both Green Island and Amuri the next underlying beds contain belemnites, so that on analogy with Europe, the phosphatic horizon could well be Danian, thus agreeing with the provisional age-determination arrived at from a study of the Wangaloan mollusca. It may be that the phosphatic zone is a concentrated deposit and that the overlying beds represent a later stage. The boundary between Cretaceous and Tertiary must then be drawn somewhere near this phosphatic zone and on present indications at the base of McKay's "Teredo Limestone."

KOTUKU OILFIELD.

Introduction.

A Scandinavian, Nils Mortensen, and his Italian mate, Giacomo Dentalla, were the first to report that petroleum occurred at Kotuku. There was some delay in testing the find. Owing to the area being in the Midland Railway Reservation, leases were not issued for several years. Boring began in 1902, was actively in progress in 1903, and has continued intermittently to the present time. The Lake Brunner Oil Co. drilled eleven holes ranging in depth from 104 ft. to 871 ft. The Kotuku Oil Prospecting Association, in addition to sinking a 6 ft. by 3 ft. shaft to a depth of 83 ft., bored, between 1902 and 1909, nine or ten holes to depths of from 40 ft. to 446 ft. The Kotuku Oilfields Syndicate, a powerful group in which the British Imperial Oil Co. was interested, acquired most of the ground in 1910 and, on a site selected by Dr. J. Wanner, a European oil geologist of note, in 1912 drilled a well which bottomed in the ancient rocks at a depth of 952 ft. A second hole by the same company also reached the old rocks. The rights of the above syndicate in the Kotuku district were taken over in 1913 by a New Zealand group which later merged into the Kotuku Deep Creek Oil Syndicate. Two wells were sunk, No. 1 to a depth of 485 ft. and No. 2, at Kaimata about three miles north of west from the Kotuku seepages, to 1,335 ft. In 1922 the Kotuku Oil Syndicate, which seems to have contained most of the members of the Kotuku Deep Creek Oil Syndicate, formed the Kotuku Petroleum Prospecting Co. Three wells were put down, the first 960 ft. deep bottomed in slate, the second was stopped in Tertiary limestone at 612 ft., and the third was bored to a depth of 1,230 ft., the last 70 ft. being in a rock, which P. G. Morgan described as "soft schistose micaceous argillite or phyllite." This company abandoned its holdings in 1924. A year or so later the Taranaki Oil Fields, Ltd., is reported as leasing a considerable area near Kotuku and in 1929 this company put down a bore to a depth of 960 ft. in Paddy Gully, some three or four miles north of Kotuku. In 1933 the Kotuku Oil and Gold Fields, Ltd., began to drill a well at a point about 20 chains west-south-west from Jack's Mill and a few chains east of some earlier shallow bores. This well, which is not shown on the map, was less than 100 ft. deep when visited last July.

Geology.

The Kotuku Oilfield is about fifteen miles south-east from Greymouth (twenty-one miles by rail) and lies in the wide lowlands which, stretching through North Westland, extend north between the Paparoa Mountains and the eastern highlands to beyond Reefton. Kotuku is about nine miles from the south end of the Paparoa Mountains and about five miles east of Bell Hill which here forms the edge of the highlands to the east. Fluviatile fluvioglacial and morainic deposits of Recent and Pleistocene age cover the lowlands, except along some of the stream valleys in which narrow discontinuous strips of underlying Tertiary beds are exposed. A great piedmont glacier at one time covered the eastern part of the lowlands where Kotuku is situated and outcrops of Tertiary strata are much too few to allow the sequence and structure of the beds to be determined. The lower part of the Tertiary beds, however, are well exposed along the lower valley of the Grey where that stream cuts across the wide anticline that forms the southern continuation of the Paparoa Mountains.

These highlands consist of ancient sedimentary rocks and intrusive granites. The old greywackes and argillites appear in the core of the great anticline a mile west of Stillwater; they also form Bell Hill, east of Kotuku, and the country of the auriferous lodes of Mount Greenland, near Ross, and of Reefton. The rocks are generally greenish coloured and are everywhere strongly folded, often shattered and, near granite intrusions, altered to hornfels and schists. They contain no internal evidence of their age, and different writers assign them to periods ranging from the Carboniferous to the Ordovician.

The main eastern highlands, the continuation of the Southern Alps, are separated from the lowlands by a range of lower hills cut into a series of isolated masses by the streams crossing them from the more elevated country. The Alpine rocks are chiefly quartzite, grey-coloured greywackes, and dark argillites. In other districts late Triassic fossils are found in some bands, and the whole vast series is probably of early Mesozoic and late Palæozoic age. The lower hills east of them consist chiefly of granite, as Mounts Smart, French and Te Kinga at the back of Lake Brunner; Bell Hill, north of these, is formed, as already stated, of the early Palæozoic greywackes intruded to the east by granite. Between the granite and the Alpine greywackes is a broad band of gneisses, schists, and other intensely altered rocks.

As in other parts of the world, the schists and gneisses, the strongly folded and shattered greywackes slates and argillites, and the granites that intrude them do not contain oil in commercial quantity. Rocks quite as old as the greywackes of the Alps or of the Paparoas may contain oil in large amount, but the alteration due to heat and pressure the older rocks of the West Coast have undergone forced out what petroleum they may have originally contained or destroyed its source in the rocks. These old rocks now form the platform or base on which rest the younger strata which are potentially, and in places actually, petroliferous.

The gravels and morainic deposits of the lowlands so effectively conceal the younger rocks near Kotuku that their sequence in the district can only be observed in the uplands and hills north-east, east, and south-east of Greymouth. The sequence of the strata taken with but slight modification from New Zealand Geological Survey Bulletin No. 13 is as follows:—

Formation.	Content and Thickness.	Age.
Old Man Bottom ..	Gravels consolidated; 600 ft.	Late Pliocene.
Blue Bottom	Gravels, shales with lignite, blue sandstones, and clays grading down to calcareous claystones and limestone; 1,200 ft.	Pliocene and Miocene.
Cobden limestone and Point Elizabeth beds	Limestone, calcareous sandstone and claystone; 1,000 ft.	Oligocene.
Omotumotu beds.. ..	Mudstone, calcareous claystone, sandstone, grit and conglomerate	
Kaiata mudstone.. ..	Dark calcareous mudstone; 3,000 ft. ..	Eocene.
Island sandstone ..	Sandstone with minor shales; 500 ft. ..	
Brunner beds	Sandstone, grit, pebble beds, minor shales, and coal seams; 500 ft.	
Paparoa beds	Sandstone, shale, and coal seams; 2,000 ft. ..	Upper Cretaceous.
	Basal conglomerate; 1,000 ft.	

These strata record the history of this part of New Zealand after the great mountain-building movements of the late Jurassic or early Cretaceous. The thick Paparoa beds are probably the deposits in the lower valley and estuary of a considerable stream. The Brunner beds, which in part rest on the Paparoa beds and in part overlap on the old rocks, are deposits of similar origin laid down after land movements of some kind, though these seem to have been insufficient materially to alter the composition and texture of the Brunner beds as compared with the upper part of the Paparoa Series. The overlying Island sandstone and Kaiata mudstone are marine beds likely to be more uniform in texture and to have a wider distribution than the strata of the two preceding series.

Following the deposition of the Kaiata mudstone the land was deformed, elevated, eroded, and again depressed. The Omotumotu conglomerates and grits, which in places contain a vast amount of detrital coal, were the first deposits on the sinking land. Near Greymouth, these beds rest on the Kaiata mudstone, but in neighbouring areas they overlap on the old rocks and in places, as at Brighton and Charleston, thirty to forty miles north of Greymouth, contain coal-seams. Concordantly overlying and also overstepping the Omotumotu beds or the equivalent basal beds of the group in other parts are the Port Elizabeth beds and Cobden limestone, strata entirely of marine deposition. The limestone, which grades into the calcareous mudstone below it, does not maintain a constant thickness, and thins from 700 ft. at Greymouth to 200 ft. five miles to the south-east.

Near Greymouth the Blue Bottom seems to succeed the Cobden limestone without break, but twenty miles to the north there is definite evidence of the erosion interval above the horizon of the Cobden limestone, a break widespread in other parts of New Zealand. These beds outcrop along the valley bottoms of the gravel-covered downs between Greymouth and Ross, and of the lowlands of the middle valley of the Grey. They are the Blue Bottom of the alluvial miners. They have the widest distribution of any of the Tertiary series on the West Coast, but, owing to their poor exposures, their sequence and thickness is not well known. They are at least 1,200 ft. thick, but as Miocene and early Pliocene strata in the Taranaki and Gisborne districts are many thousands of feet thick there are probably extensive gaps due to erosion and non-deposition. In general, fossils are not abundant, and the few known localities have not been collected from since the sequence in the North Island was worked out.

In the middle valley of the Grey the upper part of the Blue Bottom is interbedded with fluviatile and deltaic gravels, soft coarse sandstones, and lignitic bands. These beds mark the shoaling of the sea-bottom caused by the setting-in of the mountain-building movements of the late Pliocene, to which New Zealand owes its present form. A few miles north of Blackball, at the edge of the lowlands, the gravels are strongly tilted, but away from the mountains they usually lie flat or nearly flat. In other parts of the West Coast gravels indistinguishable from the tilted gravels into which the Blue Bottom grades are quite undisturbed close to the great fault-zones active during the late Tertiary orogeny. Evidently gravels were being deposited during the rising of the earth-blocks now forming the mountains as well as after the major movements had ceased. These post-deformational gravels, which constitute the Old Man Bottom gravels of the alluvial miners, are generally deeply weathered.

The later geological history of the West Coast is very complex. The land has been both higher and lower than it now is; great glaciers have occupied much of the lowland and then retreated into the mountains; the highlands have suffered enormous denudation, the products of which the streams first deposited in the lowlands and later for, the most part, swept out again.

The petroleum seepages at Kotuku are the most prominent oil-springs in New Zealand. Other occurrences of oil on the West Coast may be noted. So far as known, the oldest rock containing oil is the sandstone of Upper Cretaceous age from which oil exuded in small amount in the Liverpool Mine. A bore at Dobson yielded a little thick oil from a grit in the Brunner beds (Eocene) at a depth of 1,747 ft. Some outcrops of the Cobden limestone seem to contain a little oil, as at Punakaiki River and at Fireball, Fletcher, Flax-bush, and Glasseye Creeks. At Kotuku shows of oil are reported from the limestone, probably of this horizon, encountered in the deeper bores. Here, however, by far the greater part of the oil has been obtained from the rocks at or near the surface, where the gravels for half a mile along Deep Creek are saturated with petroleum which exudes into the stream and into whatever shallow pits are dug.

P. G. Morgan on pp. 138–39 of New Zealand Geological Survey Bulletin No. 13, 1911, describes the oil-seepages, gas-escapes, and salt springs near Kotuku; on pp. 140–50 he gives the logs of most of the bores drilled to the end of 1910, and discusses the information they yield and also the prospects of the field. The logs of the bores put down since 1910, so far as they are available, are given below:—

Bore No. 1 on Map.—Paddy Gully, about four and a half miles north of Kotuku Railway-station; drilled by Taranaki Oil Fields, Ltd.; begun November, 1929:—

Depth.	Strata.
0 ft. to 29 ft. ..	Gravel and sand.
29 ft. to 335 ft. ..	Soft blue sandstone, occasional hard concretions.
335 ft. to 337 ft. ..	Loose clay and sand (caving).
337 ft. to 375 ft. ..	Soft blue sandstone.
375 ft. to 415 ft. ..	Loose clay and sand (bad caving).
415 ft. to 760 ft. ..	Soft blue sandstone, harder band at 639 ft.
760 ft. to 766 ft. ..	Light sandstone.
766 ft. to 966 ft. ..	Soft blue sandstone with occasional hard concretionary layers (bad caving below 881 ft.).

Bore No. 2 on Map.—South of Trig. A. R. (Molloy's Lookout) and about two and a half miles north of Kotuku Railway-station; drilled by Kotuku Petroleum Prospecting Co., Ltd. (No. 3 Bore); February to September, 1923:—

Depth.	Strata.
0 ft. to 10 ft. ..	Yellow clay.
10 ft. to 70 ft. ..	Yellow gravel with bands of hard conglomerate.
70 ft. to 75 ft. ..	Blue sandy clay.
75 ft. to 130 ft. ..	Yellow conglomerate.
130 ft. to 157 ft. ..	Fine blue conglomerate.
157 ft. to 321 ft. ..	Blue clayey sandstone.
321 ft. to 325 ft. ..	Hard conglomerate.
325 ft. to 442 ft. ..	Blue sandstone.
442 ft. to 445 ft. ..	Hard blue conglomerate.
445 ft. to 448 ft. ..	Chocolate-coloured clay.
448 ft. to 450 ft. ..	Fine conglomerate.
450 ft. to 530 ft. ..	Coarse conglomerate, with pebbles as large as eggs.
530 ft. to 570 ft. ..	Coarse sharp sandstone, slight show of oil, and a little gas.
570 ft. to 573 ft. ..	Brown clay.
573 ft. to 585 ft. ..	Fine sandy shale.
585 ft. to 588 ft. ..	Coarse sandstone, fresh water, and a little oil.
588 ft. to 724 ft. ..	Soft blue sandstone.
724 ft. to 728 ft. ..	Hard band, salt water, CO_2, and a little oil.
728 ft. to 790 ft. ..	Grey sticky shale.
790 ft. to 825 ft. ..	Hard grey shale.
825 ft. to 870 ft. ..	Hard white limestone.
870 ft. to 970 ft. ..	Soft limestone.
970 ft. to 990 ft. ..	Blue micaceous sandstone.
990 ft. to 1,010 ft...	Grey shale.
1,010 ft. to 1,040 ft...	Brown shale.
1,040 ft. to 1,078 ft...	Fine blue sandstone.
1,078 ft. to 1,087 ft...	Brown coal and fireclay.
1,087 ft. to 1,104 ft...	Brown shale, inflammable gas.
1,104 ft. to 1,160 ft...	Conglomerate and sand.
1,160 ft. to 1,185 ft...	Decomposed slate.
1,185 ft. to 1,230 ft...	Slate.

Bore No. 3 on Map.—Near bridge across Deep Creek, two miles north of Kotuku Railway-station. For the log and other particulars of this bore, see No. 6 Well, N.Z.G.S. Bull. No. 13, p. 146.

Bore No. 4 on Map.—About 28 chains south-east of Bore No. 3 above and nearly two miles east of north from Kotuku Railway-station; drilled by Kotuku Oilfields Syndicate in 1912:—

Depth.	Strata.
0 ft. to 25 ft. ..	Stones.
25 ft. to 28 ft. ..	Hard sandstone.
28 ft. to 40 ft. ..	Coarse grey sand.
40 ft. to 48 ft. ..	Fine loose sand.
48 ft. to 81 ft. ..	Coarse sand and stone.
81 ft. to 91 ft. ..	Hard sandstone.
91 ft. to 154 ft. ..	Conglomerate.
154 ft. to 238 ft. ..	Marl.
238 ft. to 307 ft. ..	Conglomerate.
307 ft. to 311 ft. ..	Coarse sand.
311 ft. to 345 ft. ..	Conglomerate.
345 ft. to 498 ft. ..	Calcareous marl.
498 ft. to 552 ft. ..	Limestone.
552 ft. to 570 ft. ..	Conglomerate.
570 ft. to 602 ft. ..	Brown marl.
602 ft. to 653 ft. ..	Light-brown marl.
653 ft. to 709 ft. ..	Blue marl.
709 ft. to 713 ft. ..	Decomposed boulders.
713 ft. to 762 ft. ..	Blue marl.
762 ft. to 775 ft. ..	Sandstone.
775 ft. to 840 ft. ..	Conglomerate, slate, and quartz.
840 ft. to 850 ft. ..	Slaty conglomerate.
850 ft. to 865 ft. ..	Slate.
865 ft. to 952 ft. ..	Slate.

KOTUKU OILFIELD

MAWHERANUI AND BRUNNER S. D's., WESTLAND

Showing Geology and Position of Bores

(Geology, topography &c, by P. G. Morgan, N.Z.G.S. Bull. № 13, 1911).
With additional bores and heights by E. O. Macpherson

Scale

CHAINS 10 5 0 — 80 CHAINS (1 MILE)

METRES 100 0 ½ — 1 KILOMETRE

- Fluviatile, marine, fluvio-glacial, and morainic gravels
- Old Man or Moutere gravels.
- Blue Bottom Formation
- ●9 Bores
- Railway
- Tramways
- /\ 10° Outcrops

J. HENDERSON
DIRECTOR.

G.E.H. 1934.

H.—34.

Bore No. 5 on Map.—Near Sawpit Creek, about a mile and a half north of Kotuku Railway-station; drilled by Kotuku Oilfields Syndicate in 1912. Two wells were drilled at this point, the first being abandoned at 599 ft.:—

Depth.	Strata.
0 ft. to 16 ft.	Surface boulders.
16 ft. to 18 ft.	Fine loose sand.
18 ft. to 28 ft.	Soft blue clay.
28 ft. to 38 ft.	Sandy marl.
38 ft. to 55 ft.	Sand and small stones.
55 ft. to 65 ft.	Fine loose sand.
65 ft. to 85 ft.	Sand and small stones.
85 ft. to 96 ft.	Clay and stones.
96 ft. to 110 ft.	Sandy marl (oil traces).
110 ft. to 120 ft.	Conglomerate (soft).
120 ft. to 189 ft.	Grey marl (oil traces).
189 ft. to 200 ft.	Loose stones (water and CO_2 gas).
200 ft. to 212 ft.	Brown marl (oil traces).
212 ft. to 480 ft.	Blue marl (CO_2 gas).
480 ft. to 550 ft.	Limestone (oil traces).
550 ft. to 558 ft.	Pebbly sand (conglomerates).
558 ft. to 578 ft.	Limestone.
578 ft. to 598 ft.	Conglomerate.
598 ft. to 618 ft.	Brown marl (oil traces).
618 ft. to 658 ft.	Sandstone.
658 ft. to 662 ft.	Pebbly sand.
662 ft. to 776 ft.	Sand rock.
776 ft. to 800 ft.	Slate, argillite, greywacke.
800 ft. to 801 ft.	Coarse sand.
801 ft. to 805 ft.	Slate with bands of sandrock.

Bore No. 6 on Map.—Near main oil seepage and 92 chains north of Kotuku Railway-station; drilled by the Kotuku Deep Creek Oil Syndicate in 1915:—

Depth.	Strata.
0 ft. to 16 ft.	Sand and gravel.
16 ft. to 20 ft.	Sandy clay.
20 ft. to 60 ft.	Sand and coarse gravel.
60 ft. to 65 ft.	Sandy blue clay (water cut off).
65 ft. to 90 ft.	Sand, clay, and boulders.
90 ft. to 97 ft.	Soft blue clay.
97 ft. to 106 ft.	Boulders.
106 ft. to 109 ft.	Blue clay.
109 ft. to 125 ft.	Hard boulders.
125 ft. to 130 ft.	Brown marl.
130 ft. to 138 ft.	Soft green gravel with showings of oil and containing water.
138 ft. to 142 ft.	Brown marl (water cut off).
142 ft. to 150 ft.	Loose sand, containing water and showing of oil (1 gallon) also traces of lignite.
150 ft. to 155 ft.	Coarse sand.
155 ft. to 163 ft.	Gravel containing water.
163 ft. to 170 ft.	Loose sand.
170 ft. to 183 ft.	Sandstone.
183 ft. to 190 ft.	Brown marl.
190 ft. to 198 ft.	Gravel.
198 ft. to 203 ft.	Hard stones and sand (caving).
203 ft. to 210 ft.	Conglomerate.
210 ft. to 215 ft.	Soft coarse gravel.
215 ft. to 225 ft.	Brown shale.
225 ft. to 230 ft.	Loose sand.
230 ft. to 240 ft.	Conglomerate.
240 ft. to 250 ft.	Brown marl and lignite.
250 ft. to 280 ft.	Conglomerate.
280 ft. to 290 ft.	Grey pug (sticky).
290 ft. to 308 ft.	Hard sandstone.
308 ft. to 460 ft.	CO_2 gas, 455 ft.
460 ft. to 485 ft.	Limestone, containing salt water and oil.

10 in. casing, 140 ft. 7 in.; 8 in. casing, 305 ft. 2 in.

Bore No. 7 on Map.—About 4 chains north of east from No. 6 above. For particulars of this bore see Al Well, *ibid.*, pp. 141–42.

Bore No. 8 on Map.—About 13 chains north-east of No. 7 above. For particulars see No. 5 Well, *ibid.*, p. 145.

Bore No. 9 on Map.—About 11 chains south of No. 8 above. For particulars see No. 8 Well, *ibid.*, p. 147.

Bore No. 10 on Map.—About 13 chains east of No. 9 above. For particulars see Well No. 9, *ibid.*, pp. 147–48.

Bore No. 11 on Map.—About 70 chains west of north from Kotuku Railway-station, drilled by Kotuku Petroleum Prospecting Co., Ltd.; September, 1921, to March, 1922:—

Depth.	Strata.
0 ft. to 18 ft.	Blue clay, shale, and boulders.
18 ft. to 31 ft.	Blue clay with gravel.
31 ft. to 33 ft.	Fine gravel with water and oil.
33 ft. to 40 ft.	Blue clay.
40 ft. to 78 ft.	Blue clay with gravel.
78 ft. to 116 ft.	Hard blue conglomerate.
116 ft. to 121 ft.	Brown clay with gravel.
121 ft. to 174 ft.	Hard blue clayey sandstone with bands of gravel.
174 ft. to 180 ft.	Brown clay with gravel.
180 ft. to 189 ft.	Blue clayey sandstone.
189 ft. to 193 ft.	Hard blue rock.
193 ft. to 197 ft.	Brown sticky shale.
197 ft. to 217 ft.	Hard blue conglomerate.
217 ft. to 230 ft.	Sand and gravel with a little gas and oil.
230 ft. to 240 ft.	Hard conglomerate with quartz pebbles.
240 ft. to 244 ft.	Brown clayey shale.
244 ft. to 263 ft.	Hard light-coloured sandstone.
263 ft. to 299 ft.	Brown shale.
299 ft. to 417 ft.	Grey sandy shale.
417 ft. to 748 ft.	Grey sticky shale.
748 ft. to 757 ft.	Soft limestone with CO_2 and salt water.
757 ft. to 764 ft.	Hard white limestone.
764 ft. to 772 ft.	Soft limestone.
772 ft. to 822 ft.	Hard limestone.
822 ft. to 823 ft.	Green marl, lignite, and a little gas.
823 ft. to 825 ft.	Blue sandstone.
825 ft. to 850 ft.	Grey pebbly sandstone.
850 ft. to 930 ft.	Conglomerate (heavy boulders).
930 ft. to 948 ft.	Conglomerate with large boulders.
948 ft. to 960 ft.	Slate.

Bore No. 12 on Map.—About 13 chains east of No. 11 Bore above, and 70 chains north of Kotuku Railway-station; drilled by Kotuku Petroleum Prospecting Co., Ltd.; May to August, 1922:—

Depth.	Strata.
0 ft. to 18 ft.	Brown gravel.
18 ft. to 180 ft.	Blue clayey gravel.
180 ft. to 193 ft.	Conglomerate.
193 ft. to 197 ft.	Hard conglomerate.
197 ft. to 235 ft.	Blue clay with gravel.
235 ft. to 280 ft.	Grey sticky shale.
280 ft. to 560 ft.	Grey sticky shale.
560 ft. to 612 ft.	Limestone, a little non-inflammable gas, and salt water.

Bore No. 13 on Map.—About 20 chains north of east of No. 12 above, and a mile east of north from Kotuku Railway-station. For particulars of this bore see No. 2 Well, *ibid.*, p. 144.

Bore No. 14 on Map.—About 24 chains north-east from Kotuku Railway-station. For particulars see No. 3 Well, *ibid.*, p. 145.

The Kaimata bore not shown on the map was drilled by the Kotuku Deep Creek Oil Syndicate during 1917, at a point immediately north of Kaimata Railway-station, which lies approximately three miles north of west from the Kotuku seepages. Its log is as follows:—

Depth.	Strata.
0 ft. to 8 ft. ..	Heavy alluvial boulders.
8 ft. to 23 ft. ..	Soft marl.
23 ft. to 55 ft. ..	Layers of gravel and sandstone.
55 ft. to 190 ft. ..	Blue marl.
190 ft. to 342 ft. ..	Blue marl (sandy).
342 ft. to 389 ft. ..	Sandstone (close grained).
389 ft. to 390 ft. ..	Hard conglomerate with oil.
390 ft. to 542 ft. ..	Grey marl (sandy).
542 ft. to 544 ft. ..	Hard conglomerate.
544 ft. to 713 ft. ..	Grey marl (sandy).
713 ft. to 735 ft. ..	Layers of sandstone and conglomerate.
735 ft. to 799 ft. ..	Calcareous sandstone.
799 ft. to 860 ft. ..	Calcareous marl.
860 ft. to 949 ft. ..	Blue marl.
949 ft. to 963 ft. ..	Grey marl (sandy).
963 ft. to 975 ft. ..	Sandstone (close grained).
975 ft. to 1,020 ft. ..	Grey marl (sandy).
1,020 ft. to 1,030 ft. ..	Hard sandstone with water.
1,030 ft. to 1,198 ft. ..	Sandstone (soft).
1,198 ft. to 1,309 ft. ..	Conglomerate containing quartz and mica.
1,309 ft. to 1,335 ft. ..	Gritty conglomerate as 1,309 ft.

The interbedded gravels, sandstones, and shales close below the surface obviously belong to the shallow-water phase of the Blue Bottom, the same beds being exposed in the neighbourhood of the bores. The underlying blue argillaceous sandstones and arenaceous mudstones, in some bores reported as calcareous, are the purely marine phase of the Blue Bottom. Near Kotuku they are from 240 ft. to 330 ft. thick. The thick limestone layers the deeper bores penetrate are correlated with reasonable certainty with the Cobden limestone, by far the most widespread of any Tertiary limestone on the West Coast. The interbedded claystones, shales (in places with coal), sandstones, and conglomerates below the limestone are probably the equivalent of the Port Elizabeth and Omotumotu beds of the Greymouth area. The sequence and proportion of the beds differ a good deal in different bores, and this difference, combined with their considerable range in thickness (120 ft. to 300 ft.), indicates their deposition in shallow water. The floor on which these strata rest consists of greywacke and argillite, probably of the same group as those forming the south end of the Paparoa highlands.

Some of the strata in the bore at Kaimata, a railway-station about three miles north of west from Kotuku, can be referred to definite horizons only doubtfully. The soft marls and layers of gravel and sandstone from 8 ft. to 55 ft. probably belong to the shallow-water phase of the Blue Bottom, and the underlying blue marl, 287 ft. thick, to the marine phase. The calcareous beds between 735 ft. and 860 ft. may represent the Kotuku limestone and the underlying 386 ft. of marls, sandstones, and conglomerate the Port Elizabeth and Omotumotu beds. The 393 ft. of sandstones, marls, and thin conglomerates between 342 ft. and 755 ft. may, as far as present knowledge goes, be assigned to any of the several series occurring in this part of the Tertiary sequence in the North Island.

Structure.

The great arch of Tertiary strata known as the Brunner Anticline, from which the Davy Range and Kaiata Hills are carved, pitches southward and merges into the flat or gently undulating late Tertiary beds of the lowlands of North Westland. The core of old rocks is about a quarter of a mile wide at Brunner, but eight miles to the north the Tertiaries are stripped off and the old rocks are exposed across the Paparoa Mountains, here eight miles wide. The thick resistant Cobden limestone with weaker strata above and below stands out as a strong ridge which extends for twenty miles round the south end of the anticline, everywhere dipping regularly outward from the central part. Northward the structure is not so symmetrical, the crest approaches the east side of the structure, and the east flank steepens, and finally is replaced by the Roa Fault. This fracture is part of the great fault-zone along the east side of the Paparoa highlands; the aggregate throw of the zone for many miles is over 5,000 ft. The general strike of the Brunner Anticline from Marsden to Brunner is about north-east; the strike of the Roa Fault is north-north-east and north.

From the ridge of Cobden limestone forming the Kaiata Range the strata dip continuously eastward for four miles to Dunganville which is on or near the trough of a syncline. This trough extends south-west nearly to Kumara and north-east to the junction of Maori Gully with Stillwater Creek. Here the structural axis strikes north-north-east and if this course be maintained across the widespread gravels of the Arnold the trough will lie near Kamaka Railway-station and will probably merge northward into the Healey Gully Fault.

The few outcrops near Kotuku suggest that the seepages are on or near the crest of a very gentle anticline. The exposures along Deep Creek upstream from the sharp bend two and a quarter miles north of the railway-station suggest that the structure strikes north-north-east, as Morgan shows on his map. On the other hand, outcrops in the basins of Red Jack's, Kangaroo, and Nelson Creeks near the northward projection of the supposed axis lend no support to its existence in that direction.

The depths of the limestone, the only certainly recognizable formation penetrated by the bores, are consistent with the existence at Kotuku of a gentle anticline with a general northerly strike. At and near Kotuku, surface outcrops and the depths to the top of the limestone clearly show westward dips; but the evidence for eastward dipping beds is not so definite.

Several small faults striking in different directions disturb the later Tertiary beds that outcrop close to the sharp bend in Deep Creek, about two miles north from Kotuku Railway-station. These breaks are probably connected with a stronger fault for which clear surface evidence is lacking and which depresses the country to the north. The limestone formation in Bore No. 4 of map is 200 ft. or more below the general level of the limestone in the Bores No. 4 to No. 13. Bore No. 3, between Bores No. 2 and No. 4, which are 60 chains apart, penetrated a hard conglomerate from 66 ft. to 322 ft., at which depth it was abandoned owing to difficulties in drilling (see N.Z.G.S. Bull. No. 13, p. 146). This conglomerate is possibly a fault breccia more or less recemented.

Source of the Petroleum.

Twenty years ago many held the view that the oil at Kotuku had a deep-seated origin, being derived from the mudstones, shales, and coal-measures of the Brunner and Paparoa series, of which many thousands of feet are exposed east of Greymouth, and which in places are known to contain a little oil. At least four bores at Kotuku have reached the basement rock of the district, the hard shattered and partly metamorphosed greywacke and argillite of Palæozoic age in which there is no hope of oil occurring in commercial amount. Probably the old rocks were reached in two other bores which are logged as bottoming in coarse greywacke conglomerate and clay. In one well the "slate" was bored into for over 100 ft. Professor James Park examined the borings from the two wells put down by the Kotuku Oilfields Syndicate about 1912, and the late Mr. P. G. Morgan in 1923 identified material from the bottom of the bore near Molloy's Lookout as "schistose micaceous argillite." Without reasonable doubt the old rocks underlie the Kotuku area some 100 ft. to 300 ft. below the base of the Kotuku limestone.

The limestone has been considered as a storage-bed and as itself a possible source of oil. Limestone, almost certainly of the same age, contains a little oil at several points on the West Coast. At Kotuku at least twelve bores reached or passed through the limestone formation which has yielded vast quantities of carbon dioxide gas and water heavily charged with salts; the drillers record showings of oil from the limestone in only five bores.

By far the greater amount of oil so far found at Kotuku occurs in the surface gravels and in the upper coarse-textured layers of the young Tertiary rocks. The disappointed investor's statement appearing in *The Dominion* of the 3rd February, 1924, that "oil is got from 20 ft. to 150 ft. in small amount, but not a pint at lower levels" is substantially correct. As Professor Park* pointed out many years ago, that the source of the oil is probably the blue marine clays and argillaceous sandstones above the limestone; the oil has accumulated in the overlying coarse-textured sandstones and conglomerates, from which it has seeped into the surface gravels.

The Kotuku oil-springs lie about three miles north of Lake Brunner from which wide lowlands formed of moraine and gravel separate them. A bore, No. 14 on the map, 23 chains north-east of Kotuku Railway-station and about 140 chains from the nearest point on the lake went through, without bottoming, 482 ft. of unconsolidated gravels and clay, which Morgan (N.Z.G.S. Bull. No. 13, p. 145) interprets as "perhaps deposited in a glacial lake." The bottom of the bore is 172 ft. below sea-level. The deepest part of Lake Brunner, which occupies a depression formerly filled with ice, is 357 ft. below its present surface, and 77 ft. below sea-level. At one time an arm of the lake may have extended north to the seepages. If so, the ice has removed part of the eastern wing of the Kotuku Anticline and the oil migrating up the porous beds of the west wing seeps from the concealed outcrop into the gravels of the flood-plain of Deep Creek and so to the surface.

* In an unpublished report Mr. C. N. Taylor kindly permits me to cite.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1933–34.

General.

Last year, reference was made to the International Polar Year inaugurated in 1932. The scheme for the Polar Year encompassed an intensive campaign of research in various branches of geophysics, and especially meteorology, in the polar regions. To complete the scheme it was necessary to carry out additional observations in lower latitudes, and in this part of the work practically all meteorological services co-operated to some extent. The whole undertaking was a great success so far as the Northern Hemisphere was concerned, and numerous fully equipped expeditions spent the year in Arctic regions. As regards the Southern Hemisphere, there were no expeditions to the Antarctic, except that of Captain Riiser Larsen which met with disaster at the outset. Special observations were, however, organized on the Norwegian whaling vessels operating in the Antarctic during the 1932–33 season, and the Norwegian Meteorological Institute will prepare special weather charts for the Southern Hemisphere for the period concerned. It is hoped that results of value to local forecasters will be forthcoming. In addition, the International Polar Year Commission provided equipment for a comprehensive programme of observations in terrestrial magnetism in South America, Africa, and New Zealand. The New Zealand Meteorological Office carried out the programme of extra observations outlined in last year's report.

The number of inquiries for climatological data, especially in connection with industrial concerns, continues to increase, as also does the amount of special forecasting for the farming community, aviators, trampers, and holiday-makers, carried out through the wireless broadcasting services.

Observing Stations.

Though there have been several requests, no new climatological stations have been established. One has been discontinued through the observer being no longer available.

Nine new rainfall stations have been added to our list, three of the gauges being privately owned. Several have lapsed for various reasons.

A certain amount of inspection has been done, mainly in the North Island. A thorough inspection of climatological stations is required. In many cases the only opportunity of giving instruction to observers arises through visits of inspection. In the course of the past six years it has been possible to make an approximately complete round of visits to all stations once only.

Forecasting.

The year has been remarkable for the number of times the Tasman Sea has been successfully crossed by aeroplane. It seems certain that in quite a few years a regular trans-Tasman service will be established. This will undoubtedly entail a meteorological service for aviation of quite a different character from anything which can at present be provided. On flying routes it is necessary to know the weather in far greater detail than is required for other purposes, and frequent rapid collection and dissemination of information is an essential feature. The number of weather reports which can be got from the Tasman Sea, and their distribution, depends entirely on the number and location of the ships crossing it. It can never be adequate, and frequently it is reduced almost to zero. This is one of the permanent drawbacks to weather forecasting in New Zealand. Nevertheless, this difficulty can be overcome to quite a large extent if sufficiently complete reports be available from Australia. For these to be secured, the first essential is adequate facilities for communication by wireless. The reports received would be extremely valuable in connection with the preparation of forecasts for general purposes as well as those for aviation. The need for increased wireless facilities has been referred to in previous reports. Nearly all important meteorological services now have stations of their own, and it is difficult to see how satisfactory conditions can be reached in New Zealand, except by development on the same lines.

In last year's report the Norwegian methods of forecasting were briefly discussed. The essential idea in these is that the weather is due principally to the interaction of " air masses " of different characteristics as regards temperature, humidity, and speed and direction of motion. Rainfall is, for the most part, produced by the forcing of warm air to rise in the atmosphere by colder and, therefore, heavier air-masses. Warm air almost invariably contains more water vapour than cold. The enforced rise in the atmosphere leads to the cooling of the warm air and to the condensation of some of its moisture in the form of rain. The forecaster consequently tries to define the boundaries of the different air-masses, to ascertain their characteristics, to estimate their future motion, the changes in their properties which will result from this motion, and the action of one mass upon another. We have long known that in the low-pressure trough between two of the moving anticyclones which characterize the weather of this region, travelling with considerable regularity from west to east, there is to the eastward of the lowest pressure a current of warm, moist air from the north and to the west of it a cold current from a southerly direction. The line of lowest pressure must generally, therefore, separate two different air-masses. Such a line is called a " front " and since in this case the front is moving, in the main, from west to east it must characteristically be a " cold front." This would be in accordance with the sudden rise of pressure and fall of temperature, the squally change of wind direction from north-west to south-west, and the rain, which are the common features of the line of lowest pressure.

A large proportion of our weather changes can be accounted for in this way, but clearly not all. A long front such as that mentioned has been shown by the Norwegian school on both theoretical and observational grounds to be unstable. Consequently, instead of running in a straight or gently and uniformly curved line, it tends to break up into waves. Some of these waves become very strongly developed and form what have always been recognized here as cyclones. But the difference between them and smaller waves, which were in many cases not recognized at all, is a matter of degree only. The smaller waves account for many of the irregularities in wind, rain, &c., which occur in our normal westerly depression. The waves move rapidly along the main cold front in a poleward direction. The cold air spreads out into the warm air on the northern side of the wave, while in the middle, the warm air forms a bay in the cold. On the southern side of this warm sector is what is called the "warm front" where the warm air is climbing up over the cold. Owing, however, to the almost constant eastward advance of the low-pressure trough, carrying the waves along with it, warm front phenomena are seldom easily recognizable in New Zealand. There is no doubt that the introduction of frontal methods will explain many phenomena in New Zealand weather which have hitherto been obscure.

It is interesting to note that the Norwegian methods were officially adopted for all work a year or two ago in Great Britain and a recent Commission of inquiry in America recommended their gradual adoption by the United States Weather Bureau as officers were able to become versed in them. It is very difficult for a single worker to become expert in frontal meteorology merely by reading published papers. In Norway the method has been developed by a coterie of brilliant researchers and is continually being improved and expanded. In 1931, the writer was able to get a good preliminary appreciation of the method in the course of a week's visit to Bergen. Thereafter, gradual progress was being made in the application of the method to local conditions, which differ very considerably from those of Europe. Fortunately for this Branch, however, an experienced Norwegian forecaster, in the person of Mr. Jörgen Holmboe, was attached to the Lincoln Ellsworth Antarctic Expedition. Mr. Holmboe has spent a considerable time at the Meteorological Office, Wellington, partly before the departure of the Expedition and partly since its return. While here, he has, in such time as was available, thrown himself enthusiastically into the study of local weather conditions, and, with the assistance of his special knowledge, it has been possible to gain a much clearer insight into the methods used by his countrymen. Owing to New Zealand's isolation, this is not likely to lead to any revolutionary improvement in the weather forecast, but it will add greatly to the interest and understanding of weather processes. This is bound to produce a gradual increase of accuracy in forecasting, especially when it comes to the detailed work required for aviation purposes. For the method to be used successfully, however, we need, in addition to the Australian reports already mentioned, additional staff in order that reports may be charted as expeditiously as possible and the forecasting officer have time to consider the position fully and give proper attention to all aspects of the various forecasts required. At present the officer has to plot his reports hurriedly and without further consideration proceed immediately to the preparation of the various reports and forecasts. In no other service is the forecaster so pressed for time. In the greater majority of cases a forecast has to be issued without any information from west of New Zealand, which for our purposes is the most important region.

The special forecasts asked for during the year indicate that very much increased attention is being paid by farmers to the weather forecasts in planning the day's work. Special mention may be made of warnings of approaching frost.

Upper-air Observations.

The programme of pilot balloon observations as described last year has been continued.

Reference was made previously to the presence at Wellington of Mr. J. Holmboe, of the Lincoln Ellsworth Antarctic Expedition. Mr. Holmboe had been provided by the International Polar Year Commission with a number of "radio-sondes." A radio-sonde is a piece of apparatus which is sent up into the air attached to a hydrogen-filled balloon in order to explore conditions in the upper levels. If the temperature and pressure at all levels be known, it is possible to deduce most of the remaining characteristics of the atmosphere. The instrument, therefore, has means of recording the temperature and pressure of the air through which it rises. Connected with the recording parts is a wireless transmitter which, by means of appropriate signals, is able to indicate the progressive changes. The signals are picked up in a receiver and an account of the structure of the atmosphere is thus obtained. The type of "sonde" previously used merely carried its record with it. When the balloon burst this fell to the ground, and if fortune were favourable it was picked up and sent to the institution which made the ascent. But the chances of the record being picked up in polar regions are very slight indeed, and in New Zealand it would almost invariably be carried so far by the winds that it would fall into the sea. The advantages of the radio-sonde are, therefore, obvious. But, since it has to be extremely light, it is a very delicate piece of apparatus. Also, it is of a new type, and much remains to be learned regarding the best method of construction. It, therefore, requires very skilled use, and is easily put out of order by rough handling. Owing to the damage to its aeroplane, the stay of the Ellsworth Expedition in the Antarctic was very brief. Mr. Holmboe had no time to launch his radio-sondes, and so brought them back to New Zealand. But they suffered considerably owing to the rolling of the expedition's vessel and the jarring resulting from the ramming of pack ice. The large rubber balloons used, also, deteriorate with age. It was decided, therefore, to send up most of the sondes at Wellington after overhaul, repair, and calibration. A certain number of ascents have already been made, and although the heights reached, chiefly through the failure of the balloons, have not been as great as was hoped for, some very interesting information has been obtained. The complete discussion will, of course, take some time. Very little data are available from the high levels of the atmosphere in the Southern Hemisphere, so that Mr. Holmboe's results will be especially valuable.

He has been assisted in his work by Mr. R. G. Simmers, of the Meteorological Office staff.

Publications.

Regular publications have been maintained as follows :—

(1) Monthly, in the Government *Gazette*,—

Daily observations of pressure, temperature, &c., at the Kelburn Observatory, Wellington.
Note on the weather of the Dominion for the month.
Summary of temperature observations at climatological stations other than Wellington.
Total rainfall and number of days for all rainfall stations.
Once a year, also, a table is included giving the total rainfalls, differences from average and the greatest day's fall for all stations during the previous year.

(2) Volume of "Meteorological Observations," containing monthly and annual means of pressure, temperature, wind, sunshine, and other climatological data from upwards of forty stations. The 1932 number, the last issued, contained for the first time monthly means for each hour of the day of pressure, temperature, rainfall, and sunshine at Wellington and temperature at Alexandra prepared by Messrs. A. G. C. Crust and D. C. Meldrum; also a table of observations of total solar radiation with an Ångström pyrheliometer by Mr. R. G. Simmers. A map showing the departures from normal of the rainfall in 1932 over the whole country was also reproduced.

A series of "Meteorological Office Notes," containing discussions of various aspects of New Zealand climate and weather has been appearing hitherto at intervals in the *New Zealand Journal of Science and Technology*. A further number of these has appeared in the *Journal*, but during last year it was decided that in future these notes should be published by the Meteorological Office itself, and one has already been produced thus.

The first of the notes mentioned, No. 14, is entitled "A Year's Wind Records," and was prepared by myself and Miss M. E. Ewart. It discusses hourly values of wind direction and speed as recorded at the New Zealand Air Force Base, Hobsonville, Auckland, the Rongotai Aerodrome, Wellington, and the Wigram Aerodrome, Sockburn, Canterbury. The variation of the average speed of the wind throughout the year is first mentioned, and it is shown that spring and early summer are the periods with the most wind, October or November being the windiest month. There follow data regarding the strongest gusts recorded in each twenty-four hours. Though the average wind-speed recorded at most New Zealand stations is not high, the winds are unusually gusty. The average speed of the highest single gusts for each day for the year concerned was 27·9 miles per hour at Hobsonville, 39·7 at Rongotai, and 26·6 at Sockburn. The absolute highest was 63 miles per hour at Hobsonville, 80 at Rongotai, and 60 at Sockburn. These figures illustrate the severity of the conditions at Wellington. The paper next proceeds to discuss the diurnal variation of the wind during the day in the different seasons and for different directions. There is much less diurnal variation at Wellington than at the other stations, where the night is frequently quite calm. Various local characteristics of the wind, land and sea breezes, &c., are brought out by the discussion. The concluding section of the paper deals with gustiness in greater detail and the records of some strong winds at Wellington are reproduced.

Note No. 15, by the writer, is on "Winds in the Upper Air at Wellington." A table is included, indicating the average visibility as derived from three years' observations. Conditions are generally good, fog as officially defined, occurring at 3 per cent. of the observations only. Low cloud, obscuring the mountains, is apt to be a much greater source of difficulty to the aviator than low surface visibility at sea-level, and for this reason a table which gives the average frequency of cloud at various heights above the Kelburn Observatory should prove of value. The main part of the paper deals with the frequency of light, moderate, strong, and very strong winds from different directions and at various heights above sea-level at Wellington. Up to a height of over 2,000 ft. the direction of the wind is controlled almost entirely by the form of the surrounding country, winds having to blow through Cook Strait from either the north-northwest or south-southeast. It is not till a height of over 4,000 ft. is reached that the land ceases to exercise a controlling influence on the wind direction. Above that height there is a predominance of winds from a westerly quarter, as should be expected in these latitudes. It is interesting to note that winds from the southwest predominate over those from northwest. The observations on which the discussion is based are obtained mainly by means of pilot balloons, but at very great heights more can be done with observations of clouds. At a height of 30,000 ft. there is an average drift of the air from the west of about forty miles per hour.

The papers described are intended to give information regarding the atmosphere such as is required by those studying conditions for aviation.

Miscellaneous.

On the 24th March, 1933, Miss M. E. Ewart resigned her position in the Meteorological Office prior to becoming married. She was succeeded by Mr. C. E. Palmer, M.Sc.

It is with regret that we have to record the death on the 25th January, 1934, of Mr. W. W. Goudie. Mr. Goudie had for many years been a faithful and valued servant of the Meteorological Office, and was widely known for his cheerful and kindly disposition. Following on Mr. Goudie's death, Mr. L. N. Larsen was transferred from the Christchurch Magnetic Observatory to this Branch. The loss of Mr. Goudie's services has, however, thrown a great deal of additional work on the shoulders of Miss W. M. Swan.

I desire to place on record the cordial co-operation throughout the year of members of my staff.

It gives me pleasure also to acknowledge the ready assistance received from the Post and Telegraph Department, particularly the Telegraph Division.

To the voluntary co-operative observers who sacrifice their time on week-days, Sundays, and holidays throughout the year in order that a continuous record of our climate may be obtained, the country owes a debt which it is somewhat slow to recognize.

The Weather in 1933.

After four consecutive cold years, 1933 came as a pleasant change, temperatures being on the whole rather above normal. The excess was nowhere large, but was quite definite at inland stations. On the coast the average differed very little from normal and on the east coast of the South Island was slightly below it.

The distribution of rainfall was very irregular. On the average, the year was a dry one, especially in the more densely populated areas. Most of the Thames, Waikato, Southern Hawke's Bay, Wellington, Nelson, Marlborough, and Canterbury districts experienced a considerable shortage. Southern and eastern Marlborough, in particular, had a very dry time, numbers of stations having the lowest annual totals ever recorded. In some cases these amounted to less than half the average.

Most of the Auckland Peninsula, the Poverty Bay and Northern Hawke's Bay districts, parts of the South Taranaki Bight, and most of Otago and Southland had totals above the average. On the west coast of the South Island, conditions varied greatly. Most places had more than usual, but the reverse was the case in Southern Westland. At Lake Kanieri there was an excess of almost 100 in., while Milford Sound had nearly 314 in. Though the year was not so dry as its three predecessors, the only really wet months were February and May.

From the agricultural point of view the year was once more a good one. Though some failures occurred among the wheat crops, there were many very heavy yields of excellent quality. Milk-yields, though not quite so high as in the previous year, were very satisfactory. The lambing season was one of the best recorded hitherto, and stock generally did well. The winter was exceptionally mild, with an absence of severe conditions of all kinds, and New Zealand farmers have seldom, if ever, had a better.

DOMINION OBSERVATORY.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR THE YEAR ENDED 31ST DECEMBER, 1933.

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.

Time Service.—The Observatory signal clock has been controlled mainly by the reception of radio time signals.

A special series of meridian transit observations was carried out during October–November, 1933, in connection with the international longitude programme. Observations were made with No. 1 transit instrument on every clear evening during the period, and daylight transits were also taken when weather permitted; 365 transits of stars were observed, and 63 special radio time-signals were received.

Reception of Radio Time Signals.—The following radio time signals have been received for the purpose of checking the Observatory signal clock:—

Station.	Call Sign and Wave.	Hour (G.M.T.).	Number of Times received.	Greatest observed Error of Observatory Clock.
Nauen	DFY (LW)	00	193	0·46 seconds fast, June 1st.
Norddeich ..	DAN (SW)	00	73	0·30 seconds slow, July 26th.
*Malabar	PKX (LW)	0030	19	..
Malabar	PKX (LW)	01	139	1·99 seconds fast, August 29th.†
Honolulu	NPM (SW)	03	100	0·45 seconds slow, August 15th.
Arlington	NAA (SW)	05	1	0·05 seconds fast, October 4th.
Arlington	NAA (SW)	08	20	0·29 seconds slow, November, 19th.
Annapolis	NSS (LW)	08	11	0·28 seconds slow, March 31st.
Bordeaux	FYL (LW)	08	141	0·41 seconds slow, August 15th.
Rugby	GBR (LW)	10	28	..
*Saigon	FZA (LW)	11	8	..
Nauen	DFY (LW)	12	8	..
Rugby	GBR (LW)	18	1	0·54 seconds slow, November 2nd.‡
Saigon	FZA (LW)	19	1	0·76 seconds slow, November 2nd.‡
Annapolis	NSS (LW)	21	47	0·38 seconds fast, January 1st.
Arlington	NAA (SW)	21	65	0·59 seconds fast, October 22nd.
Honolulu	NPM (LW)	24	65	5·59 seconds slow, October 8th.§

* Special signals in connection with international longitude programme during October–November. Differences from Observatory clock not yet available. † Large difference apparently due to an error in PKX signal. ‡ Large differences due to an error in Observatory clock caused by the strong local earthquake on November 2 d. 17 h. G.M.T. § Large difference apparently due to an error in NPM signal.

The total number of radio signals received during the year was 920. The signals received comprise both mean time and rhythmic signals from Nauen, Norddeich, Malabar, Bordeaux, Rugby, and Saigon; and mean time signals only from Honolulu, Annapolis, and Arlington.

It is not possible to make regular use of the British time signals from Rugby radio, owing to the unsuitable times of transmission (5.30 a.m. and 9.30 p.m. N.Z.M.T.).

In connection with the reception of radio time signals, the Marconi magnetic drum recorder was installed at the Observatory during the year. The recorder was first used on November 17, when the Honolulu (NPM) time signal at 3 h. G.M.T. was automatically recorded on the tape chronograph.

Time Signals sent out from the Observatory.—The time service has been maintained as previously, and the regular time signals sent out. The present routine at the Observatory provides for the following time signals, most of which are sent automatically by the Observatory clock, the error of which seldom exceeds a quarter of a second of time.

Automatic time signals have been sent to—

(1) The General Post Office and the Railway Department, Wellington, by telegraph daily, except on Sundays and Government holidays.
(2) Ships and to the general public at Wellington, by electric lights at the Observatory, daily:
(3) The Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays, except on Government holidays:
(4) The South Island telegraph offices, by telegraph, on Tuesdays and Fridays, except on Government holidays:

(5) The Lyttelton Harbour Board, by dropping the time ball at Lyttelton, on Tuesdays and Fridays, except on Government holidays :
(6) The Radio Broadcasting Board's station 2YA at Wellington, at 3.30 and 7.30 p.m. N.Z.M.T. (= 4 h. and 8 h. G.M.T.), daily (except Sundays in the case of the 8 h. signal). On July 11th, 2YA commenced a daily broadcast of the signal at 23 h. G.M.T. (except Sundays).
(7) Through the Wellington Radio Station ZLW, on Tuesdays and Fridays at 8.30 p.m. (= 9 hours G.M.T.), except on Government holidays.
(8) Through the Wellington Radio Station ZLW, daily at 10.30 a.m. (= 23 hours G.M.T.).

In transmitting radio time signals, the call sign of the Observatory was ZLY.

Non-automatic time signals are issued as follow :—

(1) 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.
(2) 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.

The following list gives the number of time signals sent out during the year 1933 :—

	Number of Signals.
Radio time signals through ZLW	464
Radio time signals through 2YA	819
Time signals by telegraph	555
Time signals by lights at Wellington	365
Time signals by lights at Auckland	101
Time signals by time-ball at Lyttelton	100
Time signals by telephone	46
Total number of signals sent out in 1933	2,450

The following table indicates the degree of accuracy of the radio time signals sent out from the Observatory, through stations ZLW and 2YA, during the year 1933 (at 10.30 a.m. and 8.30 p.m. N.Z.M.T.) :—

Number of times correction did not exceed 0.25 seconds	416
Number of times correction between 0·26 and 0·50 seconds	47
Number of times correction between 0·51 and 1·00 seconds	1
Number of times correction exceeded 1·00 seconds	0
Number of time signals sent out	464

During the year 1933 the signals to ZLW failed completely on one occasion, owing to faulty contacts at the Observatory. Partial failures from indirect causes resulted on five other occasions. On November 11th, at 11 a.m., the first three radio time signals were suppressed, for the observance of the Armistice Day two minutes' silence.

The radio time signals to 2YA at 10.30 a.m. and 3.30 p.m. N.Z.M.T. failed to broadcast completely on twenty-eight occasions, and partially on thirty-seven occasions. Only eleven failures were due to faults at the Observatory.

As the broadcast of time signals through station 2YA is controlled by the station staff, the Observatory cannot guarantee regularity in this service.

The time signals by telephone were given to Government House, Post and Telegraph Department, Public Works Department, Defence Department.

Government Buildings Clock.—The Government Buildings clock has been kept under fairly close control. A record is obtained at the Observatory each day by direct circuit from the clock, and the adjusting weights on the pendulum are altered as required. The greatest errors of this clock were twenty-nine seconds slow on February 17th, and 30 seconds fast on June 28th.

General Post Office Clock.—The General Post Office clock is checked by W/T daily, at 3 p.m., except on Saturdays, Sundays, and Government holidays. The greatest errors observed were 9 seconds fast on March 23rd, and 2 seconds slow on February 17th, March 6th, June 1st and 2nd, and on December 4th and 5th.

Summer Time.—The Summer Time Act, 1929, provided for the time in New Zealand being half an hour in advance of New Zealand mean time for the period beginning at 2 a.m. New Zealand mean time, on Sunday, 1933, October 8th, and ending at 2 a.m. New Zealand mean time, on Sunday, 1934, March 18th.

However, the Summer Time Amendment Act, 1933, provides for an extension of summer time in 1934, so that in that year summer time will end at 2 a.m. New Zealand mean time, on Sunday, 1934, April 29. The period of summer time is now defined by the Summer Time Amendment Act, 1933, as commencing on the last Sunday in September and ending on the last Sunday in April.

Solar Observations.—Commencing in April, 1933, the daily observation of the sun's disk by the projection method, with the 5 in. Grubb refractor belonging to the Astronomical Section of the Wellington Philosophical Society, was made a routine duty of the Observatory. Mr. I. L. Thomsen is the observer, and the results are sent regularly to Professor W. Brunner, Eidgenössische Sternwarte in Zurich, under the auspices of the International Astronomical Union. New Zealand is considered by the authorities to be a very valuable station for this work on account of its geographical position.

From April to December, observations on ninety-nine days were made, and 80 per cent. of these showed no evidence of sunspots. This work is included in the final results as published in "Character Figures of Solar Phenomena," Vol. 3, and "Astronomische Mitteilungen," Nr. CXXXI.

Occultations.—The programme of observing occultations at Wellington with the 9 in. telescope of the Wellington City Observatory by the Dominion Observatory staff, and the 6 in. telescope at New Plymouth by the local astronomical society, has been continued. The Observatory is indebted in this work to a considerable amount of voluntary assistance by members of the New Zealand Astronomical Society, and also to the predictions in the Handbook of the British Astronomical Association. During the year occultations were observed at Wellington on the following dates: January 3, March 5, 17, April 13, May 6, June 10, July 28, 29, 30, August 28, 29, September 1, 26, October 25, November 22, 24. At New Plymouth observations were made on March 3, April 13, July 1, 28, August 29, November 24. The details of these observations have been forwarded to Dr. L. J. Comrie, Superintendent of H.M. Nautical Almanac Office, London.

New Zealand observations of occultations were included in the general reductions for 1932 by the Computing Section of the British Astronomical Association, in the *Journal* of the Association. (*Journ. B.A.A.*, Vol. 44, No. 2). These results, together with those from other observatories, are also discussed by Professor E. W. Brown in the *Astronomical Journal*. The limited staff at the Observatory does not allow the reductions to be made here at present, much as this is desired.

Aurora Australis.—Excellent work is being done by Mr. M. Geddes, of Otekura, Otago, in organizing members of the New Zealand Astronomical Society, lighthouse-keepers, and captains of ships in New Zealand waters for reports of observations of the Aurora Australis. There has possibly never been such a thorough campaign in this field of work before, and one of the main results of the work is the discovery that the Aurora Australis is much more frequent than was formerly thought.

Of special interest is the report in "Monthly Notes" of the New Zealand Astronomical Society, No. 85, 1934, January, in which Mr. Geddes summarizes the results of one of the brightest displays of the Aurora Australis seen in New Zealand for many years. This occurred on September 9–10. Reports from New Zealand, Australia, and ships totalled twenty-nine. A moderate sunspot was evident on the sun, as observed at the Observatory, which crossed the central meridian in 1933, September 5·46 (days) G.M.T. The first outbreak of the aurora was noticed at Invercargill on about September 8·3, G.M.T., showing an interval of nearly three days. The main display occurred on September 9th, reaching a maximum in New Zealand at 8 h. 30 m., G.M.T., and in Tasmania at 10 h. 49 m., G.M.T. Reports were also received of a magnetic storm which occurred on the same night. In approximate conformity with the rotation period of the sun, another aurora of moderate intensity was observed on October 7, twenty-eight days after the main display. No trace of an aurora could be detected on November 4. Professor Brunner, at Zurich, reports that there was an intense area of bright hydrogen flocculus over the sunspot observed at the Dominion Observatory.

Meteor-path.—On Wednesday, 1933, May 17th, at 10·5 p.m., New Zealand mean time, a very bright fireball was seen by many people in the Wellington District, and following an appeal in the newspapers, some fifty reports were received. From these reports the real path of the body in the atmosphere was deduced, of which the following is a brief summary. The commencement of the flight was in longitude 175° 27½′ east, latitude 41° 20′ south. The mid-point of the path, which was seen by the majority of observers was overhead at the source of the Turanganui River, and had an altitude of approximately 22 miles. The end of the path was over Palliser Bay, in longitude 175° 3′ east, latitude 41° 35′ south. The total length of the path was estimated at thirty miles, and the time of flight 3 seconds. Reports were conflicting as to the time of duration of the trail, varying from 5 seconds to 2 minutes, and it therefore seems necessary to assume a ribbon shape for the trail. All reports pointed to the great brightness of the object, and it must have been one of the most spectacular fireballs seen in Wellington for some time. Although it was unfortunate that none of the astronomical observers saw the fireball, Mr. R. A. McIntosh, who is making final reductions of the observations, considers that this is one of the best-observed objects of its kind in New Zealand that he has had to deal with, and a very good path should be found.

Byrd Expedition.—While passing through Wellington, members of the scientific staff of the Byrd Antarctic Expedition visited the Observatory, and Dr. Poulter, leader of the Scientific Section, left a number of meteor reticles to be used in New Zealand in conjunction with the Antarctic observations of meteors. These have been distributed to some of the observers of the Meteor Section of the New Zealand Astronomical Society.

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

(1) Discovery of a bright spot on Saturn, by Willis, 1933, August 5th.
(2) Discovery of Nova Ophiuchi, by Peltier on August 15th.
(3) Discovery of a comet by Whipple, 1933, October 21st.
(4) Advice concerning probability of seeing the bright meteor shower of October 9th (in Europe) as a faint comet on October 20th to 28th, by Natanson.

There were four independent discoveries of the white spot on Saturn. Hay in England and Weber in Germany were almost coincident in their discovery on August 3rd; Without knowledge of this discovery, Willis at the Naval Observatory, Washington, saw it on August 5th, and Thomsen at Wellington on August 7th. The observers at the Wellington City Observatory kept the object under careful observation, and their work is used extensively in a report by Mr. B. M. Peek, of Birmingham, in the *Journal of the British Astronomical Association*, Vol. 44, No. 6.

The position of Nova Ophiuchi was not given in the original cable, and it was therefore necessary to find the star in the whole constellation. Being of the sixth or seventh magnitude, this was not a very easy matter, but Mr. Thomsen in a photographic search on August 17th found the star, and thus obtained the only estimate of its magnitude in New Zealand. It is understood that variable star observers of the New Zealand Astronomical Society are now keeping a watch on the object. It was found to be RS Ophiuchi, a star which is subject to erratic and little expected outbursts of light from time to time.

The other two objects reported were not observed.

Longitude Work.—Observations were made during October and November, 1933, by Messrs. R. C. Hayes and I. L. Thomsen, of star transits and rhythmic time signals in accordance with the International Longitude Programme. The observations include three hundred and sixty-five star transits and sixty-three wireless time signals. The reductions for this work are far in arrears. A considerable amount of the chronograph tape has yet to be measured, and none of the work has reached the stage where final reductions can be made.

While it is recognized as of importance that the results should be obtained as soon as possible since Wellington is one of the fundamental stations in the Southern Hemisphere, the small size of the Observatory staff appears likely to render considerable delay in completing the analysis of the observations.

Property on Loan.—The two telescopes belonging to the Dominion Observatory have been lent to members of the New Zealand Astronomical Society, who use them effectively on research work. The 5 in. altazimuth refractor is in the care of Mr. M. Geddes, Otekura, Clutha County, South Otago. It is used for observations of variable stars, sunspots, and comet sweeping. The 4 in. altazimuth refractor is in the care of Mr. F. M. Bateson, 368 Main Road, Karori, Wellington. It is used for variable stars and planetary work. The conditions of loan are that the instruments must be periodically returned to the Observatory for inspection, and that the borrowers must insure them against loss by fire or damage, and make regular reports of the use made of the telescopes.

Seismology.

General.—Seismic activity in New Zealand was considerably lower in 1933 than during the previous eight years. No major earthquakes occurred, and no earthquakes were reported above 7 on the Rossi-Forel scale.

Seismograph Stations.—During the year 1933 continuous seismograph records were kept at the Dominion Observatory, Wellington, the Magnetic Observatory, Christchurch, and at the following subsidiary stations: Suva, Arapuni, Tuai, New Plymouth, Hastings, Bunnythorpe, Takaka, Greymouth, and Chatham Islands. No new stations were established during the year.

The following is a complete list of seismograph stations which were operating in New Zealand and the neighbouring islands on 31st December, 1933:—

Station.	Position.		Instruments.	Person or Institution in Charge.
	Latitude.	Longitude.		
	° ′	° ′		
Apia	13 48 S.	171 47 W.	Wiechert, three components ..	Apia Observatory.
Suva	18 9 S.	178 26 E.	Milne, twin-boom	Miss Mune.
Arapuni ..	38 5 S.	175 39 E.	Milne, E.–W.	District Engineer, Public Works Department.
Tuai	38 48 S.	177 9 E.	Milne-Jaggar	Resident Electrical Engineer, Public Works Department.
New Plymouth ..	39 4 S.	174 4 E.	Wood-Anderson	Mr. H. W. Todd.
			Milne-Jaggar	Mr. C. E. Morshead.
Hastings ..	39 38 S.	176 53 E.	Milne-Jaggar	Mr. H. de Denne.
*Dannevirke ..	40 12 S.	176 7 E.	Milne-Jaggar	Mr. L. Bastings, M.Sc.
Bunnythorpe ..	40 17 S.	175 36 E.	Milne-Jaggar	Mr. W. A. Waters.
Takaka ..	40 51 S.	172 48 E.	Imamura, three components ..	Mr. W. J. Smith.
Wellington ..	41 17 S.	174 46 E.	Wood-Anderson N.–S.	Dominion Observatory.
			Galitzin-Wilip, vertical.. ..	
			Milne-Shaw, two components ..	
			Milne-Jaggar	
			Ishimoto Clinograph	
Greymouth ..	42 25 S.	171 13 E.	Milne-Jaggar	Mr. T. A. Johnston.
*Glenmuick ..	42 54 S.	173 9 E.	Inverted Pendulum	Mr. C. J. Westland, F.R.A.S.
Christchurch ..	43 32 S.	172 37 E.	Wood-Anderson	Magnetic Observatory.
			Galitzin, three components ..	
Chatham Islands	43 57 S.	176 31 W.	Milne	Mr. L. J. Elliston.

* Privately owned stations.

Thanks are due to officials and private individuals who have assisted the Observatory in seismological work by operating seismographs and forwarding records and reports.

By the courtesy of the Government of Fiji, the records from the Suva seismograph have been regularly forwarded to this Observatory for measurement. The records from the Wood-Anderson seismograph belonging to this Observatory, and installed at the Magnetic Observatory, Christchurch, have been regularly forwarded for measurement.

The following table gives the number of earthquakes recorded at this Observatory and subsiduary stations during the year 1933 :—

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Suva	9	9	11	11	7	11	11	9	8	10	16	15	127
Arapuni	5	5	8	5	3	4	6	2	5	3	5	3	54
Tuai	..	..	2	1	3	..	..	..	..	1	..	..	7
New Plymouth ..	11	3	18	7	8	9	1	1	3	3	6	10	80
Hastings	3	1	6	4	5	4	2	4	7	7	5	4	52
Bunnythorpe ..	1	1	1	1	1	..	..	1	..	..	1	1	8
Takaka	..	2	6	1	..	4	1	1	..	..	1	3	19
Wellington	35	26	54	29	31	40	25	32	37	50	70	51	480
Greymouth	..	..	1	..	1	..	..	..	..	..	..	..	2
Christchurch (Wood-Anderson)	5	4	10	3	8	8	5	4	9	3	11	4	74
Chatham Islands ..	2	..	..	2	3	3	1	..	2	..	1	..	14

The instruments installed in the stations appearing in this list are of widely varying sensitivity. Wellington is provided with a range of instruments capable of recording not only weak shocks of local origin, but also all the main earthquakes occurring in other parts of the world. This fact accounts for the relatively large figure appearing in the above table for shocks recorded at Wellington.

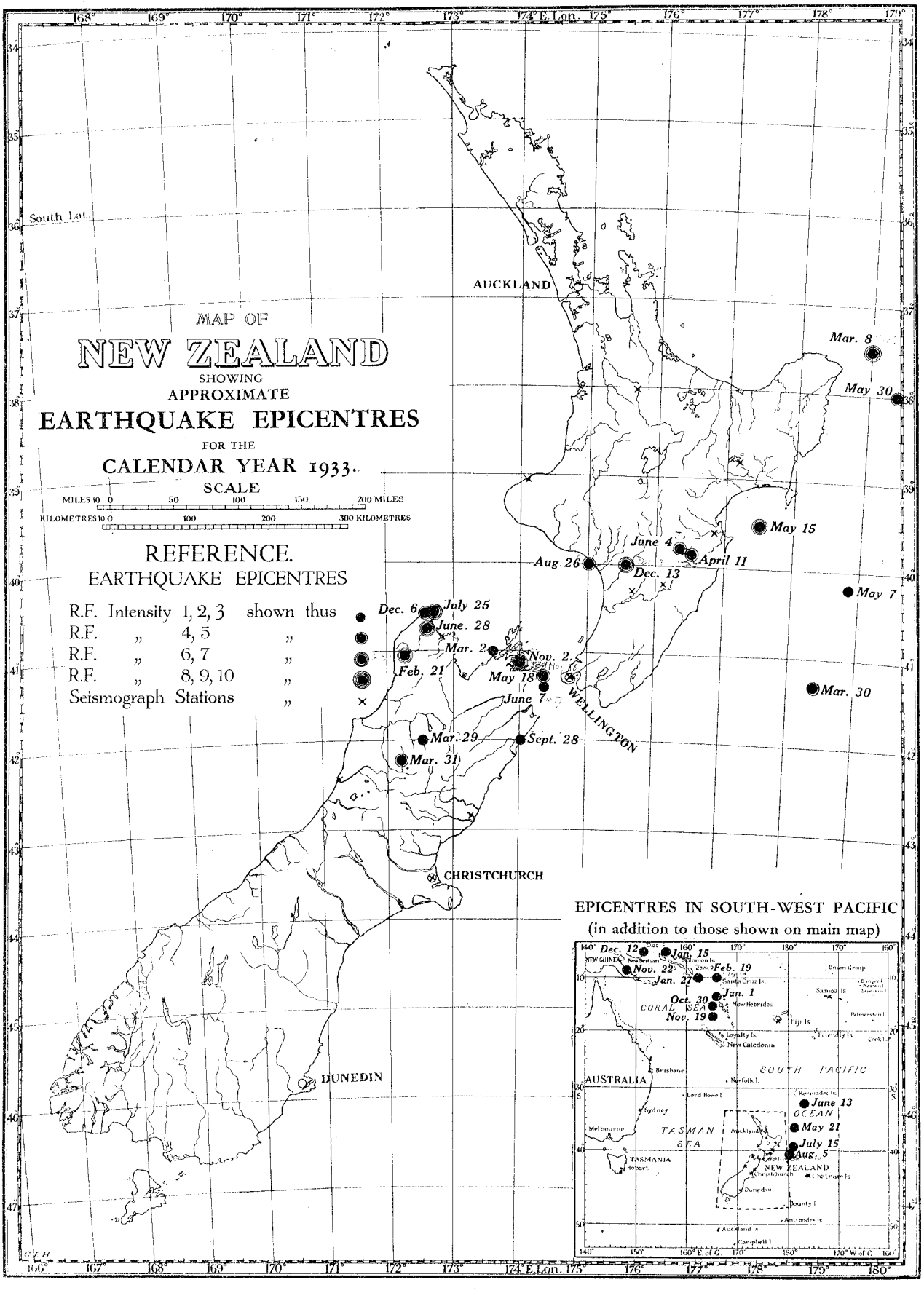
Non-instrumental Reporting Stations.—Officers of the Post and Telegraph Department and of the Marine Department, and private observers, have continued to furnish valuable reports regarding the effects of earthquakes as felt in various parts of New Zealand. The non-instrumental reports are of great assistance in the study of earthquakes. The following summary includes all earthquakes reported felt in New Zealand in the year 1933 :—

Month.	Number of Earthquakes reported felt.				Maximum Intensity.	Locality of Maximum Intensity.
	North Island.	South Island.	Both Islands.	Total for New Zealand.		
1933.						
January	5	..	..	5	4	Widely distributed.
February	..	4	..	4	7	Takaka.
March	7	9	2	14	6	Hicks Bay, Hermitage.
April	9	3	..	12	5	Waipawa.
May	12	5	1	16	6	Napier.
June	5	7	1	11	6	Takaka.
July	5	1	..	6	7	Takaka.
August	5	..	..	5	5	Wanganui.
September	4	2	1	5	5	Waiatu Valley, Owen River.
October	9	5	2	12	6	Tokaanu
November	6	7	1	12	6	Cook Strait.
December	4	2	..	6	6	Marton, Feilding, Kahurangi Point.
Totals	71	45	8	108	7	Takaka.

It will be seen that 108 earthquakes were felt in some part of New Zealand in the year 1933. Of these earthquakes, 71 were experienced in some part of the North Island, and 45 in some part of the South Island.

The following table gives the number of earthquakes in the year 1933, in which the maximum intensity reached various degrees of the Rossi-Forel scale :—

Month.	Rossi-Forel Numbers.										Totals.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
1933.											
January	..	..	2	3	..	..	..	..	..	..	5
February	..	..	1	2	..	..	1	..	..	..	4
March	..	2	4	4	2	2	..	..	..	..	14
April	..	2	7	2	1	..	..	..	..	..	12
May	..	1	6	4	4	1	..	..	..	..	16
June	..	..	6	2	2	1	..	..	..	..	11
July	..	2	1	1	1	..	1	..	..	..	6
August	..	2	1	1	1	..	..	..	..	..	5
September	..	1	1	1	2	..	..	..	..	..	5
October	..	..	6	4	1	1	..	..	..	..	12
November	1	1	4	3	2	1	..	..	..	..	12
December	1	..	1	..	3	1	..	..	..	..	6
Totals	2	11	40	27	19	7	2	..	..	..	108


MAP OF
NEW ZEALAND
SHOWING
APPROXIMATE
EARTHQUAKE EPICENTRES
FOR THE
CALENDAR YEAR 1933.
SCALE
MILES 50 0 50 100 150 200 MILES
KILOMETRES 100 0 100 200 300 KILOMETRES
REFERENCE.
EARTHQUAKE EPICENTRES
R.F. Intensity 1, 2, 3 shown thus
R.F. „ 4, 5 „
R.F. „ 6, 7 „
R.F. „ 8, 9, 10 „
Seismograph Stations „
South Lat.
AUCKLAND
WELLINGTON
CHRISTCHURCH
DUNEDIN
Mar. 8
May 30
May 15
June 4
April 11
Aug. 26
Dec. 13
May 7
Dec. 6
July 25
June. 28
Mar. 2
Nov. 2
Feb. 21
May 18
June 7
Mar. 30
Mar. 29
Sept. 28
Mar. 31
EPICENTRES IN SOUTH-WEST PACIFIC
(in addition to those shown on main map)
Dec. 12
Jan. 15
Feb. 19
Nov. 22
Jan. 27
Jan. 1
Oct. 30
Nov. 19
June 13
May 21
July 15
Aug. 5
AUSTRALIA
TASMAN SEA
CORAL SEA
SOUTH PACIFIC OCEAN
NEW ZEALAND
TASMANIA
Sydney
Melbourne
Brisbane
Hobart
Auckland
Christchurch
Dunedin
Fiji Is
Samoa Is
New Hebrides
New Caledonia
Loyalty Is
Norfolk I.
Lord Howe I
Kermadec Is
Chatham Is
Bounty I
Antipodes Is
Auckland Is
Campbell I
NEW GUINEA
Solomon Is
Santa Cruz Is
Union Group
Friendly Is
Cook Is
140° E of G
150°
160° E of G
170°
180°
170° W of G
160°

The total number of earthquakes reported felt, and the maximum intensities reached in each of the years 1921 to 1933 (inclusive) are as follows :—

Year.	Number of Shocks.	Maximum Intensity, R.–F. Scale.
1921	91	8
1922	1,187	8
1923	76	6
1924	70	7
1925	76	8
1926	173	8
1927	107	8
1928	80	8
1929	678	10
1930	748	8
1931	432	10
1932	313	9
1933	108	7

It must be remembered that consideration of the figures given in this table of reported shocks involves careful interpretation. In a year of major shocks, followed by numerous aftershocks, many of the latter go unnoticed, while during a period of quiescence there is a tendency for all shocks, however slight, to be reported. This leads to undue emphasis being placed upon the earthquake activity of what is sometimes a comparatively quiet period.

It should be noted that the great number of earthquakes reported in 1922 can be largely accounted for by the very detailed recording made of the swarm of shocks which took place in the Taupo district.

Earthquakes in 1933.—The following is a list, giving the position of the epicentre, of all important New Zealand earthquakes during the year 1933. The summary includes (1) Earthquakes of high intensity, (2) earthquakes felt over a wide area :—

N.Z.M.T. of Shock.	Position of Epicentre.		Maximum Intensity as felt. (R.–F. Scale.)	Locality reporting Maximum.
	South Lat.	East Long.		
1933. d. h. m.	°	°		
Feb. 22 0 29	41·0	172·3	6–7	Takaka.
Mar. 30 18 49	38·0	179·5	5	Tokomaru Bay.
April 11 12 45	39·8	176·5	5	Wairoa.
May 15 19 50	39·5	177·5	6	Hawke's Bay.
June 29 10 49	40·7	172·5	6	Takaka.
July 26 11 3	40·5	172·5	7	Takaka, Nelson.
Aug. 27 10 25	40	175	4–5	West Coast, North Island.
Nov. 3 4 48	41·2	174·0	6	Cook Strait.
Dec. 13 20 18	40·0	175·5	6	Southern part of North Island.

The approximate positions of all the earthquake epicentres which were determined in New Zealand and the South-west Pacific during the year 1933 are shown on the accompanying map.

Survey of East Coast.—Owing to the increased seismic activity off the east coast of the North Island, and other changes which have recently been reported along the coast, it is highly desirable that a detailed marine survey be carried out of the whole east coast, and particularly the North Island.

Buller Earthquake, 1929, June 16–17.—Seismograph records of this earthquake were obtained from observatories all over the world, and Mr. L. Bastings, M.Sc., F.Inst.P., has been making an intensive study of them. He has already published a discussion (*New Zealand Journal of Science and Technology*, Vol. XV, pp. 128–142, 1933, Dominion Observatory Bulletin No. 86) of the material from the nearer hemisphere, dealing with the magnitude, focal depth, and nature of the original disturbance, together with the travel times and velocities of the preliminary movements in this hemisphere. He also made considerable progress in reading and interpreting the wealth of material from the antipodes, and it is expected shortly to publish some far-reaching conclusions derived from the analysis of these data.

Publications.

The Observatory has continued to publish a preliminary earthquake report each month, giving sufficient data for the determination of epicentres of the principal earthquakes. These reports also include errors of the time signals emitted from the Dominion Observatory. With this report is also published a preliminary seismological report from the Magnetic Observatory, Christchurch.

Besides the preliminary reports, the following complete seismological reports were published during the year 1932 :—

E. 31.—Seismological Reports for 1931, October, November, December.
E. 32.—Seismological Reports for 1932, January, February, March.
E. 33.—Seismological Reports for 1932, April, May, June.

Also the following Bulletins:—

Bulletin No. 85.—Seismological Report of the Hawke's Bay Earthquake of 3rd February, 1931. (C. E. Adams, D.Sc., F.R.A.S.; M. A. F. Barnett, Ph.D., M.Sc., F.Inst.P.; R. C. Hayes).

Bulletin No. 86.—Some Seismological Aspects of the Buller Earthquake, 1929, June 16–17. (L. Bastings, M.Sc., F.Inst.P.)

Bulletin No. 87.—New Zealand Mean Time.

Bulletin No. 88.—Report of the Dominion Astronomer and Seismologist for 1931.

Bulletin No. 89.—Mean Time and Time Service.

Bulletin No. 90.—Seismology in New Zealand.

Bulletin No. 91.—Report of the Dominion Astronomer and Seismologist for 1932.

An article on "New Zealand Mean Time and the Time Service Arrangements" was prepared for the 1934 *New Zealand Nautical Almanac*. Articles on "Seismology in New Zealand," and "New Zealand Mean Time" were prepared for the 1934 Year-Book.

STAFF.

The staff for 1933 was as follows: Mr. R. C. Hayes, Professional Assistant; Mr. I. L. Thomsen, Clerk.

C. E. ADAMS,
Dominion Astronomer and Seismologist.

APIA OBSERVATORY, SAMOA.

Director: J. WADSWORTH, M.A. (Cantab.).

The programme of work in geophysical subjects was maintained during the year 1933–34 as in previous years.

TERRESTRIAL MAGNETISM.

The instruments used for absolute measurements of the earth's field were the Tesdorpf magnetometer No. 2025 and the Schulze earth inductor No. 2. The elements declination and horizontal intensity were recorded continuously by means of the Eschenhagen variometers installed in the Gauss House. There were interruptions in the autographic records from time to time during the year owing to defects in the driving clocks and again in December and January owing to the necessity for adjustments to the mirrors. The Godhavn balance was placed at first in the same room as the other variometers, the needle being set at right angles to the magnetic meridian; but the sensitivity of the instrument in this position seemed to be too small to show the changes in vertical force which normally occur in Samoa and it was moved in September into the spare room of the Gauss House where the sensitivity could be increased by an alteration in the azimuth of the needle. Like the Eschenhagen variometers the records of this instrument were interrupted by the failure of the driving clock.

The mean values of magnetic elements derived from the absolute observations during 1933 are as follow:—

Declination	10° 37·7′ East.
Inclination (or dip)	30° 18·4′ (South Pole).

SEISMOLOGY.

The astatic pendulum and the vertical seismograph by Wiechert have been in continuous operation during the year apart from stoppages caused by the failure of the driving clocks, and the necessity for adjustments of balance. The driving clock of the horizontal seismograph was improved in June by fitting ball bearings to the rollers which carry the charts.

The total number of earthquakes recorded during the year ending on March 31st, 1934, was 272. This number represents mostly the small shocks which frequently originate in the neighbourhood of Samoa; but there were also a few earthquakes recorded at greater distances, including in particular the big earthquake of January 15th, 1934, in India. Ten slight local shocks were sufficiently intense to be felt by residents of Samoa.

METEOROLOGY.

The programme of work in meteorology included surface observations twice a day as in previous years and some measurements of the upper winds from time to time, using pilot balloons. The method used with pilot balloons was normally the method of the single theodolite in which the rate of ascent of the balloon is assumed to be constant. The total number of pilot balloon ascents was 91 and the greatest height attained was 34,000 ft.

A daily report of weather was displayed at the Post Office and at the Customs House during the six months of the hurricane season, November to April.

A new tower was erected in September to carry the mast of the anemometer. The vane of this instrument, which is a Dines pressure tube anemometer, is now at a height of 80 ft. above the ground. This elevation is necessary to avoid the sheltering influence of the trees. At the same time, the direction recorder was replaced by a new pattern and the records of wind obtained since the building of the tower have been very satisfactory. The site chosen for the tower is on the east side of the main building of the Observatory as far removed as possible from the magnetic instruments and it is estimated that the effect of the steel used in its construction will be negligible in this position as regards the measurement of the earth's magnetic field. The tower stands on four blocks of concrete and was erected by the Public Works Department of Apia. The recording apparatus is placed in a small wooden hut at the base.

A visibility meter designed by Wigand was purchased during the year from Messrs. R. Fuess, of Berlin. The grass minimum thermometer was broken one night by a horse which strayed into the grounds and a black bulb thermometer was broken accidentally. Another black bulb *in vacuo* was stolen during February, 1934, as well as the ball of the sunshine recorder. Some old German rain-gauges have been repaired by a local tinsmith for issue to local stations in Samoa and the Assman psychrometer was set going in September. Intercomparison of the barometers shows that the Kew pattern instrument by Calderara and the Fortin pattern by Casella give readings which agree almost identically.

The heights of some of the local rainfall stations in Upolu were determined by means of an aneroid barometer.

During the cruise of H.M.S. "Diomede" to Rarotonga in April, 1933, a visit of inspection to the metcorological instruments at the radio station was arranged through the courtesy of the Commodore Commanding New Zealand Station and in August following the Commander of H.M.S. "Veronica" kindly arranged a similar inspection of the stations at Atafu and Fakaofo in the Tokelau Islands. In July the Commodore arranged a meeting at Apia which was attended by a representative of the wireless station and the Director of the Observatory to discuss the possibility of using the New International Code in the weather bulletins broadcast from Apia. It is intended to present these messages in the form known as "Weather shipping." The text will be very concise; but agreement as to the date of commencement has not yet been reached with the various island services.

Observations from Atafu in 1929 have been prepared for inclusion in the Reseau Mondial. Mr. G. Henry, resident agent at Pukapuka, received instruction at the Observatory in the reading of meteorological instruments during his visit to Samoa in October, 1933.

Since October, 1933, the territory of Western Samoa has been using Zone Time based on the meridian of 165° W. The civil time of Samoa is thus eleven hours slow compared with Greenwich.

The mean values of meteorological elements during the year 1933 are as follow :—

METEOROLOGICAL SUMMARY, 1933.

(Readings taken at Apia Observatory, Mulinu'u, at sea-level.)

Month.	Pressure.	Temperature.	Rainfall.	Humidity.	Sunshine.	Wind.
	In.	° F.	In.	Per Cent. (9 a.m.)	Hours.	Miles per Hour.
January	29·728	79·5	23·01	82	162·1	6·3
February	29·770	79·7	22·71	79	168·6	5·1
March	29·795	78·7	11·41	81	157·5	3·9
April	29·830	79·1	17·04	81	174·8	4·1
May	29·866	79·6	3·69	78	233·8	4·2
June	29·874	78·9	1·93	75	259·2	2·5
July	29·884	77·3	5·95	76	251·3	2·6
August	29·933	77·9	1·75	72	281·4	3·8
September	29·900	78·0	10·70	76	215·7	*
October	29·865	78·4	9·71	78	216·3	8·2
November	29·821	78·7	12·63	77	220·2	6·3
December	29·808	77·9	15·63	82	145·7	4·6
Total ..	..	..	136·16	..	2486·6	..
Mean ..	29·839	78·6	..	78	..	..

* Anemometer dismantled 1st–14th. New tower erected.

Notes on Tropical Storms and other Disturbances 1933–34.

April, 1933 : On the 6th of April a tropical cyclone was centred near Vila in the New Hebrides. The barometer fell to 29·40 in., and the wind rose to force 8 from south-south-east.

September, 1933 : Wet weather and unusual westerly winds were experienced in Samoa, due to the development of a shallow depression between Samoa and Tonga on the 27th.

January, 1934 : A tropical cyclone formed in the New Hebrides on the 15th moving on a southerly course. The barometer was reported to read 28·93 in. on the 16th at Port Vila, and the wind rose to force 10 from north-west the same day. Rarotonga experienced strong winds from the north-west on the 31st. These winds were associated with a cyclonic depression near the Cook Islands.

March, 1934 : Strong east winds were experienced at Norfolk Island from the 14th to 16th. They were associated with high readings of the barometer to the south.

ATMOSPHERIC ELECTRICITY.

A continuous record of the potential gradient of the air was made as in previous years using Benndorf self-recording electrometers at the station in the lagoon and the station on the mainland at the Observatory. Absolute measurements of the gradient of potential were made in June, August, and October, using the method of the stretched wire. The measurements in June and August were done with a raft in the lagoon ; but those in October were made at the old site on Watson's Island in an attempt to clear up a discrepancy in the exposure factor of the Lagoon Station. The Lagoon Station was closed in December, 1933.

MONTHLY MEAN VALUES OF ATMOSPHERIC POTENTIAL GRADIENT, APIA OBSERVATORY, SAMOA, 1933.

(The units are volts per metre.)

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Land	114	106	103	107	105	110	110	119	113	122	115	125	112
Lagoon	139	121	110	119	124	125	131	135	125	144	135	163	131

Tides.

The tide-gauge was maintained in operation at the Lagoon Station throughout the year. Hourly readings were tabulated day by day as well as the times and depths of high and low water. Copies of the tabulations were sent to the United States Coast and Geodetic Survey, Washington, D.C., U.S.A.

Time Service.

The standard clock by Strasser and Rohde was controlled from time to time by wireless time signals from Annapolis, U.S.A., and also by occasional observations of the transit of the sun with the Heyde transit telescope. The time signals for the magnetographs and seismographs were provided by the "Synchronome" clock, the necessary electric current being derived from voltaic cells. Experiments were made during the year to test the relative efficiency of dry cells and Leclanche cells. The clocks were occasionally disturbed by slight earthquakes.

The radio set was reduced to three valves in December.

Personnel, Buildings, and Equipment.

A vacancy occurring in the clerical staff was filled in May by Pele Feagai. The Administration of Western Samoa have kindly undertaken to keep the grass cut in the grounds of the Observatory as from August, 1933, and one of the Chinese labourers hitherto employed for this purpose has been dismissed. One Chinaman was still retained as caretaker and handyman at the reduced rate of pay which is now operative in Western Samoa.

In the Director's house it became necessary to renew the stove in the kitchen and the wiring of the electric lighting.

Mr. Glover left Samoa on the 7th November on furlough.

Grateful acknowledgment is due to the British Admiralty, the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the Rockefeller Foundation of New York for very generous and substantial grants made during the year.

CHRISTCHURCH MAGNETIC OBSERVATORY.

REPORT BY THE DIRECTOR.

During the year 1933, the customary observational routine of the Magnetic Observatory has been carried on and, in addition, a considerable amount of close surveys with magnetic balances were carried out in the field by two of the staff to provide data for use in connection with geophysical prospecting.

Magnetographs: During the year the Eschenhagen magnetograph has been operated at the Amberley Sub-station, and the records have been developed, annotated, and measured over intervals of hours. From the measurements mean hourly values of D, H, and Z have been computed. Tables of these for the three years 1931, 1932, and 1933 are being published in one volume during 1934. The resulting mean values for the year 1933 are:—

		Change since 1932.
Magnetic declination	18° 00′·14	+ 2′·8
Magnetic horizontal force	0·22339 cgs.	— 8γ
Magnetic vertical force	—0·55232	— 5
Magnetic inclination	—67° 58′·73	— 0′·56
N	0·21245	—14γ
E	0·06904	+15
T	0·59579	+ 2

It is a fact that at Christchurch the secular change in magnetic declination was accelerated during the period 1924–1930. Instead of being about 3′ per annum, it was in the neighbourhood of 5′ per annum.

The question arises as to the possibility of a connection between this and the interval of mega-seismic activity experienced in New Zealand lately.

During the Polar Year absolute magnetic observations have been made at Amberley at intervals of about ten days; the proper Absolute House having been shifted from Christchurch was fortunately available for these. The La Cour magnetograph cellar at Amberley has been covered effectively with a weather-proof roof, and has since dried out well. With occasional slight readjustments the La Cour magnetographs are functioning better and very little record is lost other than that due to lamp failure.

The measurement of Polar Year records obtained in 1932–33 has been effected as desired, Mr J. F. Gabites having been employed on that work. Data for twelve months have been duly transmitted to Dr. La Cour, Secretary to the International Polar Year Commission. As desired, print-through photo-copies of the Eschenhagen curves for the year have also been made and forwarded for use in the discussions. Copies of all tabulations sent have been kept here for reference. As there was a distinct lack of major magnetic disturbances during the Polar Year, the La Cour magnetographs are being continued in operation, as at many other Observatories, with the approval of the Polar Year Commission. They enable the times of occurrences of peaks, &c., during magnetic storms to be obtained with an accuracy of about ±2 seconds, and I understand that Dr. La Cour has already been able to report to the Commission a verification of the world-wide simultaneous nature of some of the phenomena of magnetic storms, about which considerable doubt formerly existed.

Appreciation is expressed of the help of the New Zealand Polar Year Committee, and thanks are due to those who generously contributed to the Magnetograph Fund and thus enabled this Observatory to take its part successfully in the Polar Year magnetic observations. Especially are thanks due to the principal contributors, His Excellency the Governor-General, Lord Bledisloe, Mr. G. Shirtcliffe, and the member bodies of the New Zealand Institute (now the Royal Society of New Zealand).

Seismology.

The Galitzin three-component seismographs have been operated at Christchurch successfully during the year. The seismograms have been carefully measured and phases identified. Very valuable records have been obtained from practically all important teleseismic disturbances, of which some 127 were recorded during the year. Accurate timing has been obtained from chronometer and clock rated twice daily by radio time signals from the Dominion Observatory. The Short-period Wood-Anderson E.–W. component recorder has also been successfully operated.

The recording of the Galitzin seismograms has since August been effected on a traversing uni-axial set of four similar drums, driven by an A.C. synchronous motor from the mains through reducing worm gears. Considerable time was occupied by the Director in constructing this mechanism, and tests have shown only very slight errors in timing. Steps are being taken to eliminate these, and to prevent the effects of wear becoming gradually evident, by a slight change in the design of the last and slowest worm drive in the reducing chain, by this means paper consumption was reduced by one-half, to the minimum suited to these instruments, and it became possible to run all components together and record in the one cellar. Furthermore the advantage was gained of precisely superposable records thus saving labour in annotating and reducing results. Since this change it has been possible to record and interpret many more records than previously. Inquiries for the "Monthly Provisional Bulletin" from overseas stations have increased many fold. Further great help to us accrues from the excellent exchange publications received through the co-operation of these stations. As indicated in the 1931 report it is intended to shift these instruments to the present Adie Cellar, which is roomy and well heat-insulated. Now that the Polar Year is completed the Adie magnetographs can be housed in the cellar at the Amberley Sub-station without interfering with the high-speed recording, except for a few days during installation.

The present synchronous magnifications of the Galitzin seismographs are for E., 346 ; for N., 290 ; and for Z., 239. Experience gained by operating at the above magnifications shows that a synchronous magnification of 300 for all three components will be most suitable here. An especially valuable record of the Baffin Bay earthquake was obtained on November 20th last. The times from the Galitzin Z component recorder here are of unique value. As at all observatories equipped with these instruments microseisms on occasions vitiate records somewhat. This is experienced equally at Riverview on solid sandstone strata. Consequently it is advisable to perform standardizing experiments during anti cyclonic weather. Monthly returns have been communicated promptly to Head Office for inclusion in the Department's preliminary Bulletins which are circulated among overseas stations.

Observations of the Atmosphere.

The Benndorf electrograph has been operated continuously, and while occasionally the activity of ballooning spiders are a detriment, valuable records have been obtained, and measurements are being made of culled records during the Polar Year, to give the variations of the electric potential gradient.

Activities in meteorology have included the usual recordings three times daily (Sundays and holidays twice) and the working-up of these observations. Pilot-balloon observations have been made on all suitable mornings, and at midday on term days during the Polar Year to December. Telegraphed reports of 9 a.m., pilot balloon, and 4 p.m. data are sent daily to the Director of Meteorological Services. Some work in determining corrections of thermometers, barometers, rain-gauges, &c., has been done when requested.

Magnetic Survey Observations.

During different periods of approximately five months each Mr. Baird and later Mr. Beagley were engaged separately on magnetic geophysical survey field-work. Since their return the only geophysical survey done here has been the determination of the magnetic properties of rocks chiefly by the method of E. F. Herroun.

It has been recommended that some repeat stations of the Magnetic Survey of New Zealand be reoccupied in order to control our knowledge of the secular change over the country. As aviation progresses it will be found necessary, very shortly, to make observations at the principal aerodromes. Apart from the desirability of exact knowledge of the magnetic values at the aerodrome grounds, and of their uniformity thereover for adjusting compasses, such observational stations are especially likely to be available for all time as secular change stations. This work is all the more necessary because, even now, oil companies and others interested in aviation seek information which make such observations highly desirable.

Henry F. Skey, Director.

Approximate Cost of Paper.—Preparation, not given; printing 910 copies (including maps and graphs), £106.

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