1938.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(TWELFTH ANNUAL REPORT OF THE).

Presented to both Houses of the General Assembly by Leave.

CONTENTS.

MINISTER'S STATEMENT.

THE fact that the promotion, co-ordination, and active prosecution of scientific research in relation to the industrial and social needs of the community has been undertaken as a State activity in every progressive country is a sufficient indication of its importance in national progress. The term "scientific research" covers an indefinitely wide sphere of activity, and it is well to emphasize the nature and scope of the work of the Department of Scientific and Industrial Research in New Zealand and its importance in relation to development of national resources—not excluding the people themselves for, as one authority has said, "Wherever and whenever new science touches society it creates a disturbance which has hitherto been mostly accepted as inevitable, but is often a high price to pay for progress."

The activities of the Department are divided broadly into two sections—viz., the provision of essential scientific services to the Government, and the fostering of scientific research in relation to the needs of special branches of industry.

In the former section are included the Dominion Laboratory, Meteorological Office, Geological Survey, Soil Survey Division, and the Plant Research Bureau with its several Divisions. The Dominion Laboratory includes among its many scientific services to the community and the Government the examination of many hundreds of milk samples in the course of each year to ensure that the desirable standard of the purity of the milk-supplies is maintained; the analysis of many and various samples of food and drugs to preserve the already high standard of quality of these commodities; the examination of diverse materials for the Police Department; and the regular examination of materials purchased by Government Departments to ensure that they comply with specifications. Recently much work has been done for the Housing Department in connection with the examination of a wide range of building materials, with the result that valuable advice has been given as to the durability and general standard of quality of the materials used. In addition to this indispensable service work, the Dominion Laboratory is also carrying out industrial research work particularly in relation to the phormium, kauri-gum, and fruit industries. For example, experiments on the gas storage of New Zealand apples with a view to improving their keeping-qualities have shown definite application of this method, and an investigation of the curing of lemons which is almost completed has produced results of real value to the industry in indicating the methods by which optimum results may be obtained.

The work of the Meteorological Branch has recently increased very greatly in scope and importance, as a result of the rapid expansion of commercial aviation within New Zealand, and the development of trans-oceanic air services. The provision of frequent and accurate weather forecasts is indispensable for the safe running of air services, and the efficiency of the organization which has been built up in New Zealand within a very short period compares very favourably with similar organizations overseas.

The Government's proposals in regard to the establishment of an iron and steel industry, and the recent activity of oil-prospecting, have brought into relief the importance of accurate data on geological structure and mineral resources of the Dominion which is being collected by the Geological Survey Branch of the Department. The geophysical surveys carried out by the Department during the past few years, the results of which are in final stages in the press, have also provided data which have considerable value in connection with prospecting for oil, gold, and other minerals. The important point is that the study of our natural resources must be carried out thoroughly and accurately so that data are available as a secure foundation upon which we can take action and conserve our resources wisely as necessity arises, and with as little lag as possible behind world developments.

Soil survey is recognized the world over as basic in regard to land development and utilization, and this need was recognized and met by the formation of a Soil Survey Division of the Department, which has already mapped a large area of New Zealand soils. During the past year an extensive programme of work was carried out in Hawke's Bay, North Auckland, Blenheim, West Coast, and Banks' Peninsula, the results of which will be published shortly. The problem of soil erosion and land deterioration in New Zealand has recently come into prominence, and in this connection the Soil Survey Division has contributed important data collected in the course of soil surveys in various districts of New Zealand, together with recommendations for remedial measures based on close observation of the conditions in affected areas.

Plant research has been consolidated into an organization fully equipped to deal with problems involved in the control of plant diseases and insect pests, and also the further improvement of our grasses and feed and horticultural crops. During the year the experiments of the Bureau on the culture of linen flax in New Zealand, supported by examinations of the fibre by courtesy of the British Linen Industry Research Association, reached a stage at which some indication of the commercial possibilities for the establishment of the industry in New Zealand can be obtained. The system of testing and certifying plant sprays and other protective materials, carried out by the Plant Diseases Division, has been further developed during the year and continues to give valuable service to fruitgrowers and horticulturists. Two officers were sent overseas, one to make a special study of the control of important insect pests of the Dominion (*e.g.*, the diamond-back moth); the other to become acquainted with the latest advances in plant bacteriology to facilitate the study and control of bacterial diseases of plants in New Zealand.

On the recommendation of the Council of Scientific and Industrial Research, the Government invited Dr. John Hammond, F.R.S., of the Animal Nutrition Research Institute, Cambridge, to visit New Zealand and report on the organization of animal research with a view to securing the most effective means of directing and co-ordinating a comprehensive attack on the problems of animal nutrition and production. Dr. Hammond's report was duly presented and will be considered by the various interests involved with a view to making recommendations to the Government.

Three new research associations were established to provide a co-ordinated scientific and technical service for the woollen manufacturing, boot and shoe manufacturing, and tobacco industries.

Much has been said, and is still being said, in regard to the impacts or reactions of scientific progress on industry and on society, and it is undoubtedly right that close attention should be given to the study of these reactions and their relation to human welfare. It was for this reason, therefore, that I established two new branches of the Department to promote research on standards and social science respectively. The advantages to be gained by the application of the principle of standardization to everyday commodities and processes are manifold and, furthermore, ensure the intelligent, speedy, and economic application of technological progress with resultant benefit to industry and the consumer.

Since its inception, the Standards Institute has promoted the development of standards over a wide front, and a detailed account of its activities and the progress made is contained in a separate addendum to this report.

The activities of the Social Science Research Bureau during the past year have been directed chiefly to a study of the standard of living of dairy-farmers, which has produced results of definite value and interest in a new field of research as far as New Zealand is concerned. The study of dietary requirements which was commenced under the auspices of the Bureau has been handed over to the Medical Research Council at a stage where family diets had been formulated, giving sufficient energy and protective food value.

One of the biggest factors in the industrial efficiency of most secondary industries is that of the technical education of managers and foremen who are in charge of special technical operations. The need for such education has been emphasized, for example, by the recent experience of the Dairy Research Institute in connection with the maintenance of the activity of single-strain starters under factory conditions. It was found that personal instruction in the special technique had to be given in the factories by officers of the Institute, and when this was done no difficulty was experienced in obtaining entirely satisfactory results.

The question of providing suitable educational facilities for training men in industrial technology, so as to provide them with a basic knowledge of science as applied to industrial processes and thus enable them to avoid troubles by anticipating their causes, is therefore an important one, and is at present being actively discussed by the Council of Scientific and Industrial Research and the educational authorities.

D. G. Sullivan,
Minister in Charge of Scientific and Industrial Research Department.

SECRETARY'S REPORT.

The Hon. D. G. SULLIVAN, Minister in Charge of Scientific and Industrial Research.

I have the honour to submit herewith the annual report of the Department for the year 1937–38.

E. MARSDEN, Secretary.

The Council of Scientific and Industrial Research held five meetings during the year. The personnel of the Council is as follows:—

Professor H. G. Denham, M.A., D.Sc., Ph.D., F.I.C., F.R.S.N.Z., Professor of Chemistry, Canterbury University College, Christchurch (Chairman).
Dr. J. C. Andrews, Ph.D., M.Sc., Freezing-works Manager, Auckland.
Mr. A. H. Cockayne, I.S.O., Director-General of Agriculture, Wellington.
Professor J. Malcolm, M.D., Ch.B., Professor of Physiology, University of Otago, Dunedin.
Dr. R. O. Page, D.Sc., Tannery-works Manager, Christchurch.
Mr. G. A. Pascoe, Department of Industries and Commerce.
Mr. J. M. Ranstead, Matangi, Farmer.
Professor W. Riddet, B.Sc.(Agric.), N.D.A., N.D.D., Massey Agricultural College.
Sir Theodore Rigg, M.A., M.Sc., F.I.C., F.R.S.N.Z., Director, Cawthron Institute, Nelson.
Dr. E. Marsden, M.C., C.B.E., D.Sc., F.R.S.N.Z. (Secretary).

Mr. T. H. McCombs, M.P., M.Sc., attended meetings of the Council as the special representative of the Hon. the Minister.

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

Permanent services—

	£
Head Office, publications (including the *New Zealand Journal of Science and Technology*), Research Scholarships, and grants to the Royal Society of New Zealand, the Australian and New Zealand Association for the Advancement of Science, and the Imperial Institute	11,782
Dominion Laboratory (with branches)	18,300
Geological Survey	7,626
Meteorological Office	17,445
Apia Observatory	3,578
Magnetic Observatory	2,695
Dominion Observatory	2,601
Grants to Imperial Agricultural Bureaux	5,588
Research investigations	93,847
	163,462
Recoveries	33,406
Net expenditure	£130,056

GENERAL.

As in previous years, grants were made to the following research organizations in Great Britain participating in the inter-Imperial Agricultural Research Scheme: The Imperial Agricultural Bureaux headquarters, £1,438; the Cambridge Low Temperature Research Station, £2,000, of which the Meat Board contributed £1,000; Farnham House Entomological Laboratory, £750; the Imperial Institute of Entomology, £450; the Imperial Mycological Institute, £350; and the British Wool Industries Research Association, Torridon, £300. Grants of £113 to the Bureau of Dairy Science and £187 to the Bureau of Forestry, both of which were recently established under the Imperial Agricultural Bureaux scheme, were also made.

During the past year the steady development and consolidation of the Department's activities in industrial research and in providing essential scientific services to the Government have been fully maintained. In addition, the needs of several industries which have hitherto lacked a centralized and co-ordinated research and technical service have been provided for by the formation of research associations. I refer to the woollen-manufacturing, boot- and shoe-manufacturing, and tobacco industries. The Woollen Manufacturers' and the Leather and Shoe Research Associations are financed by direct contributions from the industries concerned, subsidized £1 for £1 from the Consolidated Fund; while the Tobacco Research scheme is financed by funds contributed by the industry through the Tobacco Control Board, and subsidized similarly from the Consolidated Fund. All three schemes have functioned very successfully since their initiation, and the results obtained and the services rendered have fully justified their institution. The hearty co-operation of the industries concerned and the readiness of their members to bring forward and discuss their problems with the research officers have contributed greatly towards the effectiveness of the services rendered.

A Radio Research Committee, representative of the National Broadcasting Service, the Defence services, the Post and Telegraph Department, and the Department of Scientific and Industrial Research, was set up during the year to direct and co-ordinate radio research in New Zealand and to facilitate co-operation with the Australian Radio Research Board and the British Broadcasting Corporation in the investigation of problems of common interest. The Committee has completed a survey of the measurements of radio signals from the main broadcasting-stations, and the results are in many ways remarkable and of great value in the problems of coverage.

An event of outstanding importance, and one which may be expected to have far-reaching consequences, was the visit to New Zealand of Dr. John Hammond, F.R.S., of the Animal Nutrition Research Institute, Cambridge. On the recommendation of the Council of Scientific and Industrial Research, the Government invited Dr. Hammond to New Zealand to report on the organization of animal research, particularly in relation to problems of nutrition and production. Following an extensive tour of the Dominion, in the course of which he obtained first-hand knowledge of the animal industry and its attendant problems, Dr. Hammond prepared a comprehensive report on the problems of animal research in New Zealand as he saw them and the type of organization which he considered would most effectively deal with them. This report will form a valuable basis of discussion between the State Departments concerned and representatives of the producers with a view to recommending a course of action to the Government.

The Department was fortunate to obtain the services of Dr. J. H. Kolb, Professor of Rural Sociology in the University of Wisconsin, U.S.A., in an advisory capacity, to assist the Social Science Research Bureau. Dr. Kolb, whose visit was made possible by the Carnegie Corporation, has given most valuable inspiration and direction not only to the work of the Social Science Research Bureau, particularly the rural standard-of-living survey, but also to other activities of the Department touching directly upon social problems—*e.g.*, the land-utilization survey of Hawke's Bay.

The work of the Plant Research Bureau has been further consolidated, and is now a major branch of the Department's activities. Suitable accommodation for the various Divisions has been provided, and the Bureau is now much better equipped to cope with the wide range of problems presented to it. The season was a particularly difficult one as regards plant and insect pests of all kinds, and several new imported plant diseases were definitely identified. The importation of plant diseases and insect pests has become a serious problem, and, in co-operation with the Department of Agriculture, steps are being taken to secure more effective quarantine of imported plant material by making fuller use of the special facilities available in the Plant Diseases Division.

A very successful Meteorological Conference, representative of the various countries vitally concerned in the development of meteorological services for aviation in the south-west Pacific, was held during the year at Wellington.

During the year a Medical Research Council was set up under the Department of Health, the Department of Scientific and Industrial Research being represented by the Secretary in order to secure the necessary liaison with the research activities of the latter Department.

The results of the experimental work in geophysical survey carried out during the past few years have been collected in the form of a bulletin, which gives a valuable indication of the application of methods in New Zealand. This is now in the final stages of printing.

The coal-survey investigations have indicated that it will probably be desirable to conserve certain special coals for use in the iron and steel industry rather than use them for purposes for which other coals are equally suitable.

The accommodation in Head Office and Wellington branches of the Department is severely taxed, and there are, in addition, the disadvantages consequent upon the present decentralization. A start has been made, however, with plans for new buildings which will provide the much-needed space and centralization.

The Head Office staff was augmented during the year by the appointment of Mr. M. McG. Cooper to replace Mr. W. M. Hamilton, who was appointed as Assistant Scientific Liaison Officer in London, and the attachment of Mr. L. W. Tiller on his return from England to Head Office staff in the capacity of Fruit Research Officer.

Appointments to the research organizations of the Department during the year included the following: Mr. J. M. Allan, Tobacco Research Officer; Dr. T. R. Vernon, Mycologist, Dairy Research Institute; Dr. S. Townend, Textile Research Officer, Wool Manufacturers' Research Association; and Dr. H. Finlay, Micropalæontologist, Geological Survey Branch.

The staff of the Department have loyally and efficiently carried out the programme of work for the year, and their co-operation is gratefully acknowledged.

DOMINION LABORATORY.

The Dominion Laboratory and its branches examined during the year the large total of 15,452 samples for Government Departments and in connection with various industrial research investigations, an increase of 3,320 over last year's total. A full report of the work done will be issued separately.

During the year the school milk scheme was introduced, and a considerable number of samples of the milk supplied to schools were examined for purity and effective pasteurization.

The special laboratory for the physical and chemical examination of coal samples taken in connection with the survey of the coal resources of the Dominion is now in effective operation in collaboration with the geologists in the field. A geological report on the Blackburn area was published in last year's annual report, and work is at present centred mainly in the Greymouth and Westport areas.

The Dominion Laboratory is performing very essential and important services in testing a great variety of materials used by Government Departments—*e.g.*, Post and Telegraph, Public Works, Housing—with a view to determining whether they comply with specifications, and giving advice in cases where difficulties have been experienced in their use. A wide range of building-materials have been examined for the Housing Department, for example, and regular analyses of paints and paint materials used in housing contracts for the Government have been carried out.

In co-operation with officers of other branches of the Department and of other Departments, it has been decided to organize this work on more constructive lines in relation to the study of building-materials of the Dominion and problems related thereto. For example, exhaustive tests of the physical properties of pumice concretes of various mixes have been made, as well as an investigation of the effects of pozzolanic ingredients in concrete mixtures. The investigations of bricks, paints, and paint materials are also being extended.

Special investigations carried out in connection with the deposits of clays, bentonite, and diatomaceous earth in New Zealand, with a view to assessing their value for commercial uses, have shown that deposits of these materials in certain areas are of high quality. Purchases of some of these materials have been arranged.

Experiments on the curing and colouring of lemons are now nearing completion. Much useful information has emerged from this work, and the results obtained, together with the recommendations arising from them, are being made available to the citrus industry in a departmental publication.

Experiments on the gas storage of apples which were carried out during the year provided useful data for the two varieties used.

The quartz spectrograph is proving a most valuable instrument in connection with the study of a variety of problems, particularly those relating to the function of trace elements in human, animal, and plant health. An examination of a number of typical samples of pasture from selected areas in New Zealand for their content of minor elements is being undertaken in order to provide standards for comparison with areas where mineral deficiency occurs or is likely to occur. Preliminary work was begun on the estimation of trace elements in the ash of samples of milk from certain areas where mineral deficiencies are suspected to occur.

The Chemical Engineering section of the laboratory has been fully occupied during the year with the examination of the efficiency and practicability of industrial processes and machinery and in dealing with technical inquiries from industry. The examination of new or improved chemical and mechanical processes for the stripping and pulping of phormium fibre has formed an important part of the work of this section.

Kauri-gum Refining.

The reports to hand from Dr. J. Hosking, who is working in London, indicate that not only can kauri-gum refining be carried out technically and economically, but the product under service trials can find a ready place in the market if steady supplies are forthcoming.

METEOROLOGICAL BRANCH.

The principal concern of meteorological institutions in recent years has been the provision of the services required by the rapidly expanding civil and military air services. This has been as much the case in New Zealand as elsewhere. While the new demands have been anticipated as far as was possible by the international meteorological organizations, and the machinery devised by them needs only to be put in operation, the provision of the personnel required has been very difficult. This has been particularly the case in English-speaking countries, because very few of our academic institutions offer a training in meteorology. It must, however, be borne in mind that the intense study of climate is becoming of continually greater importance in relation to production and industry as these become progressively developed more and more on scientific lines.

The prospective development of regular trans-ocean airways has meant that the responsibilities of official meteorological services are not confined to their own countries, but extend over the surrounding seas. The weather over the ocean will have to be studied with practically the same detail as over the land. This will obviously involve much closer co-operation between the countries bordering the oceans and from shipping than in the past. In order that the necessary co-operation between the various governing authorities in the south-west Pacific might be arranged, it was clear that the meteorological institutions concerned should confer. The New Zealand Government therefore authorized the calling of a Conference at Wellington. This Conference, which is referred to more extensively in the Director's report, proved to be very successful. The organization required to meet the demands of aviation in the south-west Pacific was defined and the machinery for its development specified. It now remains for the various countries to implement the resolutions of the Conference. So far as New Zealand is concerned, much preliminary work has been accomplished, and it is anticipated that the development of the meteorological services will lag little behind that of the airways. The most important item in the meteorological organization is the provision of the extensive means of radio communication required. In this direction the Meteorological Office has received every assistance and sympathy from the Post and Telegraph Department and the Aeradio Committee.

The network of both rainfall and the more complete climatological stations has been further improved. The increased susceptibility of the country to flooding owing to the depletion of the forest covering and the disturbance of the soil will lead to increased demand for rainfall statistics.

Attention is called to the publications of the Meteorological Office, which the nature of numerous inquiries show to be insufficiently well known to the public. In them will be found much information regarding the climate and weather of the country.

GEOLOGICAL SURVEY.

This year the Geological Survey continued the exploration of the Dannevirke and Reefton districts and began the examination of the Greymouth, Moeraki, and Glenorchy subdivisions. The Reefton and Greymouth areas were mapped many years ago, but the work carried out on this occasion was much more detailed and was undertaken for special purposes.

The mapping of the mineralized areas of Kirwan Hill and Alexander River, the only remaining portions of the Reefton Lode-belt to be examined, was completed this year. Thirty years ago the Kirwan's Reward Co. mined blocks and fragments of quartz found on the surface and mixed pell-mell with broken slate and sandstone. This deposit appears to be a large slip derived from nearby higher lode-bearing country.

The Moeraki Subdivision, in north-eastern Otago, covers part of the belt of younger strata fringing the schists of that region. The district contains the Shag Point coalfield. Indications of oil also occur, but the chance of a profitable deposit being present is not good.

The Glenorchy Subdivision includes alluvial diggings now largely deserted as well as quartz veins carrying scheelite and a little gold. The high mountains of this region makes exploration arduous and even dangerous, and in order to expedite the mapping aerial photographs were taken.

That New Zealand has relatively little high-rank coal has long been known. The detailed geological mapping begun this season in the Greymouth coalfield is to obtain the data necessary for a more accurate estimate of the amount of coal available, in order to allow of this limited natural resource being utilized to the best advantage. The area is extremely rugged and difficult, and air photographs will be used to reduce the labour involved.

Geophysical work was carried out at Waiuta and Kotuku. Both areas are covered with gravel and moraine, and in the latter these loose deposits completely mask the structure of the petroliferous strata. At Waiuta the cover is more broken. The Blackwater lode has been worked for many years, and other auriferous quartz veins of which the outcrops are hidden may well be present in the seven miles of mineralized country between Waiuta and Merrijigs. The main features of the structure in the Kotuku region have been worked out. Suggestive results have been obtained from magnetic surveys in the thermal regions and also in relation to the ore deposits at Onekaka.

Geologists spent five weeks on a visit to the oil seepages at Madagascar Beach, on the coast between Martin Bay and Milford Sound. The seepages are in Tertiary rocks which, however, are much disturbed, and there are other definitely unfavourable features which make the chances of commercial oil extremely poor.

Dr. H. J. Finlay has joined the staff of the Geological Survey as micropalæontologist. The value of the foraminifera as a means of determining stratigraphical horizon is widely recognized in America, Europe, and the Dutch East, and the study of these minute forms will provide more data for the correlation of different groups of rocks and for the elucidation of their structure.

Two geological bulletins were issued during the year.

OBSERVATORIES.

The Dominion Observatory at Wellington, the Magnetic Observatory at Christchurch, and the Apia Observatory, Western Samoa, have carried out their usual programme of astronomical, seismological, meteorological, and magnetic observations.

The customary annual survey of seismic activity in New Zealand has been prepared by the Dominion Observatory with the co-operation of the observatories at Christchurch and Apia, the Post and Telegraph Department, officers of the Marine Department and other Government Departments, and a number of voluntary observers, whose assistance is gratefully acknowledged.

Further improvements to the seismograph equipment at the Dominion Observatory and other seismograph stations have been made during the year, and these will enable more rapid progress to be made with the study of local earthquakes and related problems. An instrument for measuring the tilting of the ground was repaired and reinstalled at the Dominion Observatory during the year. Tilt records are likely to provide valuable data on local land movements, and may be of some assistance in the problem of earthquake prediction.

Interesting observations on cosmic-ray activity have been made at Christchurch, and correlated with magnetic disturbances and auroral displays.

An extensive study of the radioactivity of New Zealand rocks and soils has been completed.

PLANT RESEARCH BUREAU.

The Plant Research Bureau organization has made good progress during the year in the co-ordination and reorganization of all plant research activities. The whole of these are under constant review by the Plant Research Bureau Committee, which, on account of its representative personnel, ensures a proper balance of research activities.

During the year the Agronomy, Grasslands, and Entomology Divisions and the Botany Section have been provided with new buildings so that they can undertake their investigations under much improved conditions. The laboratories and offices are situated in the midst of the field-trial areas. The construction of the buildings for the Plant Diseases Division at Mount Albert, Auckland, is about to commence. Meantime, the larger section of the staff is still accommodated at Palmerston North. Very good progress has been made in the preparation of the field experimental area of this Division at Mount Albert, the whole of which is now available for trial purposes.

The Botany Section, now established in Wellington, has engaged in two major investigations which have a bearing on economic problems—viz., ragwort and South Island tussock grasslands. The botanical characteristics of ragwort have been studied with a view to securing clues as to its control. These studies have revealed the remarkable capacity of the ragwort to regenerate from root fragments; the importance of abundant moisture-supply before seed germination occurs; that water, rather than wind, appears to be the main cause of spread; that plants have difficulty in establishing in a dense pasture sward; and that toxic sprays seldom injure the plant to such an extent that regeneration from roots will not occur.

The Agronomy Division is principally concerned with the arable crops of farm lands, and is located at Lincoln so as to permit of the closest collaboration with Canterbury Agricultural College and the Wheat Research Institute.

The Division has from its series of trials secured a great deal of new information regarding the field possibilities of Liral Crown pedigree linen flax, this flax variety being one which provides a high yield of high-quality fibre material. Investigations are being carried out in association with the Linen Industry Research Association of Great Britain and with the Department of Agriculture, for the purpose of ascertaining the possibilities of this crop as a basis for a linen industry in the Dominion.

Work on rape has resulted in the selection of very promising strains of both Giant and Broad Essex types, which are now keenly sought after by growers. With field peas and lucerne, selection and breeding work has made progress to such a stage that it will shortly be possible to release for commercial use improved varieties of both crops.

A new feature of the Division's work this year relates to horticultural crops, and an officer has been appointed to undertake this work.

The Entomology Division is located in Nelson for the purpose of ensuring close co-operation with the Cawthron Institute, where there is already a well-equipped entomological research station. The activities of the Division have, during the year, been centred largely on measures designed to control the two principal insect pests of rape and turnip crops—namely, diamond-back moth and white butterfly. Though two species of insects which preyed upon the diamond-back moth have been introduced, these have failed to establish owing to the presence in New Zealand of hyperparasites, and it was consequently decided that the Associate Director should proceed overseas for the purpose of studying this pest in its European environment, where apparently its ravages are not so serious as they are in New Zealand, owing, possibly, to its being controlled by other insects already well established there. The *Pteromalus* parasite of the white butterfly has not proved entirely satisfactory, as witnessed by the great prevalence of white butterflies during the 1937–38 summer. The question of the failure of the parasite to keep pace with the pest is being closely investigated.

The Division has a section at Lincoln College, where marked progress has been made in investigations relating to Hessian fly, the wheat bug, and the grass-stem weevil, while preliminary work has also been done in connection with the grass grub and the grass caterpillar.

The Grasslands Division at Palmerston North works in close association with Massey Agricultural College and with the Dairy Research Institute. The pedigree mother rye-grass seed resulting from a long period of careful selection and breeding has proved itself superior to all previous lines of true perennial rye-grass in the field trials under ordinary farm conditions located in various parts of the country.

The white clover produced by the Division has been a marked success, and work is now being directed towards the production of two distinct types, a smaller-growing one for sheep, and a more prolific type for cattle.

Selection and breeding is proceeding now on most of the principal pasture types in use in New Zealand. The pasture survey of the Hawke's Bay area has proceeded fairly rapidly, over half of the province now being completed in detail.

The feed-taint work done in association with the Dairy Research Institute has revealed the liability of any pasture containing over 30 per cent. white clover to cause taint in milk.

In order that the Division should keep well abreast of pasture research proceeding overseas, the Director was granted leave of absence for twelve months during 1937, and was given an opportunity of visiting Pasture Research Stations in Great Britain, Europe, and America.

The Plant Diseases Division is still located partly at Mount Albert, Auckland, and partly at Palmerston North. Ultimately, when the buildings are completed, the Division will be located at Mount Albert, Auckland.

During the year the Division, having made good advance with spray-testing technique, has issued certified lists of approved sprays, thus providing orchardists, importers, and manufacturers with valuable guidance regarding materials in use for pest control.

Considerable trials have been made with the growing of *Pyrethrum*, a plant which yields an organic insecticide of increasing importance. Some strains have been secured capable of providing a very high content of toxin.

Much attention has been devoted to devising measures for the control of citrus canker and citrus blast, the occurrence of which has only recently been reported in the Dominion.

Good progress continues to be made in the study of plant virus diseases, particularly those affecting the tobacco and potato crops.

A fungus responsible for the loss of vitality in Southland rye-grass seed has been traced, and at present its life-history is being worked out.

A careful survey of the rusts affecting cereal crops in the South Island is being made, as the possibilities of control depend very largely upon whether the species present in New Zealand pass through a sexual stage on some alternate host plant.

Attention is also being devoted to problems of industrial mycology, such as the destruction of tent canvas by moulds and the complete sterilization of wraps used for beef carcasses in the chilled-meat trade.

Certain investigations of problems or portions of problems of interest to the Bureau have been undertaken by members of the staffs of Massey and Canterbury Agricultural Colleges, while a large measure of co-operation has characterized the association of these Colleges, the Fields, Horticulture, and Live-stock Divisions of the Department of Agriculture, and Cawthron Institute with the different Divisions of the Bureau. In consequence, more comprehensive attacks are being made on the main crop problems of the Dominion, and a much fuller appreciation of the value and need for combined effort now exists.

DAIRY RESEARCH INSTITUTE.

Important advances in the study of the technique required for the maintenance of single-strain starters, which have been found to control openness in cheese, were made during the year, whereby it was shown that the system of "heavy inoculation" combined with a true aseptic technique was entirely successful in maintaining starter activity for an indefinite period.

In order to place the commercial application of these findings on a sound footing, a trial of the methods recommended by the Institute was carried out by members of the Institute's staff in three factories in Taranaki during February. No difficulty was experienced in maintaining the activity of a single-strain culture, and failures in other factories were shown to be due to faulty technique. Experience has proved it to be essential to give *personal* instruction in the correct technique; where this was given, no further trouble was experienced. The solution of the main problem—the maintenance of starter activity indefinitely—has left the way open to work out the most effective cheesemaking procedure. In this connection there is definite evidence that the flavour of the cheese is improved by adding to the cheese milk selected types of flavour-producing organisms in addition to the single-strain starter, and work on this subject is being continued.

Experiments on the storage of cheese at low temperatures have shown that storage at 31° F. is a perfectly satisfactory method of keeping cheese for such periods as may be called for in exceptional circumstances.

Studies on the problem of taint in dairy-produce have been continued, and buttermaking experiments have shown that good-quality butter can be made from clover-tainted cream when it is impossible to avoid some degree of taint in farming practice. Grazing and cattle-feeding experiments have also shown that these taints can be reduced to a negligible degree by controlling the clover content of the pastures.

A systematic study of the moulds liable to contaminate dairy-produce, and their source, is being made, with a view to reducing their incidence by the institution of suitable methods of control.

Further experiments have been carried out on the important subject of the influence of the type of feed consumed by milking-cows on the dairy-produce obtained.

At the request of the Department of Health, the Institute undertook the responsibility of pasteurizing and bottling milk supplied daily to school-children in Palmerston North. The Department of Health supplied the necessary up-to-date plants, which were installed in the Massey Agricultural College dairy factory. A high standard of milk quality has been maintained throughout the whole period, and all concerned have expressed satisfaction with the operation of the scheme.

The customary meeting of dairy-factory managers was held in April to explain the results of research work carried out in the past season. Addresses were also given at various dairy conferences, articles were contributed to the public press, and a large number of technical papers were published. By these methods wide dissemination of the results of the Institute's work was secured.

WHEAT RESEARCH INSTITUTE.

The Wheat Research Institute has continued to give valuable service to wheatgrowers, millers, and bakers, in addition to pursuing and developing its wheat-breeding activities and fundamental researches on the physical and chemical qualities of flour and bread.

The Chief Chemist of the Institute spent nine months abroad, and furnished a valuable and comprehensive report on the latest developments in America, Europe, and Australia in connection with the testing of flour and the artificial drying of wheat.

A large number of moisture determinations in wheat were carried out by the Institute for farmers during the past season, in order to determine whether samples of wheat were in optimum condition for harvesting.

The varying characteristics of wheat from season to season, due to varying growing and harvesting conditions, have in the past caused difficulties to bakers by reason of the different treatment required to get the optimum result from each season's flour. This trouble has now been overcome as a result of the steps taken by the Institute to secure supplies of each new season's wheats, mill and bake them by various methods, and advise the bakers by means of bulletins as to the best method of treatment.

The milling and baking qualities of Cross 7, which was grown on 12,000 acres in 1937, remain outstanding. Two other wheats of outstanding quality are nearing the end of their breeding trials, and will probably be distributed to farmers within the next two years.

During the past year a national research scholar has carried out a valuable series of investigations on the action of ascorbic acid as a bread improver and on the proteolytic enzymes of flour.

LEATHER AND SHOE RESEARCH ASSOCIATION.

During the year negotiations between the leather-manufacturers, the boot and shoe manufacturers, and the Department of Scientific and Industrial Research for the formation of a combined Leather and Shoe Research Association were brought to a successful conclusion. The technical problems arising in these industries are so closely interrelated that mutual benefit cannot fail to be derived from investigations conducted by a combined research organization which makes possible the desirable co-ordination of work.

Among the leather research investigations undertaken during the year were the following: An examination of the factors affecting the hardness imparted to leather by tannage, thus following up a previous finding that hardness is definitely correlated with the wearing-value of sole-leather; and the development of a tanning process which will produce a leather representing a good compromise between the tanners' requirements of resistance to water-absorption together with high wear resistance, and the shoe-manufacturers' requirements that it shall be easily worked under modern methods of mass production.

In shoe research, the first problem submitted for investigation was the tempering of sole-leather, and as a result of the work carried out and the recommendations made, the process has been placed on a much sounder and more uniform basis.

Monthly circular letters have been maintained as an important part of the service. These letters, besides communicating the results of research work, have an educational function, and reports received indicate that they have been greatly appreciated.

SOIL AND LAND-UTILIZATION SURVEYS.

Substantial progress has been made with the major soil surveys in Hawke's Bay and North Auckland, and the former is very near completion. The soil survey of Hawke's Bay is associated with a comprehensive land-utilization survey of the province, including the detailed mapping of the pastures by the Grasslands Division of the Plant Research Bureau and a study of farm management and farm practice by officers of the Department of Agriculture. The soils of the greater part of Hawke's Bay have now been surveyed, and soil maps are being drafted for publication. The Heretaunga Plains soils have been surveyed in considerable detail, and the maps which have been prepared are now in the press. These soil maps, together with the data obtained from the orchard and agricultural surveys, will form a valuable guide to the present utilization and future potentialities of the area.

The pasture and farm-management surveys of Hawke's Bay are also approaching completion, and a number of maps are in the final stages of preparation for publication.

In North Auckland the soil survey now covers about half the province, and an account of the soils of Whangarei County is being written up for publication.

Soil surveys of the following areas were completed during the year: Bank's Peninsula; the Wairau Plains—undertaken primarily to provide some of the data for the Public Works Department in connection with an irrigation project; the pakihi lands of Westport; a reconnaissance survey of the pumice soils of Gisborne; and a preliminary survey of phormium soils. The survey of phormium areas indicated that the more fertile and well-drained the soil, the more vigorous and healthy is the flax. Good alluvial soils in particular appear to be well suited to flax.

A valuable and stimulating report on soil erosion and land deterioration in the heavier rainfall districts of New Zealand was prepared, which draws attention to the seriousness of the present situation, but at the same time indicates that it is not too late to take steps to prevent more widespread and irremediable damage to our agricultural and pastoral lands.

FRUIT RESEARCH.

A full programme of research was carried out during the year under the general direction of the Fruit Research Committee and the Fruit Cold Storage Committee, both of which are fully representative of the various interests involved—*i.e.*, the Department of Scientific and Industrial Research, the Horticulture Division of the Department of Agriculture, the Cawthron Institute, the New Zealand Fruit Export Control Board, and the New Zealand Fruitgrowers' Federation.

In addition to the current activities at the various experimental orchards, comprising manurial, rootstock, pruning, and spraying experiments, and plant-protection studies, a number of new projects have been started.

The production of unfermented fruit-juices on the Continent, and recently also in the United Kingdom, has aroused considerable interest in New Zealand as a promising means of utilizing low-grade fruit, for which there is at present no economic means of utilization. The Fruit Research Officer, during his recent visit to Great Britain, collected a great deal of information in regard to the production of unfermented fruit-juices, and on his return initiated experiments in order to test the practicability of utilizing New Zealand apples for this purpose. These experiments, which were facilitated by the co-operation of a local producer of this type of fruit-juice, are promising but as yet incomplete, and the final results are awaited with much interest.

Experiments on the curing of lemons, which have been in progress at the Dominion Laboratory for some time past, are now completed, and the results are being prepared for publication. This work has thrown much light on the mechanism of the curing process, and has enabled the requisite conditions for optimum results to be laid down for guidance in commercial practice.

During the year a new stripper with tail-stripper attachment, adapted from a sisal decorticator, was completed in collaboration with the Bureau of Industry. In commercial trials the throughput was satisfactory. Costs are less, and the product is of higher yield and quality than with the stripper at present in use. A final model is under construction. With the knowledge of the yields per acre of the new varieties, the conditions of minimum insect attack, and the use of the new stripper it is now safe to state that phormium can be produced at a price which will meet world markets. More knowledge is desirable from the soil and water-table point of view, but sufficient is known to justify a definite long-range forward move.

RADIO RESEARCH.

During the year a fully representative Radio Research Committee of the Council of Scientific and Industrial Research was set up with the following objectives:—

(*a*) To co-ordinate the radio research activities of the Broadcasting, Post and Telegraph, Defence, and Aviation Services, and of the several University Colleges.

(*b*) To establish liaison with the radio research organizations in other parts of the Empire, notably with the Australian Radio Research Board, so that research in the Southern Hemisphere may be carried out in the most profitable way.

(*c*) To promote the development of radio research in New Zealand in its scientific aspects and with special reference to local geographical and meteorological factors in this country.

Research is at present proceeding along three main lines—namely, in connection with the ionosphere, the reception of distant signals, and the propagation of wireless waves over the earth. Research on the ionosphere, which plays a predominant part in the propagation of wireless waves over any considerable distance, is being actively pursued at Canterbury and Victoria University Colleges.

At the request and with the co-operation of the British Radio Research Board, research on the reception of distant short-wave signals is being undertaken. Much scientific and practical importance attaches to this work—*e.g.*, in relation to the location and arrangement of aerials for receiving or transmitting short-wave signals from or to England. Preliminary work has begun at Auckland University College, and the full programme of research will be developed as soon as a man capable of carrying out the highly specialized technique can be secured.

A considerable amount of valuable and interesting data has been accumulated in the course of a study of the field strength of signals from North Island broadcasting-stations and the distortion produced by obstacles of various kinds.

TOBACCO RESEARCH.

Following upon representations by the Nelson Provincial Tobacco-growers' Association urging the establishment of a tobacco research station in the Nelson Province to investigate problems relating to the culture and manufacture of tobacco, steps were taken during the year to set up an organization for tobacco research with finance contributed by the industry through the Tobacco Control Board and subsidized £1 for £1 by the Government.

In order that the research work should be closely related to the needs of the various phases of the industry, an advisory committee was set up to represent the growers and the manufacturers and the Tobacco Control Board on the one hand, and the State Departments and scientific institutions concerned on the other—viz., the Departments of Scientific and Industrial Research and Agriculture and the Cawthron Institute.

A Tobacco Research Officer was appointed, and a programme of work on the control of tobacco diseases, particularly mosaic disease, and chemical work on tobacco soils and factors relating to the quality of tobacco-leaf, was drawn up. A grant was made to the Cawthron Institute for assistance, and special facilities made available for the study of tobacco diseases, and for a detailed survey of tobacco soils to be carried out in co-operation with the Department of Scientific and Industrial Research.

Arrangements were also made for the lease of a suitable area of land at Motueka for the purposes of the Tobacco Research Station.

A survey of the incidence of tobacco-mosaic disease in a large number of tobacco-fields has been carried out, and the relative importance of a number of factors operating in its dissemination has been determined. A full report of this work will be published shortly in the *New Zealand Journal of Science and Technology*.

A number of selected soil samples have been analysed for plant food status, and as a result there are indications that in certain cases harm has resulted from the excessive application of lime and wood-ash. Preliminary investigations of the relation between the quality of tobacco-leaf and its chemical composition will be developed more fully in the coming year.

WOOL MANUFACTURERS' RESEARCH ASSOCIATION.

The advantages to be gained from a combined research organization for the purposes of investigating problems pertaining to the woollen-manufacturing industry in New Zealand were recognized by mill-owners in a practical way during the year by their consent to the formation of a Wool Manufacturers' Research Association. The amount contributed by the industry is being subsidized in the usual way by the Government on the basis of £1 for £1 expended.

The helpful co-operation of the University of Otago enabled the laboratory of the research association to be located at Otago University under the direction of Professor F. G. Soper. A research chemist has been appointed, who is making a detailed study of the wool-scouring process, as a result of which it has already been possible to effect savings in scouring material and improvement of the scoured wool.

A number of service problems have also been investigated, including the diagnosis of stains, the cause of rotting of bathing-costumes used under certain conditions, and the examination of water-supplies. In co-operation with the Bacteriology Department of the University, work has been started on bacterial attack on wool and its prevention.

A Textile Research Officer has also been appointed, and is spending some time in Great Britain and the Continent to study the latest developments in manufacturing processes before proceeding to New Zealand.

A monthly circular-letter service has been instituted for the rapid dissemination of the results of the work being carried out, and members of the association have fully expressed their appreciation of the services rendered.

SOCIAL SCIENCE RESEARCH BUREAU.

Since its inception a little more than a year ago, the Social Science Research Bureau has made very good progress with the projects which were selected for research. The major project—an inquiry into the standards of living of dairy-farmers in New Zealand—has produced results of considerable interest and practical value, a résumé of which is included in this report. A similar inquiry into the standards of living of two groups of urban workers has begun.

The Bureau has also fostered research on problems of human nutrition by making a grant available for dietary studies at the Home Science Department of the University of Otago. A report on minimum adequate low-cost dietaries has been completed, and is being published in the *New Zealand Journal of Science and Technology*. A study is also to be made of the actual dietaries of a group of industrial workers' families, in conjunction with the urban standard-of-living survey.

Through the courtesy of the Carnegie Corporation, the services of Dr. J. H. Kolb, Professor of Rural Sociology in the University of Wisconsin, United States of America, were made available to the Bureau in an advisory capacity for six months, and his specialized knowledge and experience have been of great value.

A bibliography of social and economic research in New Zealand has been prepared, with the object of surveying the work that has been carried out in this sphere and collecting it in readily available form.

NEW ZEALAND STANDARDS INSTITUTE.

The activities of the New Zealand Standards Institute during the past year, and the substantial progress made in the development of the numerous projects in hand, are fully reviewed in a special supplementary report (H.–34A).

OVERSEAS CONTACTS.

The Department's Scientific Liaison Officer, Mr. Nevill Wright, and his assistant, Mr. W. M. Hamilton, who are attached to the High Commissioner's Office in London, have continued to perform valuable services in maintaining contact with research organizations in the United Kingdom; in representing the New Zealand Government on various scientific bodies; in making the necessary arrangements for the examination of experimental shipments of meat, fruit, and dairy-produce; and in procuring information in connection with scientific matters in general.

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

DAIRY RESEARCH INSTITUTE.

Dairy Research Management Committee: Mr. A. Morton (Chairman), Messrs. G. A. Marchant, A. Linton, A. J. Murdoch, A. H. Cockayne, J. Murray, Q. Donald, T. C. Brash, W. Singleton, and Professor H. G. Denham. Director of Research: Professor Wm. Riddet. Secretary: Dr. E. Marsden.

Research work carried out during the year has been principally a continuation of that in progress in the previous year. Investigation of factors affecting the quality of cheese, flavour and keeping-quality of butter, and the relationship of some pasture plants to the quantity and quality of milk produced by cows fed thereon have been the chief lines of work. As in the past, these broad problems have been subdivided into projects which have been allotted to specialist workers, and the results of these separate efforts have been collated in the interpretation of the main issues.

The several projects and salient findings from each are briefly summarized in a statement below, where are given the names of the workers chiefly responsible for each project. A review of the summaries clearly shows that good progress has been made in the past year.

As pointed out in the last annual report, the fundamental cause of "fermentation" and "slit" openness in cheese has been shown to be certain gas-producing organisms that develop in the cheese while it is in the early stages of curing. These undesirable organisms generally have their origin in the milk-supply and, although their numbers and effects may be minimized by sanitary methods of milk-production and careful pasteurization of milk, there are no known methods either of absolutely preventing them from gaining access to cheese or of rapidly identifying them in milk. Fortunately their effects can be materially restrained by the use of starters which themselves contain no gas-producing organisms. Conversely, their influences are accentuated by weak starters and by other starters which sometimes contain a proportion of gas-producing organisms apparently added to starter to produce cheese flavour. Thus the Institute's success with single-strain starter cultures makes a notable advance in the control of openness in cheese texture. It has now been clearly shown that the activity of these starters can be preserved by rigid application of the technique recommended for their preparation. It has been equally well shown that good cheese can be made when the selected single strains are used as the sole source of starter, provided that care is taken to avoid either over- or under-development of acidity during the cheesemaking process. In addition to assisting in making cheese closer in texture, the use of these single-strain starters makes for uniformity in quality and time of manufacture from day to day. It should be obvious that openness of texture cannot be entirely overcome by the use of these starters. A clean milk-supply is also essential. The principal sources of infection of the milk-supply with gas-producing lactobacilli and methods of treating milk to overcome their effects are now engaging attention.

While single-strain starters make easier the production of cheese close in texture, and make cheese of reasonably good flavour, there is definite evidence that the flavour of the cheese is improved by adding to the cheese milk selected types of flavour-producing organisms. There is also some evidence that these have a restraining influence on the incidence of discoloration. These matters are being closely examined.

Chemical and cheese-manufacturing studies indicate that it should ultimately be possible to specify manufacturing procedure adaptable to different starters and milk each of known composition, thus removing much risk in the art of cheesemaking and putting it on a scientific basis.

Cheese-storage trials have indicated methods of keeping cheese for long periods as may be called for in exceptional emergencies.

Buttermaking experiments have shown that good-quality butter can be made from clover-tainted creams when it is impossible to avoid some degree of taint in farming practice. Grazing and cattle-feeding experiments have also proved that these taints can be reduced to a negligible degree by controlling the clover content of the pasture. Fundamental studies in buttermaking show that starter organisms exert a prejudicial influence on the keeping-quality of butter and that their effect is not entirely dependent on the acidity of the butter as has been commonly believed in the past. Thus the use of starters in making butter that has to be kept for a long period is called in question.

The keeping-quality of butter is also affected by the temperature employed in pasteurizing the cream from which it is made. Studies in moulds have stressed the necessity for adopting careful sanitary measures in the manufacture, packing, and storage of dairy products and for avoiding contamination of materials used in the manufacture of the products.

Dairy-husbandry trials have clearly demonstrated the important influence that the type of feed exerts on the quantity and quality of dairy products produced by milking-cows fed on these feeds. These trials also show that the solids-not-fat in milk can be materially influenced by the plane of nutrition of the milking-cows. The study of the relation of pasture species and possibly soil type to the quality of dairy products is an exceedingly important branch of dairy-research work that should be greatly expanded. The Institute is exceedingly fortunate in being situated alongside the headquarters of the Grasslands Division of the Plant Research Bureau, and it is greatly indebted to the Director and his staff for their active co-operation at all times in this work, for which they have always grown and supplied the pasture plants.

The following is a more detailed account of the projects which have been referred to above :—

Cheesemaking Projects.

(*a*) *Cheese-starters* (Dr. H. R. Whitehead and G. J. Hunter).—A large proportion of the time available during the period under review has had to be devoted to attempts to put into commercial practice the particular technique for the maintenance of starters which had been found at the Institute to eliminate failures. The system of "heavy inoculation" combined with a true aseptic technique has been entirely successful in the field, where it is applied by workers from the Institute. Active single-strain starters prepared at the Institute can therefore be used successfully in factories with a resultant steadiness in manufacture from day to day. The failures which still occur in practice are in the great majority of cases avoidable ; they are due to faulty technique which permits cultures to become contaminated with bacteriophage from the surroundings. *Experience has shown that it is very difficult to instruct any one in the correct technique by correspondence ; personal instruction seems to be essential.*

Demonstrations of the recommended methods for starter propagation culminated in a prolonged trial in three factories in Taranaki during February. Members of the Institute staff maintained a single-strain culture (HP) in these factories for a month without the occurrence of any difficulty. The starter behaved in the same manner as it has done in the Institute over the past two years. During the trial tuition in the methods employed was given, and as a result no further difficulty with the culture was experienced in the three factories for the rest of the season. *Failures in neighbouring factories indicated the importance of personal tuition.*

As a result of experience during the past year we believe that the "heavy inoculation" system of starter maintenance entirely eliminates the spontaneous development of bacteriophage within a starter culture. The failures which occur owing to faulty technique are the result of contamination with bacteriophage from the surroundings. During last season the most probable source of this contamination was found. It appears that bacteriophage may be present in the whey in a cheese-vat even when the curd in the vat is developing acid quite normally. Thus a technique which allows the slightest trace of whey to gain access to a starter culture will lead sooner or later to starter failure. The occurrence of bacteriophage in whey is being investigated more fully, since it has obvious importance from both the fundamental and the practical points of view.

The question of whether single-strain cultures used alone are suitable for the manufacture of the most desirable cheese is still unsettled. They undoubtedly lead to the production of cheese of closer texture, and, given the appropriate making procedure, can yield a cheese which develops an excellent flavour as ripening proceeds. The culture (HP) which has been most generally used up to the present necessitates the adoption of a manufacturing procedure different from that which is usually employed with mixed starters. Unless care is taken with a starter like HP an excessive amount of acid is developed at one stage or another, and this leads to defects in the ripened cheese. The solution of the main starter problem (the maintenance indefinitely of starter activity) has enabled us to proceed in a logical manner with this matter of investigating the most effective cheesemaking procedure, and it should prove ultimately possible to specify with milk of a given composition the best manufacturing details to adopt with given starter cultures. It may prove necessary to use mixed starter cultures of known composition or to select more precisely the single strains to be used, but the underlying principles have at any rate been worked out, and it is possible to make much more rapid progress towards the goal, the consistent production from day to day of the finest quality cheese.

(*b*) *Role of Organisms in Cheese-ripening* (I. R. Sherwood).—As mentioned in previous reports, lactobacilli have been shown to be of considerable importance in cheese-ripening. The development of flavour, for instance, appears to be mainly due to their activity. Certain types of these organisms, however, possess objectionable qualities not only in so far as flavour is concerned, but also in connection with cheese texture and colour. The presence in cheese of gas-producing strains frequently leads to the development of slit openness, while many strains produce discoloration.

The immediate practical problem under investigation, therefore, is the control of the types of lactobacilli which grow in cheese, so as to ensure the dominance of desirable strains. There seem to be three possible ways in which this may be done :—

(1) *By attempting to prevent undesirable types of lactobacilli from gaining access to the milk.* Comparatively little is known concerning the distribution of the various strains of lactobacilli in nature. It is conceivable that objectionable types may find their way into milk from a few specific sources, in which case the infection could possibly be prevented. To decide whether this can be done a detailed study of the natural distribution of lactobacilli is necessary. Work along these lines has been handicapped in the past through the lack of a suitable medium for the direct isolation of lactobacilli. Recently, however, a low pH medium has been developed which promises to render possible a more detailed investigation of the lactobacillal flora of various materials than has previously been carried out. Preliminary results obtained with the use of the new medium show that the various types of lactobacilli present in different milk-supplies can be isolated with comparative ease. Another step forward has been the direct isolation of lactobacilli from the cheese curd during the manufacturing process. By an extension of this work it is hoped to reveal the various sources from which the different types of lactobacilli gain access to milk and to decide whether in practice infection with undesirable types can be prevented.

(2) *By the addition to the cheese-milk of sufficient numbers of desirable types of lactobacilli to outgrow less desirable kinds initially present.* This method has proved successful in the Dairy Research Institute factory over the past several seasons, but it has not yet been tested sufficiently

in commercial practice. (It is possible that in cases where the milk quality is low the addition of a reasonable number of desirable lactobacilli may not lead to any improvement in the quality of the cheese, on account of the larger number of undesirable organisms present in the milk.) The only objection to the use of this procedure in commercial practice is the difficulty necessarily experienced in propagating pure cultures of lactobacilli under factory conditions. Accordingly, an investigation is being made of convenient ways in which strains of lactobacilli can be incorporated in cheese without the necessity for any specialized technique. One of the most promising methods lies in the blending of suitable types of lactobacilli with the starter. A number of cheesemaking experiments with the use of three such composite starters have been carried out this season, but as many of the cheeses have not yet been examined at maturity, a definite statement as to the results obtained cannot be made at present.

(3) *By making certain modifications in manufacturing details.* In view of the important effects of variations in manufacturing procedure upon cheese quality, many cheesemaking experiments have been conducted during the past season with the object of working out the optimum manufacturing conditions for certain single-strain starters. This work, which is not yet complete, is expected to yield also valuable information on the selective influence of different making conditions upon the growth in cheese of the various types of lactobacilli originally present in the milk. Indeed, it is conceivable that certain manufacturing modifications may be found to encourage the growth of desirable types of lactobacilli to such an extent that artificial inoculation of the cheese milk with these types may not, in normal practice, be necessary.

(*c*) *Payment for Milk for Cheesemaking* (Dr. F. H. McDowall).—As a result of investigations carried out during 1934–35 an alternative system of payment for milk for cheesemaking—viz., the "costed cheese" system—was devised, involving payment on the basis of weight of potential cheese delivered by each supplier, with a deduction at a determined rate per 10 lb. of milk delivered to cover the "milk costs," or those costs dependent on the volume of milk handled. The weight of potential cheese was determined from the "cheese test" of the suppliers' ten-day composite samples, which was read from a table giving cheese tests corresponding to milks of all ranges of fat and casein (Walker) tests. The system of payment provided an equitable distribution of the returns from the manufacture of cheese, and the allocation of costs provided an accurate apportionment of the costs of manufacture of cheese from each individual milk-supply. The yearly pay-outs calculated on the "costed cheese" system would thus be a correct division among the individual suppliers of the proceeds of the year's working of the cheese-factory. Following on the publication of the data on which the new system was based, it seemed desirable that some information should be available as to the actual degree of unfairness of the present system of payment on butterfat content. Through the co-operation of the directorates and managers of some seventeen commercial factories a trial of the "costed cheese" system was made during the months of October to March, 1935–1936. The examination of the results of this investigation has been completed in the year under review, and a report giving the data is ready for publication. It was found that, with costs of manufacture properly allocated, the extent of unfairness in the present system of payment on butterfat was not as great as had been thought. The total pay-out for the seventeen factories during the time the investigation was in progress was £284,760, and of this amount £2,570, or 0·90 per cent. of the total, would have required redistribution according to the "costed cheese" system as compared with the "straight fat" system of payment. Of the 531 individual suppliers, 24, or 4·5 per cent. of the total, were underpaid to the extent of more than 4 per cent., and 26, or 5 per cent. of the total, were overpaid to the extent of more than 4 per cent. of their pay-out for the year. For the great majority of the suppliers, therefore, (481 of the 531, or 90 per cent.) the "straight fat" system gave a distribution of proceeds accurate to within £4 per £100 of pay-out. The degree of unfairness for some individual suppliers was quite appreciable, involving in some cases underpayment and in other cases overpayment, to the extent of 10 per cent. of the pay-out for the year. From the point of view of these suppliers the present system is definitely inequitable. The investigation has provided the industry with data necessary for a rational decision as to whether a change in the system of payment for milk for cheesemaking is desirable. The "costed cheese" system has been shown to be practicable. It has been in use as a basis of payment in one commercial factory for the past two years and has given satisfaction.

(*d*) *Storage of Cheese at Low Temperatures* (Dr. F. H. McDowall).—The temperature of storage of cheese has an important effect on the rate of ripening of the cheese. Some investigations have been made of the effect of freezing temperatures of storage on the quality of cheese. It was found that cheese could be stored quite successfully at 31° F., at which temperature a steady but slow maturation took place. The cheese held at this temperature did not suffer any deterioration in quality. Storage at 14° F.—*i.e.*, below the freezing-point of the cheese—caused a disruption of the texture of the cheese and the development of an unpleasant tallowy flavour. This flavour disappeared to some extent when the cheese was held at 45° to 50° F. for some time after removal from cold storage. Storage of cheese at 31° F. has been shown to be a useful and perfectly satisfactory method of prolonging the life of the cheese.

(*e*) *Acidity in Cheesemaking* (R. N. Dolby).—A study has been made of some factors influencing the rate of acid development in the cheese-curd, and an attempt has been made to relate these to the quality of the resultant cheese. In all the cheesemaking experiments during the season under review the successive operations have been timed by pH measurements on the curd instead of by acidity determinations on the whey. It has been shown previously that acidity determinations on the whey retained during the later stages of the cheesemaking process are unreliable. The measurement of pH, on the other hand, gives a true indication of the state of acidity in the curd. The experiments were so planned as to provide some indications of the most suitable conditions for

operating the single-strain starter cultures developed at this Institute. The conclusions formed are tentative pending completion of the examination of the cheese at maturity—

(1) Effect of Percentage of Starter: With variation in the proportion of starter added, the difference in ratio of acid development was less pronounced in the later stages of the process than in the earlier stages, and the differences in acidity or quality of the cheese were not very marked even when half or double the normal quantities of starter were used.

(2) Effect of Running Acidity: The pH measurements confirmed the generally accepted finding that with a higher running acidity there is a more rapid development of acidity in the earlier stages of the process. High-running acidities tended to produce a more acid type of cheese with a mealy body and sharp flavour, while the low-running acidities gave cheese with a smooth body but a tendency towards excessive "sweetness."

(3) Effect of Time of Salting: The observation that time of salting had little effect on the final acidity of the cheese was confirmed. It was found that salting at a high acidity gave cheese with a mealy type of body, while salting at a low acidity gave cheese with a smoother body but a greater tendency towards mechanical openness.

(*f*) *Strength of Cheese Bandages* (J. D. Sargent).—In collaboration with the British Cotton Research Association, Manchester, an attempt has been made to define the most desirable and yet least costly type of bandage for export cheese. Working with eleven specially woven bandages differing in physical properties and make-up, it has been shown that the ultimate shape of cheese exposed for sale depends upon both the type of cheese-curd and type of bandage. The load required to break a piece of bandage cloth of standard dimensions under specified conditions is an important consideration. It is equally important that the bandage should not stretch. It is also obvious that the texture of the woven threads and the nature of the materials used should be defined. These several points are receiving consideration and it is hoped that the results will not only lead to definition of the most economical bandage to be used, but also provide a basis for establishing standards for cheese bandages.

(*g*) *Standardization of Cheese-manufacture* (W. Riddet, J. D. Sargent, and E. A. Sawyer).—Interwoven with specific projects on the relation to the quality of cheese of starters, acidities of curd at critical stages in the manufacturing process, and the addition to milk of selected organisms, an attempt has been made to define the effect of cheese-manufacturing technique on the time occupied by manufacture and on the general quality of the cheese when mature. This work, which is fundamental to the interpretation of any cheesemaking experiments, has been proceeding for a number of years and the data collected are proving valuable in predicting and detecting critically the influence of each step in the cheesemaking process. It ultimately aims at defining the cheese-making procedure best suited to a particular starter and milk-supply.

Buttermaking Projects.

(*h*) *Control of Feed-taints by Feeding Experiments* (I. Campbell and others).—Continuing work of the previous season on the influence of mixtures of rye-grass and white clover fed to cows in stalls, it has been shown by the alternate twenty-one day plan of animal feeding experimentation that 30 per cent. white clover in the ration produces negligible taint in cream, while 70 per cent. creates a definite taint under the same conditions. Confirmatory results have been obtained with cows grazing pastures of rye-grass and clover. As in past years, it has been shown that taint from clover falls off in intensity as the rate of growth of the plant recedes from November onwards, and under these conditions the clover content of pasture may be increased without any adverse effect on the taint of cream. An attempt was made to contrast under grazing conditions the respective influences on taint of milk of rate of clover growth and state of maturity of the plant when consumed, but the experiment was spoilt by the unexpected onset of a long period of dry weather in the normally active growing pasture season.

Green lucerne, constituting 30 per cent. to 70 per cent. of the ration for two respective groups, was fed to the stall cows for sixteen days. The group fed the higher proportion gave a strong flavour indistinguishable from that resulting from clover feeding, while with 30 per cent. lucerne only occasional mild flavours were recorded. Creams were exchanged periodically with Mr. Marryatt, of the Fields Division of the Department of Agriculture, Hamilton, who was studying another aspect of the same problem at Ruakura. These samples were pointed for feediness both in the Waikato and at the Institute. From the exchange of these fresh samples it was shown that the same type of flavour was being produced at both centres and that the Institute grading standard agreed approximately with that used by Mr. Marryatt.

In order to find out more about the physiology of tainting, cows were drenched with various liquids. The amount of active drench, the time between drenching and milking, and the intensity of the flavour produced in milk were noted, and interesting results obtained. Expressed white-clover juice, land-cress juice, and mustard oil (the tainting principle generally recovered from the hydrolysis of cruciferous plants) were used. It was found that five minutes after drenching with a milk emulsion containing 1 gram or 2 grams of mustard oil pronounced flavours similar to mustard oil were produced in the cream. Only mild "mustard" flavours were recorded two hours after drenching. The juice from as little as 1 lb. of land cress (*Coronopus didymus*) gave characteristic strong flavours and odours. It is hoped to develop this "extraction and drenching" technique further, as it seems to offer useful possibilities in future experimentation.

In order to determine the possibility of taint being introduced into the blood by absorption of gases from the lungs and thence conveyed to the udder, a cow was made to breathe turpentine fumes just prior to milking. A powerful oil-of-turpentine taste and odour was immediately observed in the milk produced.

(*i*) *Elimination of Feed Taints by Processing Cream* (E. A. Beatson, J. O'Dea, and J. D. Sargent).—Experiments carried out in the present dairying season clearly show that clover taint can be almost completely removed from affected cream by the process known as "vacreation." This term is now well known in New Zealand, but is new to other countries except Australia. It has been introduced by Murray Deodorisers Co., Ltd., makers of a machine called a "Vacreator," which, in successive steps at increasing degrees of vacuum, pasteurizes, deodorises, and partially cools cream. Vacreation cannot be regarded as a substitute for the production of cream free of clover taint, but it can be accepted as a useful supplement to farming methods of overcoming this defect. This treatment of cream results in a higher loss of butterfat than does ordinary pasteurization, but this slight loss is offset by the higher grade of butter produced. The addition of a trace of starter to vacreated cream slightly enhances the grade of butter produced therefrom, but great care is necessary to ensure that the acidity of the butter does not fall below pH 6·5, otherwise its keeping-quality is impaired.

(*j*) *Unsalted Butter* (W. J. Wiley).—The experiments outlined in the previous report on the effect of acidity on the keeping quality of unsalted butters have been completed. At 65° F. and 40° F. deterioration caused by bacterial action was not delayed by the presence of acid in the butter. At 0° F. and 14° F. the greatest deterioration was observed in butters made from creams ripened to pH 5 (*i.e.*, about 0·4 per cent. acidity). Butters from cream acidified to the same acidity by addition of pure lactic acid did not deteriorate to the same extent. The fat of the butters from ripened cream (pH 5) showed notable oxidation after cold storage, whereas that from the acidified cream did not. It has been found that even the experienced grader is unable to detect acidity in butter when this acidity is produced by the addition of pure lactic acid. The detection of acidity in butter by a grading on the senses is therefore dependent on the detection of the by-products of acidity production, such as diacetyl. Since these substances are still present in a butter from neutralized cream it is obviously difficult to assess the actual state of acidity in a highly flavoured butter without the assistance of a determination of the pH or of the titratable acidity of the serum. The investigation has not supported the views advanced by some workers in other countries that unsalted butter is more stable when acid and made from ripened cream than when neutral.

(*k*) *Starters for Butter* (G. A. Cox, W. J. Wiley, and H. R. Whitehead).—A start was made during the later part of the season on attempts to prepare good butter cultures from mixtures of known organisms. Hitherto all the butter-starters used in commercial practice have been fortuitous mixtures of several types of streptococci and it has been impossible to preserve consistently a good culture in a constant state for any length of time or to reproduce the characteristics of a good culture once they were lost. It would obviously be an advantage if we were able to mix two or three stock cultures of single strains (these cultures retain their characters indefinitely) and obtain regularly a desirable butter-starter, even if such a starter retained its characteristics only for a limited period.

The work opened up the whole question of the relationship between the organisms in a culture, the diacetyl produced by the culture, and the flavour of the butter. The adoption of a recently described colorimetric method for the estimation of diacetyl made it possible to carry out the necessary determinations on starter, cream, and butter much more quickly than was possible by the older methods. It is too early as yet to say whether progress is possible along the lines visualized, but already some interesting observations have been made which suggest that the usual methods of evaluating a starter for butter-manufacture are sometimes misleading. Starters apparently do not behave quite in the same manner in cream as they do in milk.

(*l*) *Oxidation Changes in Butter* (W. J. Wiley).—Some experiments have been carried out to determine whether temperature of pasteurization has any influence on the susceptibility of butterfat in butter to oxidation changes during storage. The butters made from creams treated under different conditions of pasteurization are now in storage and await further examination.

Mycological Projects (Dr. T. R. Vernon).

(*m*) Mycological investigations commenced last year with a study of the condition of New Zealand butter and cheese arriving on the London market. This study revealed a generally high standard, marred occasionally, however, by mould deterioration. It was realized that although the amount affected by moulds was comparatively small it was of greater importance commercially than one would expect. A large number of samples were examined to determine the types of organism present and the frequency of their occurrence. This work is now being continued in New Zealand and a systematic study is being made of the fungi liable to contaminate dairy-produce. To date the work suggests that while a certain amount of atmospheric contamination may be unavoidable (without recourse to the air-conditioning of factories) the organisms responsible for deterioration come mainly from the factories themselves.

Mould on paint-work in factories is not only unsightly but is an important source of contamination. Experiments on paints show that moulds develop rapidly on oil-bound water paints, penetrating the paint film and obtaining nutrition from the wood below. Gloss paints are more resistant and enamels most resistant. If, however, gloss paint or enamel paint is applied to a moulded surface, particularly under damp conditions, moulding may occur. Experiments are in progress with various types of paint with a view to increasing resistance to mould-attack. The cheaper paints and washes may be made resistant by the addition of fungicides.

The possibility of reducing mould-growth on cheese by better air-conditioning in the curing-rooms is being investigated.

Dairy Husbandry Projects.

(*n*) *Pasture Plants and Dairy Products* (co-operative work of the Dairy Research Institute, and Grasslands Division, Plant Research Bureau).—In addition to determining the influence of white clover and perennial rye-grass on the flavour of milk, a careful study has been made of the effects of these feeds on the composition of the milk of cows fed thereon. The grasses and clovers used in this work were provided by the Grasslands Division of the Plant Research bureau. A record has been kept of the amount of pasture consumed by milking-cows fed in stalls *ad lib.* quantities of these species four times per day and a corresponding record has been kept of both the milk produced and its composition. From analyses made of the feeds by the Chemist of the Grasslands Division of the Plant Research Bureau it will be possible to determine from the data collected the relationship of the feed consumed to the milk produced and, in turn, its effect on the composition of the milk. Similar records have been kept of the milk produced by two groups of cows grazed during the season on specially seeded areas of rye-grass and rye-grass and white clover. An enormous mass of analytical data collected daily over the past three milking-seasons has now been accumulated and it is intended to work this up during the winter months.

(*o*) *Relation of the Plane of Nutrition of Milking-cows to the Composition of their Milk* (W. Riddet, F. H. McDowall, I. Campbell, and G. A. Cox).—It has been recognized for long that the solids-not-fat, especially the casein fraction of milk is depressed when milking-cows are at pasture in long periods of drought. This problem presents difficulties to producers of city milk which needs to conform to a minimum standard of 8·5 per cent. solids-not-fat. It also presents difficulties to cheese companies who experience a falling off in cheese-yield per pound butterfat in dry periods. No satisfactory explanation for the phenomenon has been given. Based on the beliefs that it may be due to under-feeding milking-cows or to their dependance entirely on "dry" feed after receiving luscious pasture, an experiment was carried out to test the validity of these theories during the winter of 1937. Working with six animals, divided into three groups of two and fed on the thirty day experimental alternate feeding plan, it was found that the solids-not-fat of milk were perceptibly decreased by reducing the cow's feed to half her normal requirement. It was also observed that the iodine value of the fat was raised at the same time. The substitution of pasture for meals in part of the ration exerted no influence on the composition of the milk. A second experiment of the same nature was carried out during the period January till April, when cows more advanced in lactation were used. The results followed the same trend as those observed in the first trial, but the differences were less marked.

A modification of this experiment was carried out with two groups of cows grazing comparatively bare pasture during the period January till March. Grass ensilage in *ad lib* amounts was fed to the groups in alternate periods of twenty-one days. The results of this trial are now being worked up.

Standards for Dairy Requisites.

Members of the staff have acted on a sub-committee set up by the New Zealand Standards Institute to define standards for dairy requisites. This sub-committee is working in close co-operation with a corresponding committee of the British Standards Institution.

Pasteurization and Bottling of Milk for Schools.

At the request of the Department of Health, which found it impossible to get any person or firm to contract to supply pasteurized and bottled milk to schools in the Palmerston North area, the Institute undertook the responsibility of pasteurizing and bottling milk supplied daily to school-children in the Palmerston North City area. The Department provided the necessary up-to-date plant, which was installed in the Massey Agricultural College dairy factory. It also entered into contracts with farmers to supply daily the requisite quantity of raw milk from milking-sheds registered under the Dairy Industry Act, 1908, and made arrangements for the distribution of milk to city schools. A local committee representative of city schools, Education Departments, City Council, Government Departments, and others interested was set up by the Department to control the local milk scheme. This Committee has closely co-operated with the Institute and has been of great assistance in making the scheme work smoothly since its inception. The Institute has been reimbursed from the Health Department's milk in schools vote for all costs attendant upon this work. Thus the Institute has virtually acted as agent for the Department of Health. The supply of milk to schools was commenced on 17th November, 1937, and has been carried on since that date without interruption, except during school holidays. Over four thousand bottles each of ½-pint capacity have been supplied daily to some ten schools. A high standard of milk-quality has been maintained throughout the whole period; no difficulties have been experienced, and all concerned have expressed satisfaction with the operation of the scheme.

Staff Changes in 1937–38.

Dr. T. R. Vernon, Ph.D. (London), joined the staff in the United Kingdom in July, 1937, as specialist officer in mycology. After making a survey in the United Kingdom of mycological problems bearing on New Zealand dairy products he took up duties at the Institute in December, 1937.

Dr. H. R. Whitehead proceeded to the United Kingdom and Europe in May, 1937, to attend during August the World's Dairy Congress at Berlin and to undertake special investigations overseas. He returned to duty in November.

Mr. C. R. Barnicoat, who was granted a Commonwealth Fund Scholarship in 1936, was absent from duty during the whole year while attending the Minnesota University at Minneapolis, United States of America, where he has been carrying out a research project on dairy chemistry of fundamental interest to the New Zealand dairy industry.

Mr. A. J. Wood, a graduate of the University of British Columbia, who came to the Institute in November, 1936, to undertake special studies returned to Canada in October, 1937. While at the Institute he made a study of the metabolism of lactic-acid bacteria, and an account of his work is embraced in a thesis submitted to the University of British Columbia.

Dr. W. J. Wiley, who was seconded for duty at the Institute in February, 1937, by the Australian Council for Scientific and Industrial Research, was a member of the staff for the whole year and took a leading part in the research work.

The presence of overseas workers at the Institute has been a decided advantage to its work and is a recognition of the importance of the Institution in the estimation of other countries.

Several changes in the personnel of the laboratory, dairy factory, experimental milking-shed, and office general staff occurred during the year.

Dissemination of Results of Work.

A meeting lasting three days was held from 27th April to 29th April to explain to dairy factory managers and first assistants the research work carried out in the past season. This meeting was attended by approximately sixty managers and first assistants, drawn from all parts of the Dominion, and was appreciated by all. During the year addresses were given by members of the staff at the National Dairy Conference and at meetings convened by the New Zealand Factory Managers' Association, by the South Island Dairy Association, and by dairy companies. Demonstrations of the Institute methods of propagating starter cultures were given by members of the staff in certain cheese-factories where the Institute had been asked to investigate difficulties experienced in maintaining vitality of starters.

A monthly article on dairying was contributed to the *New Zealand Exporter*, and the following technical publications have been issued during the year :—

Institute Publication No.	Title.	Author.	Journal.
85	Experiments in the Packing and Storage of Butter	C. R. Barnicoat	*N.Z. J. Sci. & Tech.*
89	Studies on the Chemistry of Cheddar-cheese Making. Part VII—Acidity in Cheese : The relation between Hydrogen Ion Concentration, Titratable Acidity, and Quality in Cheese	R. M. Dolby, F. H. McDowall, and W. Riddet	*J. Dairy Research.*
101	Studies on the Neutralization of Cream for Buttermaking —Part V : The Reaction of Sodium Bicarbonate on Milk and Cream and the Effect of Pasteurization on the Reaction	F. H. McDowall and A. K. R. McDowell	*N.Z. J. Sci. & Tech.*
102	Studies on the Neutralization of Cream for Buttermaking. Part VI—Factors affecting the pH of Salted Butter : The Relation of pH to Quality of Salted Butter	F. H. McDowall, J. W. Smith, and A. K. R. McDowell	*N.Z. J. Sci. & Tech.*
103	Milk-supplies to Cheese-factories	F. H. McDowall	*N.Z. J. Sci. & Tech.*
104	The Titratable Acidity and pH of Butter	W. J. Wiley	*N.Z. J. Sci. & Tech.*
105	The Effect of Acidity on the Keeping-quality of Unsalted Butter	W. J. Wiley	*J. of C.S.I.R.* (Australia).
106	Annual Report, 1936–37		
107	Experiments on the Packing and Storage of Butter—II : Storage of Butter at Chilling Temperatures	C. R. Barnicoat	*N.Z. J. Sci. & Tech.*
108	Experiments on the Packing and Storage of Butter—III : Factors Influencing Surface Defects of Butter	C. R. Barnicoat	*N.Z. J. Sci. & Tech.*
109	Experiments on the Packing and Storage of Butter—IV : Wrapping-materials and their Properties	C. R. Barnicoat	*N.Z. J. Sci. & Tech.*
110	Butterfat Losses in Buttermilk	F. H. McDowall	*N.Z. J. Sci. & Tech.*

The following are in the press :—

Institute Publication No.	Title.	Author.
111	Solubility of Cheddar Cheese in Sodium Chloride	F. H. McDowall and L. A. Whelan.
112	Storage of Cheese at Freezing Temperatures	F. H. McDowall.
113	Starter Cultures for Cheese-manufacture : Maintenance of Acid-producing Activity in Cultures of Lactic Streptococci	H. R. Whitehead and G. J. E. Hunter.

As in the past, the Institute is much indebted to the Massey Agricultural College for the use of the College herds, buildings, and plant, and it is desired to express to the Board of Governors the thanks of the Institute for this privilege. It is also desired to acknowledge the ready co-operation afforded by the Dairy Board, by the Director and staff of the Dairy Division of the Department of Agriculture, the Grasslands Division of the Plant Research Bureau, the Primary Products Marketing Department, and by a number of commercial organizations. To all of these it is desired to express the grateful thanks of the Institute.

PLANT RESEARCH BUREAU.

Plant Research Bureau Committee: Mr. A. H. Cockayne, Chairman; Dr. F. W. Hilgendorf, Vice-Chairman; Professor G. S. Peren, Massey Agricultural College; Professor E. R. Hudson, Canterbury Agricultural College; Sir Theodore Rigg, Cawthron Institute; Dr. E. Marsden, Department of Scientific and Industrial Research; Mr. R. B. Tennent, Fields Division, Department of Agriculture; Secretary and Chief Executive Officer: Mr. F. R. Callaghan.

The Plant Research Bureau comprises four Divisions and one Section, viz.:—

——	Location.	Director.
Plant Diseases Division	Mount Albert, Auckland	Dr. G. H. Cunningham.
Grasslands Division..	Massey College, Palmerston North	Mr. E. Bruce Levy.
Entomology Division	Cawthron Institute, Nelson	Dr. D. Miller.
Agronomy Division	Canterbury Agricultural College, Lincoln ..	Mr. J. W. Hadfield.
Botany Section	Sydney Street, Wellington	Dr. H. H. Allan.

Participating in the Bureau are: (1) the Department of Agriculture and its various Divisions; (2) the Department of Scientific and Industrial Research and its several research sections; (3) Massey Agricultural College; (4) Canterbury Agricultural College; and (5) Cawthron Institute.

The Bureau is organized so as to arrange for co-ordination of all researches relating to plants at present being conducted throughout New Zealand and to associate this work appropriately with the teaching and extension work of the Agricultural Colleges and the Department of Agriculture.

During the year the Agronomy, Grasslands, and Entomology Divisions have been provided with new office and laboratory accommodation, while the erection of similar accommodation for the Plant Diseases Division at Mount Albert, Auckland, has commenced.

Regular meetings of the Plant Research Bureau Committee have been held during the year, and a great deal of progress has been made in implementing the policy of co-ordinated effort relating to investigations of plants and plant products.

PLANT DISEASES DIVISION.

(Director: G. H. Cunningham.)

As the new buildings for the Division have not yet been erected, the staff is somewhat scattered. Most of the officers are yet stationed at Palmerston North in the unsatisfactory quarters which have housed them for the past ten years; others are situated in temporary offices in High Street, Auckland, and one is stationed temporarily at Hawke's Bay.

In January the Division's entomologist, Mr. W. Cottier, was transferred to Auckland. Mr. J. G. Gibbs returned to duty in October, 1937. He has been absent on special leave for the past two years, working in the United States of America under a Commonwealth Fund Service Fellowship. Mr. W. D. Reid was sent abroad in March to the University of Edinburgh for an intensive post-graduate course in bacteriology.

Officers responsible for the different investigations are indicated at the end of each section.

I. Mycological Investigations.

(*a*) *Brassica diseases.*

(1) *Dry-rot.*—A technique had been developed for study of the longevity of the dry-rot organism *(Phoma lingam)* in the soil. By this means it has been possible to ascertain that the disease may persist in infected soils for two seasons.

An infected line of swede-seed has been obtained by artificial inoculation of siliquas. This material, which carries 3·5 per cent. infection, is being used in further work on seed disinfection.

(2) *Club-root.*—Two strains of club-root-resistant rape have been hybridized, with a view to producing a more resistant rape with desirable feeding-qualities. Seed harvested in December has been sown in the glasshouse to secure F_2 seed for sowing in the spring of 1938.

Seed of seventy selected selfed resistant rape plants and of fifty-two swedes were sown on club-root-infested soil at Palmerston North and Auckland to test for resistance. At Palmerston North four strains of rape showed a high degree of resistance, but none of the swedes survived infection. Auckland results have not yet been secured.

(3) *Soft-rot.*—It has been determined that the soft-rot disease of swedes and turnips in New Zealand is due to two bacteria, *Bacillus campestris* and *B. melonis*. Entry is gained through injuries, usually leaf scars, and facilitated by animal injury or previous attacks of virus disease.

(4) *Turnip-mosaic.*—Additional hosts for this virus have been found in wart-cress *(Cardamine heterophylla* and wallflower. The physical properties of the virus have been ascertained.

(*b*) *Grass diseases.*

(1) *Low Germination of Rye-grass.*—A thorough investigation has been made of field conditions associated with the problem. Several fungi have been isolated from seed heads and are being tested for their respective effects on the seed. This work was carried out in co-operation with the Grasslands Division and the Seed Analyst.

(2) *Ergot of Grasses.*—About forty strains have been collected from different Dominion-wide localities and are being grown in cultures for comparative studies. Experiments are in progress to ascertain the most satisfactory method for early testing of strains of grasses to ergot susceptibility.

(*c*) *Cereal diseases.*

(1) *Oat-rusts.*—Plots of 135 strains of oats produced by the Agronomy Division were grown at Palmerston North for studies on their resistance to the rusts *Puccinia coronata* and *P. graminis*. Most showed resistance to one or more strains of *P. coronata*, of which there would appear to be two present in the Dominion. None was immune. Infection by *P. graminis* was slight and irregular, consequently it was not possible to secure accurate observations. Collections of the rusts were sent to the University of Sydney for identification of the strains.

(2) *Wheat-rusts.*—A survey of the position regarding distribution of the rusts *P. graminis* and *P. elymi* was made in Otago and Canterbury provinces.

(3) *Barley diseases.*—The annual disease survey of the barley crops of Canterbury was completed. Smut was absent from crops grown from seed of New Zealand origin, and a trace only was found in one imported line. During the course of the survey records were secured of the percentages of other diseases present—namely, leaf-rust, barley-stripe, and mildew.

(4) *Halo-blight of Oats.*—This disease was found in crops grown in the Manawatu and at Lincoln. The organism has been isolated and found to be *Bacterium coronafaciens*, which is responsible for the disease in other countries.

(*d*) *Potato diseases.*

Two bacterial diseases, mattery-eye and black-leg, have been studied, and morphological, cultural, and physiological reactions made of the causal organisms. The former is now known to be due to *Bacterium solanacearum*. the latter to *Bacillus atrosepticus*.

The masked virus present an Aucklander tall-top and short-top has been transmitted to tobacco, Turkestan tobacco, petunia, and Devil's thorn apple.

(*e*) *Legume diseases.*

(1) *Bacterial-wilt.*—A large number of imported and local varieties of French beans have been grown at Palmerston North and Auckland for tests of resistance to this disease. Seed from several lines showing resistance has been selected for multiplication.

(2) *Bean-mosaic.*—The same virus has been found responsible for mosaic of runner and dwarf beans in New Zealand. It is seed-carried, approximately 30 per cent. of seed from diseased plants being infected. The virus would appear to be " Phaseolus Virus 1 " of Smith.

(3) *Pea-mosaic.*—Tests have shown that of thirty-three garden varieties of peas eleven proved immune, and of ten field peas only one was immune to this disease. Reactions of the virus show it to be " Pisum Virus 2 " of Smith.

(4) *Nodule Bacteria.*—Cultures have been supplied to farmers sufficient to threat the following quantities of seed : Lucerne, 96,000 lb. ; while clover, 1,665 lb. ; lupins, 6,400 lb. ; and peas, 12,320 lb.

Work has also been undertaken, in collaboration with the Fields Division of the Department of Agriculture, on the effects of different strains of the legume organism on establishment of white clover.

(*f*) *Fruit-tree Diseases.*

Work undertaken during the year is covered under a separate report. (See " Fruit Research " report, p. 40.)

(*g*) *Small-fruit Diseases.*

(1) *Tomato diseases.*—A bacterial disease of field and glasshouse plants, previously confused with verticillium-wilt, has been found to be due to the bacterium *Aplanobacter michiganense*, an organism of American origin.

The host range of spotted-wilt in New Zealand has been extended to include twenty-one species belonging to seven families of plants. It also produces a serious disease of lettuce in the Hutt Valley. The physical properties of the virus have been determined, showing that it is identical with spotted-wilt occurring in other countries.

(2) *Passion-fruit Diseases.*—A disease of bacterial origin, known as grease-spot, has been investigated and the pathogenicity of the causal organism proved. The organism has been named *Phytomonas passiflorae*.

A disease known as brown spot has been found to be due to the fungus *Alternaria passiflorae*, recently described from Queensland material.

(3) *Tobacco diseases.*—A method has been evolved for sterilizing smoking-tobacco carrying tobacco-mosaic, which may be spread by smokers from prepared leaf to plants growing in the field. The virus is destroyed without detriment to the flavour by subjecting tobacco to steam treatment in an autoclave for fifteen minutes at 10 lb. pressure.

The host range of tobacco-mosaic in New Zealand has been extended to include eleven species of the family Solanaceæ and one of the Compositæ. It has been found to be " Nicotiana Virus 1 " of Smith.

(4) *Cucumber diseases.*—The host range of cucumber-mosaic has been extended in New Zealand to nineteen species belonging to four families or plants. The physical and other properties show the virus to be identical with " Cucumis Virus 1 " of Smith.

(5) *Hop diseases.*—Inoculations were carried out with material taken from diseased hop roots secured from Nelson and Palmerston North. Positive results were obtained both from direct and soil inoculations. The fungus responsible is *Phytophthora cactorum*, the first record of its attacking hops.

(6) *Onion disease.*—Onion-smut due to the fungus *Urocystis cepulae* was to be found to be prevalent in Marshlands district of Canterbury. A survey of the position showed the disease to be present in sixteen properties. It would appear to have been introduced with imported onions four or five years ago.

(*h*) *Miscellaneous.*

(1) *Sterilization of Meat-wraps.*—An investigation into the most efficient method of eliminating moulds from meat-wraps, carried out in collaboration with the management of the Longburn Freezing-works, has been completed, and is being employed commercially at Longburn Freezing-works.

(2) *Preservation of Tent Fabrics.*—Experimental work on preservation of mould deterioration of tent calico, conducted during the past two years, in collaboration with the Public Works Department, has now been completed. Results will be published shortly.

(3) *Soil Biology.*—Isolation of the chief fungi of the soil have been made from various New Zealand soil types. An apparent negative correlation has been found between one species and fertility as measured by crop vigour. Experiments are in progress to determine the effects of this fungus on plants grown under controlled conditions. This work is being carried out in collaboration with the Soil Survey Division.

II. Entomological Investigations.

(1) *White-butterfly Control.*—The third year's work on control of this pest by the aid of various sprays and dusts has been completed. A cheap and practical control has been evolved. Results of the past three seasons' work are being prepared for publication.

(2) *Eelworm in Currant.*—Methods for control of this pest in rooted cuttings are being evolved, materials having been planted at Mount Albert for the purpose.

(3) *Fruit-pest Control.*—Investigations carried out during the year are supplied in the separate report dealing with Fruit Research (see page 42).

(4) *Cocksfoot Midge.*—An investigation was made in Canterbury into the low yield and percentage germination of cocksfoot-seed. At first thought to be of bacterial or fungus origin, the trouble was traced to larvæ of a midge which was found infesting seed heads to the extent of 80 per cent. in Ashburton district and up to 50 per cent. on Banks Peninsula.

III. Plant Protection.

(1) *Seed Disinfection.*—Work has been completed on the effects of "Agrosan" and "Ceresan" dusts on seed of wheat, oats, barley, and peas treated in advance of sowing. Little or no adverse effects were detected on treated seed when stored for periods up to five months, either in subsequent germination or disease control. Farmers may therefore safely treat their seed with either preparation at any convenient time between harvest and sowing.

Tests made of various new seed dusts showed that none was superior to "Agrosan" or "Ceresan."

Further work has been conducted on the efficacy of several experimental seed dusts for control of damping-off of tomato seedlings. Results have been published.

(2) *Production of Therapeutants.*—Approximately 16,000 cuttings from thirty-six pure clonal lines of pyrethrum were struck. When planted out at Auckland only a small percentage survived, owing to the dry weather experienced.

Selections for high pyrethrum content have been made, and from these—108 in all—flowers have been collected for analysis at the Dominion Laboratory. From a block of plants at Palmerston North, 150 lb. of dried flowers were obtained and will be used in field experiments.

(3) *Improvements in Spray Programmes.*—Particulars are provided in the separate report on "Fruit Research" (see page 42).

(4) *Testing of Therapeutants.*—Details of this work, too, are given in a separate report (page 43).

IV. General.

(*a*) *Experimental Areas.*

Mount Albert Area.—Since this was taken over in January, 1937, it has been cleared of gorse and blackberry, old fences have been razed, and stones carted off. The area has been tile-drained where required, 1,650 ft. of 3 in. tiles being laid and 1,000 ft. of open drains dug. Fourteen springs have been tapped and led off.

During the winter months, blocks of apples and citrus were planted, and about two thousand trees from Palmerston North set out. All have grown well during the year. Areas have also been planted in hops, strawberries, and other small fruits, beans, potatoes, brassicas, and tomatoes. Shelter-hedges have been planted, and roads prepared and metalled.

Two glasshouses have been constructed, of the series required for research work, and the site of the main building excavated to a depth of 3 ft.

The area has recently been reploughed and sown to a winter cover crop, necessary to prevent scour on the volcanic soils of this locality.

The area of 4 acres at Huapai has been renovated; all trees pruned and sprayed; and the land ploughed, manured, and drained. Sixty trees were replaced with stock of the Division's own working. A stationary spray-pump was installed during the winter and has proved most satisfactory.

(*b*) *Taxonomic Studies.*

Several officers are engaging in their spare time on systematic studies of New Zealand fungi and insects. Mr. Neill is working on the mould fungi, Mr. Taylor on the mildews, Mr. Reid on classification of bacteria, and Mr. Chamberlain on the terminology of the virus diseases. The last named is preparing a monograph on these diseases, Mr. Cottier one on the Aphides of the Dominion, and the Director one on the Gasteromycetes of Australia and New Zealand. The last should be ready for publication in book form early in 1939. Mr. Brien has prepared a list of plant diseases of the Dominion.

GRASSLANDS DIVISION.

(Director: E. Bruce Levy.)

The various activities of the Division have progressed well during the year, the increased work necessitating an increase in staff. The new building at the Tiritea Area was occupied by the end of January, and officially opened on the 31st March, 1938. The following are the reports for the various sections :—

(1) Strains and Plant Introduction.

Strain Ecology and Certification.

The number of tests for strain identification and certification purposes have been as follows :—

Perennial rye-grass	537	Red clover	246
Italian rye-grass	149	White clover	930
Cocksfoot	169	Subterranean clover	4
Brown-top	187		

Pedigree-seed Production.

Pedigree selections from this Station are proving their superiority in the field and already there is a demand far in excess of the supply of seed produced annually.

The following quantities of nucleus stock seed have been harvested at the Station this year and passed on for increase :—

Perennial rye-grass ..	18 bushels.	White clover	100 lb.
Italian rye-grass	10 ,,	Red clover	80 lb.

Previous nucleus stocks have been increased to supply commercially some 5,000 bushels of perennial rye-grass and 1,000 lb. of white clover at the one harvesting.

Strain Trials.

The introduction and trial of all useful strains of grasses and clovers available commercially has always been part of this Station's work. Already there are 172 species and strain trials and 68 subterranean clover strain trials in progress on many different soil types in New Zealand. For further field trial 47 bulk lots of seed, representing mostly pedigree selections made by overseas research stations, have been obtained. These will be compared with material selected by the Dominion.

Plant Introduction.

A definite scheme for plant introduction has been commenced. Seed samples of some ninety-seven grasses and thirty-five clover or clover-like species have been received from various sources. Each sample is being grown and studied carefully, with a view to providing material for regrassing any depleted areas.

Research Projects.

Perennial Rye-grass: Plot and Single-plant Trials.—In plot trials no imported line has been superior to the New Zealand certified type.

Station selections and Government stock and "pedigree" seed grown from these selections have shown marked resistance to attacks of leaf-rust and stem-rust. The selections are giving increased leaf production, together with improved palatability, when compared with the present "Certified Mother Seed" strain. A trial comparing plants of some forty Certified Mother Seed lines from South Island areas, which are now five years old or over, with nineteen samples representing Hawke's Bay Old Pasture Mother Seed areas has demonstrated the fact that the individual lines comprising the certified Mother Seed class are remarkably similar in single-plant type and performance, and the fact that the Mother Seed has been harvested in Hawke's Bay certainly does not warrant the payment of a premium for that seed.

Low Germination Problem.—Further experiments concerning susceptibility to the disease have been carried out. Control by seed-treatment has been attempted. Some inoculation work designed to assist in the finding of disease-resistant perennials has been commenced.

Italian Rye-grass.—In the testing of New Zealand material two interesting samples have been located and are being studied closely. These have made excellent growth following establishment and also have recovered exceptionally well after cutting back.

Cocksfoot, Timothy, Meadow Fescue, Dogstail, Chewings Fescue, Brown Top, Prairie Grass, and Phalaris tuberosa.—A definite but limited amount of strain investigational work has been carried out with each of the above species.

Red Clover.—A special single-plant study of the early flowering and ordinary later flowering types is in progress. The aim is to study all available material and then to improve on commercial material by selection and breeding.

White Clover.—A mass selection of Type 2 plants has been seeded under isolation, and seed supplies are being increased. This strain is designed for use in districts where Type 1 is too aggressive.

Subterranean Clover.—Small plot trials have been continued, and a duplicate series of trials have been conducted at the Pure Seed Farm, Lincoln. Seed supplies of the Nangeela and Burnerang strains are being increase grown at this Station. The Department of Agriculture, Melbourne, has generously assisted by supplying seed-supplies of strains unprocurable commercially. Two lines of New-Zealand-grown seed have been passed as being of a type suitable for certification.

Lotus Major.—A mass selection of leafy plants has been seeded and further increase grown to return 185 lb. of dressed seed. Probably this will be offered for distribution as certified seed.

Alsike Clover, Suckling Clover, Lotus corniculatus, *Strawberry Clover, Crimson Clover, Cluster Clover, Hop Clover, Reverse Clover.*—Samples of each of the above have been received and are under trial at this station.

(2) Plant Breeding.

Perennial Rye-grass.

Approximately 13,000 single plants from local and overseas sources are at present being studied, with a view to selection for plant-breeding work. In addition, some 7,230 plants from controlled pollinations are being studied. In the 1937–38 season 124 crosses were made. From these crosses and selfings of the present plants progenies totalling 10,000 plants are to be planted out this autumn.

High-producing Short-rotation Type.—Seed has been sown from two lines in which are present types that may prove suitable for the building-up of a high-producing short-rotation type of rye-grass. Approximately 5,000 single plants are to be planted out.

Low Germination in Perennial Rye-grass.—To obtain information on the inheritance of low germination and the possibility of obtaining a line of perennial rye-grass resistant to the specific fungus, a number of crosses have been made between perennial and Italian rye-grass, and 400 hybrid seeds have been sown. The resulting plants will be planted out as single plants and used for future genetical work. This material will also be used to explore the possibility of obtaining a high-producing short-rotation type of rye-grass.

Italian Rye-grass.

From 8,050 plants obtained by controlled pollination in the 1936–37 season, 305 plants were selected and 228 crosses made. Approximately 16,000 plants from these crosses and selfings are to be planted out.

Sward and Row Tests of Different Types.—Seed has been obtained from two types of Italian rye-grass by isolating together a number of plants of similar type. This seed is to be used for row and plot tests of these types.

White Clover.

A total of 15,120 plants from controlled pollinations are at present planted out. One hundred plants were selected this season and 100 crosses made. The majority of the plants crossed were of Type 2, the object of the work being to produce a type for trial purposes lower in production than, but as persistent as, the pedigree Type 1 line already on the market. In this connection work is also being carried out with hybrids of Type 1 × plants of the low-producing but persistent Kent type. F_1 plants of type 1 × Kent have been intra-family crossed, and further F_2 material has also been obtained by crossing Type 1 plants by Kentish. From these crosses 9,000 single plants are to be planted out in the spring.

Type 2 Selection.—A mass selection has been produced by isolating together, under controlled pollination conditions, eleven plants of Type 2. This will be increased and the seed used for trial purposes.

Montgomery Red Clover.

From progenies of former crosses 115 plants were selected this season and 149 crosses made. The progenies from these crosses will be planted out with the progenies obtained next season from crosses of plants to be selected from "original" plant material now being studied in the single-plant plots.

Glasshouse Selection.—Seed has been obtained this season by isolating together eighteen plants selected from the best families obtained from previous crosses. This seed will be increased for pedigree-seed production.

Plot Tests of Various Types.—A supply of seed of six separate types has been obtained by isolating together in cages plants conforming to these types. This seed will be used for plot tests to furnish data on the behaviour of these types under sward conditions.

Early Flowering Red Clover.

Observations are being recorded on a block of 3,720 plants from lines of earlier flowering types than Montgomery red clover. Plants will be selected from this block next spring and incorporated in the breeding programme, with the object of ultimately producing a leafy early flowering pedigree line.

Lotus Major.

Periodic notes are being taken on some 350 single plants obtained by crossing and selfing selected plants. This season a mass selection was made by isolating together eight of the best plants from tiller rows. This seed will be kept for increase when required.

(3) Pasture Survey.

The pasture survey of Hawke's Bay has occupied the greater portion of the time in this work, the survey being carried out fairly continuously during the year. The following survey districts have been completed: Matapiro, Heretaunga, Clive, Maraekakaho, Te Mata, Kidnapper, Ruataniwha, Waipukurau, Oero, Waimaramara, Motuataraia, Pourerere, Blackhead, Tuatane, Weber.

The following survey districts have been partially completed: Pohui, Maungaharuru, Patoka, Puketapu, Wakarara, Takapau, Porangahau, and Ngaruroro.

Completed pasture maps of the undermentioned districts are now in the process of being finally draughted and prepared for publication: Te Mata, Kidnapper, Oero, and Waimaramara. Maps of a further group of four districts are now ready to hand to the draughtsman.

Altogether, approximately 1,900 square miles of pasture in Hawke's Bay have been mapped. Data relative to pasture have been secured, and trials with species and strains of various grasses and clovers worthy of trial have been sown on several areas.

Further data for the completion of the general pasture map of the whole North Island have been secured, the following districts having been mapped in a general manner: North Auckland, Poverty Bay, Hawke's Bay, King-country, portions of the Waikato, Bay of Plenty, Manawatu, and Taranaki.

Bulletin No. 2 of the Plant Research Bureau, "Pasture Survey—Technique of Intensive Mapping used in Hawke's Bay," was published during the year.

(4) Feed Flavour and General Ecological Work.

Feed-flavour Investigations.—The work at Palmerston North has proceeded along lines previously followed. During the year a trial was carried out on pastures containing approximately 30 per cent. and 70 per cent. of white clover to ascertain the degree of taint induced by these concentrations of white clover in the field. Small palatability trials were carried out on species of rye-grass and mixtures of rye-grass and clover.

Mowing trials were also commenced, to compare the rate of growth of pasture in the Waikato with specially selected pastures in Palmerston North. This trial is still being carried out. The feed-flavour investigations have been carried out in co-operation with the Dairy Research Institute and the Department of Agriculture.

Pasture Ecology and Field Trials of Various Species and Strains.—In addition to a considerable amount of field observations and eye estimations of the botanical compositions of various swards under differential treatments, work has continued on the critical analysis of pastures, using the three standard methods of analysis: (*a*) Establishment counts; (*b*) point analysis of ground cover; and (*c*) actual yield and potentialities at various seasons as shown by actual analysis by weight of dissected samples of plucked and cut herbage.

In the main it is found that any one system of pasture analysis is insufficient when used on its own. In order to obtain a complete picture it is necessary to use the three methods to show clearly the germination and establishment of the individual species and weed invaders, the true habitat of the species shown by the ground-cover analysis, and finally the producing-powers as shown by the weight analysis. Comparisons of the last two methods give very instructive ratios of cover to production and are very useful in comparisons of species and strains of pasture plants.

Work has continued on the standardization of field and laboratory sampling technique, consideration having to be given to such factors as variability of samples according to number and size of species, stage of wilting, height of tallest and lowest species, accuracy desired, &c. Detailed figures and graphs have been kept of several critical trials run in collaboration with the Department of Agriculture in order to study the actual production, &c., of the species under trial and as a response to manurial and management practices.

Hill-country Pasture Trials.—Trials of surface sowings of various clovers and grasses have been laid down on the Massey Agricultural College farm and on the hill country of Hawke's Bay and Apiti districts, working in collaboration with the Department of Agriculture. These trials consist of the three strains of subterranean clover, early, mid-season, and late flowering; two strains of *Lotus major*, pedigree and commercial; three strains of white clover, No. 1, No. 2, and Kentish wild white; and strains of English and New Zealand rye-grass. These strains are sown both with and without a base mixture of permanent species, and also with variable quantities of superphosphate and, in some cases, slag.

Detailed point analysis are being kept, together with observational notes on the change, if any, of the closed swards of danthonia and brown-top on which they are sown.

(5) Chemistry.

Soil and Pasture Investigations.—The investigation of the effect of various fertilizer treatments on the chemical composition of herbage has been continued, and soil analysis in connection with the movement of added phosphate and lime have been continued for a further year. The addition of carbonate of lime to plots receiving phosphate in the form of superphosphate, basic slag, and North African phosphate has in all cases increased the amount of available P_2O_5 as measured by the citric-acid method. This is rather contrary to what would be expected in the case of the North African phosphate, as it is usually considered that the addition of lime decreases the availability of this fertilizer. In the Marton trials the plots receiving North African phosphate and lime show a higher available P_2O_5 content than any other treatment; but, in spite of this, the yield from this treatment is not as great as from other phosphate and lime treatments. The effect of lime treatments on the availability of the organic matter in the soil has been strikingly demonstrated, and it seems probable that the increased yield due to liming is not entirely due to the reduction in acidity, but also to the increase in the available nitrogen as a result of the greater decomposition of the organic matter. There has been a striking build-up in the total nitrogen content of the top layer of the soil under the conditions of grazing carried out in this experiment. Chemical investigations have not supported the contention that transference of fertility from one plot to another is seriously affecting the accuracy of the yield data.

Feed Flavour.—Routine analyses of the material fed to the stock have been carried out. Attempts to obtain from plant material any substance which would produce flavour in cream in any way similar to the naturally occurring clover taint have failed.

General.—Plots have been laid down to provide material for the investigation of mechanical differences in strains of rye-grass and clover. Work on technique of analyses of these samples is in progress. Experiments in the rooting of cuttings with the use of root-forming hormones have been carried out, and more detailed investigations are in progress. Results to date indicate that the successful rooting of cuttings of many species cannot be satisfactorily obtained, irrespective of the time of the year and the condition of the wood. The best results may be expected under conditions such as experienced propagators expect to get best results without the use of hormones. Considerable time was taken up in the transfer of the laboratory to new premises and the fitting-up of new laboratories. The greater facilities are much appreciated.

(6) Greenkeeping Research.

Very little investigational work was done during the year, although many requests were received for identification of weeds and grasses. The fourth annual report was issued during the year.

ENTOMOLOGY DIVISION.

(Director: D. Miller.)

Staff.

During August, 1937, the members of the staff formerly stationed at Palmerston North transferred to the Division's headquarters at the Cawthron Institute, Nelson. In September, Mr. L. J. Dumbleton, who had been employed as entomologist under the Fruit Research Scheme at the Cawthron Institute, was transferred to the staff of the Division. In regard to co-operation with Lincoln College, it was agreed that Mr. Morrison, part-time entomologist to that College, should act as a representative of the Division in Canterbury, and for this service provision is made in the Division budget for part of his salary and expenses.

Mr. Muggeridge, Associate Director, who sailed for London on 1st March, 1938, will give attention to the parasite complex of the diamond-back moth in England and Europe, as well as to other problems in which the Division is interested. He will also attend the International Congress of Entomology at Berlin. His contact with Farnham House Parasite Laboratory will be of great value in regard to the organization of the activities of that laboratory on behalf of the Division.

Accommodation.

During the year insectary accommodation for the increased activities has been provided and a heat-controlled glasshouse has also been added. In regard to laboratory and office accommodation, certain alterations in the existing buildings have been effected, while a new building has also been erected For the cultivation of the many crops associated with the researches, field space has been provided by the Cawthron Institute in a section adjoining the entomological block. For the growing of crops under field conditions the trustees have also provided space on the Marsden Estate at Stoke.

Research Activities.

White Butterfly Position, 1937–38.—Though the white butterfly must be looked upon as an insect of major importance, there is a widespread disposition to consider that the damage to crops is in direct proportion to the numbers of butterflies flying over them. The large size and conspicuous appearance of the butterfly results in estimates of the butterfly abundance being far too great. The white-butterfly damage is frequently confused with that caused by diamond-back moth. The indubitable butterfly damage, which is usually most pronounced round the margins of the crops, is not a fair indication of the actual damage over the whole of the crop. In addition, the part which rainfall and soil play in the production of good cruciferous crops is frequently disregarded and the whole blame for poor crops placed on the insect pests.

Notwithstanding this, the parasite control of white butterfly this season has undoubtedly not been satisfactory. The butterfly has been abundant in Hawke's Bay, Manawatu, and South Canterbury, and considerable damage has resulted to the crops in the first two districts at least. Field collections show that there is a very high rate of parasitism of pupæ in late summer from all these districts. The past season has been decidedly abnormal. From November onwards the mean monthly temperatures have been several degrees above normal, and this condition would have the effect of accelerating the development of the white butterfly to such an extent that the parasite was unable to overtake it until late in the season. It remains to be seen whether the parasite will give a satisfactory control in more normal seasons. At present we have no reliable information on the factors which favour the butterfly or militate against the success of the parasite, but a study of the problem is now being made.

In the early years of the distribution of the parasite *Pteromalus* (1932–33, 1933–34, 1934–35 seasons) large numbers of the parasites were liberated in the North Island, particularly in Hawke's Bay, but also in the Manawatu and in Wellington Province. In the following season (1935–36) large numbers were liberated in the Auckland Province and also in Marlborough, Canterbury, and Otago. In the past two

seasons (1936–37 and 1937–38) the majority of the available parasites have been liberated in the South Island, particularly in Canterbury and Otago. The following table illustrates the wide area over which parasites have been distributed and established :—

	Season 1937–38.	Total in Three Past Seasons.
North Auckland	1,175	
South Auckland	1,475	39,305
Bay of Plenty	800	
Taranaki	2,750	4,945
Manawatu	6,655	9,990
Poverty Bay	..	1,200
Hawke's Bay	1,000	1,950
Wairarapa	500	500
Nelson	1,250	5,010
Marlborough	3,105	13,255
North Canterbury	3,875	
Mid-Canterbury	10,605	120,550
South Canterbury	17,075	
North Otago	1,550	
Otago	650	14,588
Otago Central	1,050	12,755
Southland	..	2,000
Westland	700	2,160
	68,215	228,208

With the material available it is anticipated that 100,000 parasites will be distributed in the coming season. Arrangements have been made for the distribution of the parasites to be undertaken by officers of the Fields Division of the Department of Agriculture. No parasites will be sent out from Nelson in response to individual requests, as it has been found that a great amount of material is otherwise wasted and the best results not secured. The allocation of the available material to the different districts will be made after considerations of (*a*) the abundance of the white butterfly in the district ; (*b*) the importance of cruciferous crops in the district ; and (*c*) the number of parasites which have been previously liberated in the district.

Diamond-back Moth.—The work upon this insect has been devoted to researches upon its parasites : *Angitia* spp., *Diadromus*, and *Apanteles*. Of these parasites, most of the work has been concerned with the *Angitia*, shipments of the other parasites having been only comparatively recently received from England.

In regard to the imported *Angitia* (*A. fenestralis* and *A. cerophaga*), the breeding of these two species, which were imported during 1936–37, was continued throughout 1937–38, a total of 36,838 adults having been reared in the laboratory and 25,744 in field cages during the summer. Field liberations have been made as follows : The first liberation of 6,104 adults was made during 1936–37 in Hawke's Bay ; in 1937–38 a total of 31,229 were liberated in the Nelson town area, in the vicinity of Richmond ; at Waimea West ; and in the Blenheim district.

A field survey to ascertain the results of these liberations has been carried out, 51,373 diamond-back-moth pupæ having been collected for this purpose from the various districts where liberations of the parasites had been made.

Though several adult parasites were found under field conditions in Hawke's Bay, the latest recovery being in April, 1937, no recoveries were secured from the 10,407 diamond-back-moth pupæ collected in the same area during the 1937–38 season. The same results were secured from a study of the area at Palmerston North, where liberations had been made earlier.

However, during 1937–38 the parasites had become established and were recovered from the Nelson and Blenheim areas.

Though the percentage of parasitism in the field was very low (2 per cent. to 5 per cent.) in the Blenheim, Waimea West, and Richmond areas, the position was much more satisfactory at the Cawthron Institute experimental area, where a high degree of parasitism was secured at the beginning of summer ; this establishment was the result of escapes from the breeding-cages. In this experimental area approximately 55 per cent. parasitism was found in December, 1937, and this gradually increased to 70 per cent. by the end of January, 1938. However, at the end of March this figure had fallen to 5 per cent. A survey of the position during the forthcoming summer will reveal whether these parasites will be able to increase in a satisfactory manner without further liberations.

An important factor that apparently causes the decrease of parasitism by *Angitia* toward the close of the season in the field and will doubtless prove detrimental to this parasite is the influence of the hyperparasite *Eupteromalus* sp., which caused heavy mortality among the *Angitia* in Hawke's Bay during the previous season. Apparently when *Angitia* reaches a high percentage of from 50 to 70, the *Eupteromalus* proportionately increases, and the result is a rapid decrease of *Angitia* by the autumn. In the Northern Hemisphere the records show that this fall of *Angitia* does not take place, but that the parasite continues to increase to a maximum in the autumn.

Regarding the *Diadromus* parasite, eight consignments totalling 11,304 parasitized diamond-back-moth pupæ were received from England during the year ; from this material the percentage of *Diadromus* secured was very low (1·2 per cent.). Most of the material available is being maintained under experimental conditions, while the remainder is held in cool store for the time being.

In the case of the third type of parasite (*Apanteles plutellae*), six consignments of 8,380 cocoons of the diamond-back-moth have been received, and a seventh is expected. The first four consignments yielded 12 per cent. of parasites; the remaining consignments are yet in cool store.

Before field liberation of *Apanteles* can be made it will be necessary to ascertain what influence it may have on *Angitia*, since both are larval parasites. It has been decided that more information should be secured by Farnham House in England regarding these parasites and their interrelations before any mass consignments are sent to the Dominion.

Lucerne-flea.—A survey during 1937–38 has established that the lucerne-flea (*Sminthurus viridis*), which is in Australia a serious pest of clovers and lucerne, is present and widely distributed in both North and South Islands. In the North Island there are isolated occurrences at Pokeno and Maraekakaho, and it occurs throughout the area from Dannevirke to Eketahuna and Palmerston North. In the South Island it occurs from Temuka to Gore, but has not been found north of the Rangitata River.

The insect is believed to have been established in both Islands for a period of years, possibly ten years or more. In general the extent of damage to clovers and lucerne is not serious. In the case of the occurrence at Maraekakaho slight damage was done to subterranean clover, and at Pokeno considerable damage was done to the clover components of a pasture shut up for hay. It is difficult to forecast the seriousness of the pest, particularly on the white-clover pastures of the nothern half of the North Island, but it is believed that the damage on pastures subject to grazing will not be great.

In Australia the bdellid mite (*Biscirus lapidarius*) is considered a useful predator on the lucerne-flea. This mite is already present in New Zealand—in the North Island at least. It is therefore proposed to watch the position of the lucerne-flea until experience indicates that some method of control will have to be adopted.

Insect Pests of Wheat.—A survey of the insect pests of wheat has been undertaken in Canterbury. The Hessian fly (*Mayetiola destructor*) was found to be widely distributed, but the percentage of damage caused by it varied, being obviously destructive in certain localities of South Canterbury and of North Otago, but becoming of decreasing importance northwards until of minor importance in North Canterbury. It would appear that an important factor in the incidence of Hessian fly is farm practice, though the influence of climate has not yet been studied. From the data so far secured it would seem that parasites, though present, have but little influence in the control of the fly, owing to the extremely low percentage of parasitism. Attention was given to the susceptibility of wheat varieties to Hessian-fly attack, and it appears that some varieties are more susceptible than others; for example, Dreadnought and Hunters showed a higher percentage of infestation than did Tuscan and Cross 7, though this was not constant for all localities.

As an outcome of this preliminary survey it was found that the wheat sheath stem maggot (*Cerodonta denticornis*), which has been recorded from rye-grass in New Zealand, has been found attacking wheat in Canterbury; this insect damages grasses, oats, and wheat in the United States of America and in Europe. It was considered to be causing very little damage to wheat in Canterbury during 1937–38; it occurred also in barley.

Frequently associated with both Hessian fly and stem maggot were the larvæ of the Argentine wheat-weevil (*Hyperodes griseus*). This weevil has been already found in New Zealand. The available data show that this weevil is not yet a serious pest, but, as with the other wheat insects, more information is required.

Other wheat insects dealt with are the larvæ of species of noctuid moths, which damage the heads of the developing crop, and a larva boring in the stems. Mention should be also made of the so-called "wheat-bugs," which puncture and injure the grain.

Other Problems.—During the year the depredation of grass-grubs (*Odontria*) and grass-caterpillar (*Porina*) have been giving some concern, and it is desirable that an adequate study of these problems be undertaken. Though there are much data available concerning grass-grubs, knowledge of the grass-caterpillar situation is very meagre. However, observations are being carried out as far as possible.

A special study of the sheep maggot-fly problem is being undertaken by the Division in co-operation with the Cawthron Institute and Department of Agriculture. An extensive trapping experiment has been established in Marlborough to ascertain the seasonal incidence of the different species of blow-flies. A monograph on these flies will shortly be presented for publication.

An insect reported as causing serious damage to cocksfoot seed has been recorded from Mid-Canterbury; this is a species of midge of the genus *Stenodiplosis*. This species is apparently a new one not previously recorded, and thus no information is yet available concerning it. The problem is being studied, and the possibility of utilizing parasites attacking related seed-midges is being gone into.

The maize-seed beetle (*Clivina rugithorax*), which has been present in the Dominion for many years, caused serious damage during the year to maize at Hastings; the losses due to the insect amounted to 25 per cent. to 75 per cent. of the planted maize-seed. It was also reported as damaging strawberry-fruit in the same area.

Routine.—A considerable volume of advisory work has been attended to, involving the identification of insects sent in by private individuals and Government field officers, as well as furnishing information and advice on the pests concerned. A very valuable co-operation is maintained with the field staff of the Fields, Horticulture, and Veterinary Divisions of the Department of Agriculture.

Summary.—The major problems to which the Division is giving detailed attention as the leading avenues of research are the white butterfly, diamond-back moth, grass-grub, and grass-caterpillar.

Of the other problems mentioned above, the lucerne-flea, wheat insects, and cocksfoot-midge are outstanding. In the case of the lucerne-flea it has been decided to watch its development for a time before deciding whether special control measures should be undertaken against it. The wheat-insect survey shows that (at least during the period of the survey) the Hessian fly, stem-maggot fly, and Argentine weevil were not of very outstanding importance except perhaps for the Hessian fly in certain restricted localities; as with lucerne-flea, the development of these insects will be kept under observation. The cocksfoot-midge is apparently a major pest, though not universally so, influencing as it does a single type of localized crop. In regard to sheep blow-flies, there are indications that the major proportion of mortality amongst hoggets is due mainly to worm infestation rather than to maggot-flies, though the latter are epidemic during some seasons. The possibilities of the maize-seed beetle becoming a regular pest will be kept under review.

With limited staff it is necessary to concentrate on major problems and to guard against spreading activities over subjects which at the moment are apparently not particularly urgent.

AGRONOMY DIVISION.

(Director: J. W. Hadfield.)

The headquarters of the Agronomy Division has now been permanently established at Lincoln, in close proximity to Canterbury Agricultural College. Facilities in the matter of finance, land and buildings, and assistance are more satisfactory than has been the case in the past.

The Agronomy Division is concerned directly with all phases of crop improvement, and this objective is approached by plant introduction, plant breeding, and pure-seed production. A recent addition to these activities has been effected by the appointment of an officer who is to specialize in vegetable crops.

Plant Introduction.

This phase of crop improvement may be divided into two lines of activity. First, the introduction of new crops to New Zealand, and, secondly, the introduction of new varieties of those crops already grown in this country.

Linen Flax.—In the former class the most important item is an attempt to test the economic and agronomic possibilities of the production of linen fibre in New Zealand. From trials conducted during the past two seasons the agronomic possibilities certainly appear promising. The yield and quality of the fibre has also proved satisfactory and there appear to be no insurmountable difficulties attending the growing, harvesting, and decortication of the straw. It would seem, moreover, that very extensive areas in the South Island could with advantage be diverted to linen-flax production. The commercial aspect needs, and is receiving, particular attention, but it may be stated that the Russian and European economic policies have created concern as to future supplies of fibre for British manufacturers, who import 80 per cent. of their fibre requirements.

Soya bean.—During the last few years an attempt has been made to introduce the soya bean into cultivation. It has not been possible, however, to find any economic use for this crop in New Zealand. Trials are also being conducted with hemp, but possibilities in this direction are by no means as promising as are those in connection with linen flax, owing to difficulties of harvesting, processing, and seed production.

Other Crops.—Of those crops already grown in New Zealand, active endeavours are being directed to the introduction of varieties which may prove, in one way or another, superior to those already being grown commercially. Particular attention is being paid to oats, barley, linseed, lupins, potatoes, peas, and brassicas. The oat "Resistance" is becoming more widely grown, especially in Otago and Southland, on account of its yield and resistance to lodging. Anthony, Markton, and Huskless are proving useful introductions. Of the barleys, a wide range has been tested this past season and contains some promising material. The introduction of the Sweet Yellow lupin has been effected, and the potentialities of an alkaloid-free lupin may prove to be very great in New Zealand. Those varieties of potatoes showing promise overseas are introduced regularly, but the most interesting introduction of recent years has been of those species discovered originally in South America and which are being used extensively for breeding purposes. Certain vetches introduced some years ago, and found to be immune to black aphis, are being grown extensively under trial by orchardists as a green manure.

Plant Breeding.

Activities are being directed mainly to lucerne, oats, peas, potatoes, and brassicas.

Lucerne.—As a result of seven years' work on lucerne, the first strain is now being increased for seed production. It has arisen from selected progenies of the most promising crosses effected between plants which, on inbreeding, exhibited little or no reduction in vigour. A second strain is following this, having been built up from selected progenies of the most promising crosses effected between the best inbred families. Thus, the former has not been inbred, although selection has been based largely on the behaviour of inbred progenies. The latter is an attempt to combine the desirable features of homozygous inbred plants. Plot trials are being conducted simultaneously with seed production.

Oats.—Breeding in oats has been largely an attempt to combine disease resistance, mainly to leaf and stem rust, with the desirable agronomic features of varieties grown commercially in New Zealand. It is yet too early to predict results, but some of the advanced segregates now in F_6 show distinct promise.

Field Peas.—An attempt to improve the yield and quality of field peas appears to have met with distinct success. The main objectives have been, first, the production of an improved White Ivory type for the split-pea trade, and, secondly, a boiling-pea of better quality than Blue Prussian. The F_7 segregates now under trial show marked superiority in yield and, in some degree, in improvement in quality. These crosses are now sufficiently fixed to undergo field trials, and material is being increased with that end in view.

Potatoes.—Potato breeding has been confined to the utilization of South American species certain of which are frost-resistant and others resistant to late blight. The F_1 yield and quality of some crosses between *Solanum andigenum* and commercial varieties of *Solanum tuberosum* is very satisfactory. Great care has to be taken to prevent virus infection, but facilities are not as yet available to permit of selection for frost and disease resistance. This is a long-range project and it may be many years before any improvement is affected.

Brassicas.—Brassicas occupy a far greater area than any other crop in New Zealand and warrant special consideration in the direction of disease control. They are particularly susceptible to both insect pests and diseases, and, although resistance may be difficult and even impossible of attainment, attempts are being made with this end in view. As a result of several years' work, material improvement has been effected in the rape crop, and the demand for certified seed of improved strains is far in excess of supply. Marrow stem kale is becoming increasingly popular and steps are being taken to raise seeds of improved strains and eventually to place seed production under certification. Interspecific and intervarietal crosses between and within rape, swedes, and turnips are being studied, and certain crosses between rape and club-root resistant swedes, back-crossed on to rape, are showing promise. This method may afford a means of introducing into rape the resistance of the parent swede.

Pure-seed Production.

The demand by farmers and merchants for pure seed of standard varieties may be regarded as perennial. To meet this demand this Division raises nucleus lots of seed which are further multiplied by Canterbury Agricultural College or the Fields Division of the Department of Agriculture, and thereafter are distributed under certification. To this end pure-seed stocks of most varieties of cereals and peas are maintained. The farm attached to this Division consists of 52 acres worked under a strict rotation in which green manure and fallow appear every fourth season. The greater part of this area is devoted to pure-seed production, and every endeavour is made to distribute seed that is free from seed-borne diseases.

The greatest demand for pure seed is found in the case of wheat, garden peas, and rape. Wheat varieties become mixed during threshing and there is often a steady increase in the incidence of loose smut. Garden peas are grown largely for export, and a very high standard of purity has to be maintained. Not only do varieties of garden peas become mixed during threshing and harvesting, but variants appear in many varieties, necessitating rogueing. The production of pure seed is an activity of this Division that is greatly appreciated by merchants.

Under the system adopted it generally takes three years to raise nucleus seed. Commencing with a number of single plant selections, the seed from each is sown in a plot. Each plot is observed carefully and those that are pure are increased individually for a second season. The seed harvested from those that remain pure for two seasons is then bulked and an acre, more or less, is sown for distribution. Any lines showing deviation from the normal are discarded. Since this is a continuous process, it happens that in many cases a line distributed is wholly the progeny of a single plant, and in this manner a high degree of uniformity is attained.

In some varieties, as, for example, Dun oats and Hunter's wheat, this method of studying single plant progenies has brought to light wide variations. In such cases the variants have to be tested for yield and quality, and four to six years may be spent in deciding which is the best before seed is liberated.

BOTANY SECTION.

(Botanist: Dr. H. H. Allan.)

Routine.

Routine work has proceeded on the lines indicated in previous reports. Numerous additions have been made to the herbarium—especially of weeds—by all members of the staff, and important accessions have been received from abroad. The usual botanical assistance has been rendered to the various Divisions of the Bureau, the Department of Agriculture, State Forest Service, and other Government Departments. Over 1,500 specimens have been received and reported on. Some twenty hitherto unrecorded weeds have been noted, but none have been of major economic importance. Samples of charlock received from Invercargill indicate the need for examination of seed samples of crucifers on a purity basis. Samples of seed for trial in the experimental area at Pisa Flats have been received from the Soil Conservation Service, United States; the Plant Introduction Officer, Canberra; and the Pasture Research Station, Pretoria. Other material is being sought. Samples of New Zealand grasses are being sent in exchange.

Major Researches.

(1) *Ragwort Investigation.*—A summary of results to date, giving the life-history of the plant and the effect of the different methods of hand-control tried out, has been published in the *Journal of Agriculture.* Important studies have been made on the root-system of the plant, its life period, and powers of vegetative reproduction. The experiments are being continued, and include further work on the methods of distribution of seed—wind, animals, and water. The difficulty of establishment from seed on a closed pasture in good heart has been demonstrated. A fuller paper is being prepared for the *Annals of Applied Biology.*

(2) *Survey of Montane Tussock Grasslands of South Island.*—This has special reference to the present state of the pastures, the causes of deterioration, and methods of improvement. Work on the botanical aspects is being done in co-operation with the work of the Department of Agriculture. From material accumulated in the course of a two month field survey a preliminary classification of the grasslands will be made as a basis for more intensive work on selected areas. Special attention is being paid to the more useful of the native and introduced grasses, and seed for experimental sowings is being gathered.

(3) *General Weed Survey.*—Progress has been made in the distributional ecology of the major weeds. An illustrated book on the whole of the naturalized species will shortly be ready for the printer. A paper dealing with the origin and distributional history of the alien flora has been published in the *Proceedings of the Linnean Society.*

(4) *Taxonomy of the Indigenous Grasses.*—Much further material was gathered during the survey of the tussock grassland and is being worked up. A taxonomic revision of all genera and species is in progress. This is an essential to sound ecological work in the future.

Minor Projects.

Work on the taxonomy and ecology of indigenous plants has been continued. Mr. Zotov has published a paper on the correlation of climate and vegetation and has in the press a detailed study of the vegetation of the Tararua Mountains. Mr. Poole has published a useful account of the Pukekura State Forest, Westland, from the sylvicultural point of view. Papers have been published on an artificial cross between *Phormium colensoi* and *P. tenax*, and on the whole subject of Wild Hybridism, the latter in the *Botanical Review.* Work has been commenced on the use of edible shrubs in ungrassable land in the North Island. A taxonomic study of *Pyrethrum* for the Plant Diseases Division is under way, as also is an account of the legumes occurring in New Zealand. Many other minor projects are receiving attention as opportunity occurs.

During the year the section was transferred to Wellington. Better facilities and contacts are now available, but in view of the work the section wishes to develop it is still understaffed.

ANIMAL RESEARCH BUREAU.

The desirability of co-ordinating animal research in New Zealand and enlarging its scope to a degree commensurate with the needs of the animal industry has been recognized by the Council of Scientific and Industrial Research for some considerable time. A conference, under the authority of the Hon. the Minister in Charge of Scientific and Industrial Research and the Hon. the Minister of Agriculture, was held in May, 1936, and this was attended by representatives of the Council of Scientific and Industrial Research, interested Government Departments, the Agricultural Colleges, and the Cawthron Institute. The broad field of animal research and its organization in New Zealand was discussed by the conference, and it was recommended that a Bureau of Animal Industry be set up under the Department of Scientific and Industrial Research and directed by a Committee representative of the Departments of Agriculture, Health, Scientific and Industrial Research, Massey and Canterbury Agricultural Colleges, and Cawthron Institute.

The Hon. the Minister in Charge of Scientific and Industrial Research approved these recommendations, and two preliminary meetings of the Committee were held to consider the inauguration of the Bureau and to survey the existing facilities for, and the scope of, animal research in New Zealand.

In August, 1937, with the approval of the Hon. the Minister in Charge of Scientific and Industrial Research, an Animal Research Bureau was set up under the following advisory committee :—

Messrs. A. H. Cockayne and W. C. Barry ..	Department of Agriculture.
Professor E. R. Hudson	Canterbury Agricultural College.
Professor G. S. Peren	Massey Agricultural College.
Sir Theodore Rigg	Cawthron Institute.
Professor W. Riddet	Council of Scientific and Industrial Research.
Dr. M. H. Watt	Department of Health.
Dr. E. Marsden	Department of Scientific and Industrial Research.

Dr. C. S. M. Hopkirk and Mr. M. McG. Cooper (Secretaries) and one representative each from the New Zealand Meat-producers Board and the New Zealand Dairy Board. Messrs. A. Linton and J. D. Ormond, jun., were elected representatives of the Dairy and Meat Boards respectively.

The above Committee has met on two occasions, and much useful work has already been undertaken.

Dr. Hammond's Visit.

One of the preliminary steps taken by the Bureau was to recommend the Government to invite Dr. John Hammond, of Cambridge University, England, to come to New Zealand to report on the organization of animal research. Dr. Hammond arrived early in January and spent two months in the country, during which time he made a comprehensive study of the organization of the animal industry and the problems affecting its efficiency. He made a detailed tour and paid visits to representative farms, freezing-works, and dairy factories. He spent a considerable amount of time at the research institutions and made personal contacts with research workers, advisory officers, and leaders of the farming community. On the completion of his tour Dr. Hammond prepared two reports, one embodying his recommendations for the organization of animal research in New Zealand, which has been submitted to the Government for consideration, the other dealing with problems of animal research, a report which will be of considerable value to the Bureau in its subsequent operations.

Workers' Committees.

Two workers' committees—the Cobalt Committee and the Mastitis Committee—have been set up under the Bureau. The Cobalt Committee directs the investigational work on mineral-deficiency diseases of stock, and consists of officers of the Department of Scientific and Industrial Research, the Department of Agriculture, and Cawthron Institute. The Committee has rendered excellent service in co-ordinating the various aspects of the investigational work and has afforded a valuable means for workers to discuss their related problems. A full account of the cobalt investigations is furnished elsewhere in this report. (See pages 000–000.)

The Mastitis Committee was fortunate in having the services of Dr. G. J. Hucker, of the New York Experiment Station, who is an American authority on the disease. Dr. Hucker was visiting New Zealand through the offices of the New Zealand Dairy Board and the Department of Agriculture. He brought with him a very stimulating outlook and a broad knowledge of the disease. Largely as an outcome of his visit, the Department of Agriculture has made available to farmers a test for the early determination of mastitis infection and information for the combating of the disease.

Sterility.

Work on sterility in sheep has been under way at Massey College for some two years, and on the recommendation of the Bureau finance was made available to continue this work, particularly in regard to the bio-chemical investigations for which there was an urgent need.

Co-operation with the Wool Publicity Committee.

Representatives of the Animal Research Bureau met members of the Wool Publicity Committee to discuss and recommend the allocation of funds that the Wool Committee have available for research into problems relating to the production of wool. It is probable that a considerable volume of work will be undertaken in this connection during the coming year.

General.

The Bureau has been concerned in the initiation of surveys of the incidence of animal disease, particularly in the Canterbury Province. The Bureau's activities so far have been comparatively restricted, and its full function will not be realized until Dr. Hammond's report has been considered and the Government has decided what steps may be taken to provide an organization for combating the ravages of animal disease and for improving the conditions of animal production.

WHEAT RESEARCH INSTITUTE.

ANNUAL REPORT FOR THE YEAR ENDED 31st MARCH, 1938.

Advisory Committee: Dr. H. G. Denham (Chairman), Messrs. C. E. Boon, J. Carr, G. Fleetwood, J. W. Hadfield, R. K. Ireland, R. J. Lyon, W. W. Mulholland, W. H. S. Newsome, R. T. H. Norton, J. P. O'Connor, W. O. Rennie, C. S. Sapsford, P. R. Talbot, and R. B. Tennent. Director: Dr. F. W. Hilgendorf.

Staff.

There have been no important changes in staff except that Mr. R. V. Peryman joined the Wool Research Association and was replaced by Mr. L. H. Bird, M.Sc. Mr. E. W. Hullett, Chief Chemist, spent nine months in America, Europe, and Australia investigating the methods there used in the testing of flour-quality. His report shows a critical insight into the fundamentals of the problem, and especially as it is affected by New Zealand conditions. He also made inquiries on the subject of artificial driers for wheat.

Wheat-breeding.

Cross 7, the new wheat produced by the Institute, was grown on 12,000 acres for the harvest of 1937. Its yield was 5 bushels above that of Tuscan. Its milling and baking qualities remain outstanding. In trials on a commercial scale bakers were unanimously of the opinion that the loaf produced was equal to that produced by Tuscan plus 10 per cent. Canadian. It is probable that the threshing for the harvest of 1938 exceeded 30,000 acres.

Two other new wheats are near the end of their trials and will probably be distributed to farmers within the next two years. One of them is similar to Tuscan in all respects except that its yield is 10 per cent. to 12 per cent. more; the other is equal to Tuscan in yield, but in quality is equal to Marquis, the highest-quality wheat grown in New Zealand.

Laboratory Work.

New season's wheat has always been a source of trouble to bakers, for each year's wheat has different characteristics and therefore needs different manipulation in the bakehouse. To guide bakers in the change of technique required the laboratory has secured the earliest possible supplies of each of the new season's wheats, milled them on the experimental mill as well as commercially, baked them by various methods, and then sent out a bulletin to all bakers indicating the directions in which changes in bakehouse method would probably be advantageous. As a result of this, bakers' trouble with new season's wheat is now a thing of the past.

The harvest of 1937 was generally good, but the latter part of it was wet, and a good deal of wheat that was out of condition was delivered to stores. Tests were carried out over long periods on the rate of drying of wheat in sacks in various kinds of stacking, and the information is available for future use.

A long series of investigations was made in the attempt to determine the quality of a wheat, not only when it was baked alone, but also its quality in blends. As a result of this work the information sent to millers on the wheats they send in for test has been considerably modified, and it is now probably a more useful guide to them in their endeavour to produce an even quality of flour all the year round.

Investigations on the quality of gluten and of the effect of various enzymes thereon have been conducted by a National Research Scholar.

Wheatgrowing Practice.

Experiments on the effect of soil-moisture and of feeding-off wheat have been continued.

The number of header harvesters is now probably in excess of 400, and the average area of wheat harvested by each is almost exactly 200 acres. These would therefore account for 80,000 acres, or over 25 per cent., of the whole crop. The handling of headed wheat requires much experience if it is to be stored in good condition. Over 3,000 lines of wheat sent in by farmers were tested for moisture so that it would not be stored until it was properly dry. Investigations were made into the rate of drying under different methods of storing in the field or in sheds, so that recommendations may be made for future seasons.

Co-operation with the Department of Agriculture.

The Department of Agriculture has continued to be of the very greatest assistance to the Institute, both by making variety trials in all parts of the country and by allowing its officers to act on the Specialists' Committee which discusses the kind of experiments that should be conducted on all problems connected with the growing and utilization of wheat.

PHORMIUM RESEARCH.

REPORT ON WORK FOR THE PERIOD 1st APRIL, 1937, TO 31st MARCH, 1938.

By Dr. J. S. Yeates.

Easton Area.

There has been no extension of planting in this area since last year's report. Apart from cross-pollination, mentioned later, the only work has been cultivation to keep down weed-growth. A rotary hoe purchased for this work has proved incapable of withstanding the fairly heavy and continuous work needed on the area.

Good results in weed-control are being obtained by the use of sheep belonging to a nearby farmer. To be really effective, however, a larger number of sheep is necessary than the farmer can supply.

Growth has been good, and in some varieties excellent. The variety Paretaniwha has grown especially well. Planting of this variety was done at intervals from September to December, 1937.

The fans planted in September have multiplied so much that in eighteen months from planting many single fans have produced twenty new ones. Amongst the other varieties, S.S. is multiplying faster than any. Ngaro, of which there are 20 acres in this area, is growing well, being over 8 ft. in height in some spots. This variety, however, grows in height rather than stools out, and has not so many fans as the Paretaniwha, though the Ngaro has been planted for two years and nine months.

No floods have been experienced at the Easton Area in the past year. The stop-banks and their protective willows are now in much better condition than at any time previously. One more growing season for the willows and for the vegetation on new earthworks will make the stop-banks safe against any floods likely to be experienced.

College Area.

Cutting and milling tests in the past year have given interesting results. The first cutting tests were on ten bushes of a hybrid plant (13K × S.S.), of which the excellent recovery after cutting was noted in last year's report. These bushes were cut in August 1937, approximately two years after the

previous cutting. The average leaf-yield was 182 lb. per bush. The leaf was of good length and was remarkably free from dead, diseased, or short leaves. The regrowth from August to date (31st March, 1938) has been quite as good as previously, and it appears that the above yield can be maintained unless disease interferes.

It is interesting to consider the implications of this yield per bush. The bushes in question are in one row and are spaced approximately 6 ft. apart (centre to centre). In the two years of their regrowth they had a row of bushes at about the same stage of growth some 11 ft. away on one side. On the other side were young plants within about the same distance (11 ft.). It is therefore difficult to assign any definite spacing to these plants.

A yield of 182 lb. per bush every two years would be equivalent to 30 tons per acre in that time if 370 bushes per acre could be grown—allowing for a spacing such as 6 ft. 6 in. by 18 ft. This is a spacing which should be ample to reproduce the above results in growth.

Such a yield (30 tons) per acre each two years is about twice as much as is considered an excellent yield at present, and if it could be realized in practice would greatly reduce growing costs. As pointed out in last year's report, these results are likely to be obtained only when vigorous, selected hybrid plants and other conditions are combined. These problems need systematic large-scale experiments if progress is to continue.

The second cutting trial, though only a rough one, illustrates the part played in leaf-yield by one of the factors—namely, hybrid vigour—concerned in the previous test. A long row was planted some four years ago with unselected seedlings of S.S., of Ngaro, and of hybrids (Ng. × S.S.) from the crossing of these varieties. When they grew in size and began to crowd one another, the seedlings were thinned out to about 3 ft. apart, this thinning having in some measure the effect of culling. When cut the leaf from each bush was weighed and the following results were obtained :—

Twelve S.S. seedlings averaged 74 lb. of leaf each.
Fifteen Ngaro seedlings averaged 107 lb. of leaf each.
Fourteen hybrid seedlings averaged 138 lb. of leaf each.

There were no sufficient differences of soil or other conditions to explain these variations in yield, and one can only conclude that the hybrid plants grow more vigorously than the others.

Where fibre-quality is concerned, the milling-tests gave most satisfactory results, though it must always be realized that only the better bushes, as indicated by hand-stripping tests, are usually submitted to milling-tests.

The following table shows the grading figures allotted to ninety-four samples of the Ngaro by S.S. hybrids, and to thirty-eight samples of Ngaro seedlings. All grading was done by Mr. E. W. Sutton, mill-manager to Messrs. Ross, Rough, and Co., Ltd.

Grading Points awarded to Samples of Fibre from Hybrid and Inbred Bushes.

—	98 Points.	93–96 Points.	90–92 Points.	89 Points or less.
	Bushes.	Bushes.	Bushes.	Bushes.
Ng. × S.S. hybrids	13	37	33	11
Ngaro seedlings	4	12	13	9

For the sake of comparison it may be noted that the grade of which most is exported is "high-fair," graded at 65–69 points.

All the hybrid plants which gave fibre grading at 95 or better have been broken up and set out for vegetative reproduction. A considerable number of them were sent to Westport for growing on pakihi land in manurial trials carried out by the Cawthron Institute.

The high-testing Ngaro seedlings are being kept for further inbreeding and crossing experiments in an endeavour to raise still better hybrid plants.

Growth in general has been good at this area. There is at present extreme congestion because of the large number of plants now ready for setting out from the nursery stage. These include 20,000 two-year-old hybrids of Ngaro and S.S.

Breeding-work.

At the request of the Flax Plan Industrial Committee intensive crossing of Ngaro by S.S. was carried out. The amount of flowering on Ngaro was exceptionally low, there being about fifty inflorescences on 20 acres. Flowers on these stalks were emasculated by hand and then pollinated with S.S. pollen collected by Mr. Alfred Seifert's permission from bushes of that variety near Shannon. Altogether some 14 lb. of seed was procured in this way, and a test showed that there were nearly 38,000 seeds to the pound.

Cross-pollination was also carried out as indicated below, the amount of seed being shown also :—

Variety 156 by Ngaro	9 oz.
Variety S.S. by Ngaro	1 oz.
Variety 273 by 56	Small quantity.
Variety 156 by 317	,,
Variety 156 by 56	,,
Variety 317 by 56	,,

From open pollination 40 lb. of seed was obtained from fifty bushes of Variety 273, and 11 lb. from eighteen bushes of Variety 56.

About one-half of this seed has been planted, the lack of ground at the College area preventing the planting of the balance.

Growth measurements of leaves have been recorded for sixteen months now in the varieties Ngaro and 156. Detailed analysis of these records is being postponed until the first-measured leaves die in the next six or eight months.

Soil Survey of Phormium Areas.

In September a period of ten days was spent with Mr. N. H. Taylor and Dr. J. K. Dixon, of the Soil Survey Division, in soil examinations of phormium areas in several districts.

Although no comprehensive examination of the problem could be made in so short a period, most interesting results were obtained. In general it might be said that the best phormium areas have a high soil fertility and a low-water table. The general relationship of high-water table to unthriftiness in phormium has long been realized by many growers, and more precise information on this aspect is urgently needed.

Entomological Work.

Miss G. E. Wall has continued to carry on her investigation of phormium pests, paying particular attention to the leaf-eaters *Melanchra steropastis* and *Xanthorhoe praefectata*. Work on these species at the College has been limited on account of their very scanty occurrence in our area. This applies especially to *Xanthorhoe*. This may be taken as an indication that in well-tended phormium plantations the conditions are not satisfactory for the multiplication of these insects. Miss Wall's own account of her work is as follows :—

"During the past year the life-history study of *Melanchra steropastis* has been continued and a written account of this, together with a written account of the anatomy of *Opogona omoscopa*, was forwarded to the Department. Following the observation of the grass-eating habit of the larvæ of *M. steropastis*, a series of experiments was carried out in the field to note the effects of cultivation on the prevalence and general activity of the pests. An area containing about twenty-four one-year-old fans was completely freed from grass. These plants were then infested at intervals with a total of 450 first instar larvæ. Throughout the period of observation no larvæ were found on the plants after the day of infestation and there was no subsequent injury to the plants through insect attack.

"As a control experiment three flax-plants growing among grass were chosen. These plants were carefully examined and all stages of *Melanchra* present were removed. At a distance of 3 ft. from the base of each plant an area 2 ft. wide was dug, thus removing a circular band of grass and isolating each plant. These were then infested each with 200 first instar larvæ. During the following weeks the larvæ were observed feeding on the surrounding grass. The first attack on the flax itself was made four weeks after the date of infestation. From that time the larvæ migrated from the grass to the flax and continued to feed upon the latter. These experiments and later observations have proved that grass or some plant other than flax is essential to the earlier stages of *M. steropastis*, Satisfactory control of this pest would most probably be obtained if the grass could be replaced by a cover-crop during the two main breeding-seasons of each year. Experiments are now being carried out to discover which plants, other than grass, provide suitable food for the young larvæ of *M. steropastis*.

"During the summer the scale insect *Leucaspis stricta* became a pest of the flax, especially of variety No. 56. Control was attempted by means of spraying. Black Leaf 40 was used, but proved unsuccessful, and later Red Oil was used, effecting good control. Further work is necessary before it will be possible to say what strength of spray it is most economical to use and also whether one concentrated or two consecutive weaker sprayings gives the higher control.

"Only a very small percentage of the plants growing in the nursery suffered from yellow leaf during the summer. Attempts were made to transmit this disease to healthy plants by injecting into them the sap extracted from diseased plants. Infection was attempted both by rubbing and by the use of a hypodermic syringe, but the results were negative in every case."

We have again to thank all flaxmillers and others who have helped the work during the past year.

MINERAL CONTENT OF PASTURES.

TENTH ANNUAL REPORT ON MINERAL CONTENT OF PASTURES INVESTIGATION AT THE CAWTHRON INSTITUTE, NELSON.

Cobalt Investigations at the Cawthron Institute, Period 1937–38.

Sir Theodore Rigg, Officer in Charge.

Introduction.

During the past year animal experiments in connection with the use of cobalt salts for the control of stock ailment at Glenhope, Nelson, and Morton Mains, Southland, have been continued. In addition, similar work has been initiated at Westport, where calves grazing pastures established on pakihi land have suffered from a wasting ailment resembling bush sickness.

In the chemical laboratory much time has been spent in studying the cobalt status of typical pastures in the Nelson district and in determining the effect of various cobalt top-dressings on the cobalt content of the pasture.

A start has been made with the collection and examination of pasture samples from different localities in the South Island, where a somewhat low cobalt status of the soil suggested the possibility of pastures being deficient in cobalt.

Considerable time has been spent in investigating the preparation of cobaltized fertilizers and in carrying out in co-operation with fertilizer firms semi-commercial tests for the manufacture of cobaltized superphosphate.

Animal Experiments.

The experiments at Glenhope and the Sherry Valley have given further proof of the great value of cobalt-salt licks and of cobalt top-dressing in overcoming sheep ailment. At Glenhope sheep very seriously affected with bush sickness have not only completely recovered, but have been maintained in perfect health for a period of fifteen months when grazed on a typical unhealthy pasture top-dressed with superphosphate containing 2 lb. of cobalt chloride per acre.

In the Sherry Valley the use of a salt - bone-meal lick containing 15 oz. of cobalt chloride per ton has enabled ewes with lambs to be carried successfully for two seasons.

At Morton Mains, Southland, experiments have been continued on the value of cobalt and cobalt plus nickel drenches and the value of pasture treatment with cobalt salts. The inclusion of nickel in the drench solution has been associated with greater live-weight figures than those from the cobalt-drench treatment, but there is still some doubt as to whether the difference in live-weight from the two treatments is statistically significant. Excellent results have been obtained by the use of 10 lb. of cobalt chloride per acre for pasture top-dressing. Lambs have been carried on through a second season on top-dressed pastures, and very satisfactory live-weight increases have been made. Corresponding lambs on non-top-dressed pastures have suffered severely from Southland ailment, and a high percentage of deaths has occurred.

Owing to dry weather experienced during the past season in Southland the conditions have not been favourable for the conduct of animal trials. No sickness has developed either in the treated or the control groups of sheep.

At Westport cobalt drenches have given wonderful results in overcoming ailment in calves grazing pastures established on pakihi land. There is considerable evidence to show that the cobalt-drench dose for calves on pakihi pastures must be increased above 7 mg. cobalt per week. With this dose some calves failed to progress satisfactorily. When the dose was increased to 36 mg. cobalt per week, calves seriously affected with ailment made a rapid recovery. On the different blocks of the pakihi reclamation scheme of the Lands Department all classes of cattle have shown great benefit as a result of using a combined lick containing equal parts of Nelson soil, dairy salt, and steamed bone-meal supplemented with cobalt chloride at the rate of 16 oz. per ton.

Cobalt Status of Nelson Pastures.

A number of typical Nelson pastures have been sampled regularly during the season for cobalt estimations. The analyses show that the unhealthy pasture at Glenhope has a very low cobalt content. Figures as low as 0·01 p.p.m. of cobalt have been obtained for this pasture. The cobalt content appears to vary somewhat during the season, but an average value of 0·03 p.p.m. cobalt probably represents fairly well the status of this pasture. Healthy pastures in other parts of the Nelson district have given values ranging mainly between 0·10 p.p.m and 0·20 p.p.m. cobalt on the dry basis.

Cobalt Status of Westport Pastures.

A number of samples have been obtained from pastures established on the pakihi lands near Westport, and also from typical alluvial soils of the Buller and Orowaiti rivers. The pakihi pastures showed an average content of 0·05 p.p.m. cobalt, while pastures on the alluvial soils ranged from 0·16 p.p.m. to 0·33 p.p.m. cobalt on the dry basis. One interesting feature of the analytical data for the pakihi pastures was the low copper content of certain samples collected from the peaty types of pakihi land. The copper figures suggest that on certain areas copper supplements in addition to cobalt may be required to give the optimum effect.

Cobalt Status of Southland Pastures.

Samples of pasture have been collected regularly from replicated plots with a view to determining the seasonal variation in the cobalt status. In addition, a commencement has been made with the sampling of pastures for cobalt estimations over an extended area of Southland. The presence of an ancient loess soil as a predominant type in the Gore-Invercargill district and the discovery that cobalt salts overcome sheep ailment at Morton Mains on this soil type suggests the possibility that cobalt deficiency occurs in varying degrees of intensity over a large area of pasture land.

Cobalt estimations, so far available, suggest that pastures on the loess type of soil contain only 0·05 p.p.m. cobalt on the dry basis. Pastures on the alluvial soils of mixed origin have given much higher values for cobalt.

Cobalt Status of Ashburton Pastures.

Preliminary work has been done on selected pastures in the Ashburton County. The results so far obtained indicate a fairly satisfactory cobalt status of the pastures and suggest that stock ailment—so prevalent in February and April of this season—was not caused by cobalt deficiency.

Influence of Cobalt Top-dressings on the Cobalt Status of Pasture.

Several experiments with different cobalt compounds used at varying amounts per acre have been established both in the Nelson district and at Morton Mains, Southland, to determine their effect over an extended period in increasing the cobalt content of the pasture. In every case notable increase in the cobalt content of the pasture has taken place. In one experiment where 10 lb. of cobalt chloride was used per acre, the cobalt content, eighteen months after the application of the cobalt top-dressing, was still double that of the untreated pasture. The results so far obtained suggest that comparatively small applications of cobalt salts, if renewed each season, will effect a marked increase in the cobalt content of the pasture, thereby providing a satisfactory cobalt supplement.

Cobalt Content of Fertilizers.

Seventeen samples of fertilizers comprising bone-dusts, blood and bone, Seychelles guano, North African phosphate, Nauru phosphate, Ephos phosphate, basic slag, and superphosphate have been examined for cobalt content. The highest figure obtained was 3·9 parts per million of cobalt in one sample of basic slag. For the most part the cobalt content of the fertilizers ranged between 0·2 p.p.m. to 0·5 p.p.m. of cobalt.

The analytical results indicate that the fertilizers in common use in New Zealand exert little effect in improving the cobalt status of unhealthy pastures. The higher figures for basic slags, however, are of interest in view of the opinion expressed by farmers that on certain pumice soils the use of basic slag for pastures has been associated with a reduction in stock ailment.

Cobaltized Fertilizers.

Laboratory tests have been made with a number of fertilizers and cobalt compounds or cobalt-containing materials with a view to the commercial production of a cobaltized fertilizer. The laboratory investigations have shown that there is no difficulty in making a cobaltized superphosphate, in which practically the whole of the cobalt is retained in a water-soluble condition. Cobalt chloride, cobaltite, and Rhodesian slag—containing 11 per cent. of cobalt—have all been used with success in the preparation of cobaltized superphosphate. By arrangement with Messrs. Kempthorne, Prosser, Ltd., Dunedin, the Dominion Fertilizer Co., Dunedin, and the Challenge Phosphate Co., Auckland, a total of 30 tons of cobaltized superphosphate containing approximately 0·20 per cent. cobalt was manufactured. No difficulty was experienced in the preparation of the cobaltized superphosphate, and the amount of water-soluble cobalt was over 85 per cent. of the total cobalt contained in the superphosphate. Arrangements have been made to test the value of the prepared cobaltized superphosphate for pasture top-dressing on farms in the volcanic-ash country of the North Island, in Southland, at Glenhope, Nelson, and on the pakihi lands at Westport.

In conclusion, mention must be made of the very valuable assistance rendered by all officers associated with the conduct of the cobalt investigations in the South Island. Dr. H. O. Askew has been in charge of all analytical work and, in addition, has supervised the field experimental work in the Nelson district. Dr. J. K. Dixon has been in charge of the field experimental work at Morton Mains, Southland, and has supervised the collection of pasture samples in the Southland and Ashburton districts. Acknowledgment likewise must be made of the generous co-operation of the Southland Frozen Meat Co., Kempthorne, Prosser, Ltd., the Challenge Phosphate Co., and the Dominion Fertilizer Co. in different aspects of the work. The conduct of the field-work has been greatly facilitated by the assistance of Mr. T. Blackmore at Morton Mains, Mr. N. McConochie at Glenhope, and Mr. C. Lemon at Westport.

LEATHER AND SHOE RESEARCH ASSOCIATION.

Director: Mr. P. White. Assistant Director: Mr. F. G. Caughley.

An important development during the year was the co-operation, for the purpose of research, of the leather-manufacturers and the boot and shoe manufacturers. As a result of the discussions by those interested, a Shoe Research Association was formed and linked up with the already existing Leather Research Association, the combined organization being given the title of Leather and Shoe Research Association.

One of the major advantages which may be expected to result from the combined Association will be a fuller mutual understanding of the difficulties and limitations under which the participating industries work. This is essential for success in two industries which are so intimately associated. If this result alone can be achieved the Association will have justified its existence.

The combined Association will facilitate a co-ordination of effort towards one common end. This is not possible to the same extent in two separate organizations each of which has to consider its own particular aspect. In addition, in two separate organizations there is liable to be a duplication of effort which it is hoped to be able to avoid in the combined Association.

In the comparatively short time in which the new organization has been in existence good work has been accomplished along the lines indicated. Leather research has been given a "shoe" bias, and shoe research is being developed with a "leather" bias where leather problems are concerned.

LEATHER RESEARCH.

Advisory Committee: Messrs. A. E. Lawry (Chairman), C. Arlington, J. E. Astley, S. L. Wright, W. Donovan, F. Johnson.

The work carried out during the year was a continuation of that described in the previous annual report—viz., the examination of sole-leather in relation to its reaction to actual wearing conditions.

Hardness of Sole-leather.

As a result of the work it has been established that one important quality of sole-leather affecting resistance to water-absorption in wet weather is the hardness of the leather in the wet condition. As resistance to water-absorption and good wearing value go hand in hand for wet-wear conditions, hardness is also definitely correlated with the wearing-value of sole-leather. Hardness may be imparted to leather either by definite tanning processes or by rolling.

An investigation of some of the factors affecting the hardness imparted to leather by tannage has been carried out. The main lines of the investigation included an examination of the following factors :—

(*a*) The effect of liming and deliming on the hardness of sole-leather.
(*b*) The effect of buffers on the swelling and plumping of the hide in the early stages of tanning.
(*c*) The buffer capacities of water solubles and leather fibres in relation to the reaction of the leather when placed in acid solutions.
(*d*) The conditions necessary for the hot pitting process to produce firm leather.

Factory Sole-leather.

Sole-leather, from the tanners' point of view, should be resistant to water-absorption and have a high wear resistance. The shoe-manufacturer requires in addition that the leather shall be easily worked under modern methods of mass production. To some extent these two aspects are in conflict. An investigation of the shoe-manufacturers' requirements has been carried out and a tanning process suggested which will produce a leather which is considered to be a good compromise between the two points of view.

British Leather Manufacturers' Research Association.

During the year a closer co-operation with British Leather Research Association was established by submitting to them the results of the work carried out. This has been greatly appreciated, and some of the monthly circular letters have been recirculated in the monthly letters of the British Association.

Defence Department.

As in previous years the Director was consulted by the Defence Department on the care, condition, and treatment of the leather equipment at Trentham.

General.

During the year the activities of the Research Association in applying the results of research to the solution of factory problems have been fully maintained. The examination and testing of raw materials, the processes used, and the finished material have been carried out and critically examined in the light of the latest available information on the subject.

Publications.

The following paper was published : "The Effect of Water Solubles on the Wearing Qualities of Leather." *N.Z. Jour. of Sci. & Tech.* (1937), *19*, 4, 245 (also printed in *J.I.S.L.T.C.* (1937), *21*, 429.

SHOE RESEARCH.

Advisory Committee : Mr. H. Duckworth (Chairman), Mr. E. Bridgens, Mr. W. Denby.

The Shoe Research section has been organized on lines similar to those which have proved so successful in connection with Leather Research. The ultimate aim is to improve the quality of the finished product and to increase the efficiency of manufacture by the application of the results of research to the industry. The means taken to achieve this end will be—

(1) Service—*i.e.*, investigations of factory problems.
(2) Research into fundamental problems.
(3) Circular letters of an educational nature.

The investigation of factory problems will take precedence over research work. This emphasizes the importance of service. It will be the application of the results of research to the solution of factory problems, which will to a large extent measure the success of the Association.

The first problem submitted by the Committee for investigation was that of tempering sole-leather. Each factory had its own methods based more or less on the type of leather to which it had become accustomed to use. If the tempering process could be placed on a sound footing, based on the properties of leather, the result would be beneficial to both the shoe-manufacturer and the tanner. The different methods of tempering have been considered in relation to the subsequent processes through which the leather passes. As a result of the work, suggestions of a general nature have been made which when applied to the different factories have resulted in—

(*a*) A reduction of water-stains on the finished sole.
(*b*) Better opening and closing of the channels.
(*c*) More uniform levelling.
(*d*) Reduction in time of drying.
(*e*) Easier scouring.
(*f*) Better finishing.
(*g*) Better organization of the work.
(*h*) A fuller knowledge of the basic principles of wetting sole-leather.

Circular Letters.

A monthly circular letter service has been instituted. These letters deal with the results obtained in the laboratory from work on research and factory problems, and are also of an educational nature. Attention has been drawn particularly to the qualities of leather in relation to definite processes in shoe-manufacture. From reports received, the letters have been greatly appreciated.

Pelt Research.

Pelt research has been curtailed owing to the cessation of the grant from the Imperial Economic Committee.

Seasonal Variations in Skins.

The microscopical examination of monthly samples of skins, which has now been carried out for two and a half years, was continued. The results obtained show that the quality of the skins varies not only during the season but also from season to season, and that climatic conditions have a very great effect on the quality of sheep-skins.

At the end of last season larger-scale trial shipments of pelts to illustrate the seasonal variations were sent to England. The full reports are not yet to hand, but from indications received they will confirm the results obtained on a small scale in 1936.

In conjunction with Canterbury Agricultural College, a trial shipment of lamb-pelts was sent to England with a view to studying the effect of various crosses in breeding on the quality of the skins. The results have not yet been received.

Effect of Pickling and Storage in the Pickled Condition.

Reports from England have confirmed the opinion, which has been held for some years, that storage in the pickled state has some action, chemical or physical, on the skin. This action makes the leather produced very soft and therefore unsuitable for certain purposes. An investigation of the problem of how to cure pelts so as to control this softness has been commenced.

FRUIT RESEARCH.

Advisory Committee.—Mr. A. H. Cockayne (Chairman), Sir Theodore Rigg, Dr. G. H. Cunningham, Messrs, W. Benzies, T. C. Brash, F. R. Callaghan, J. A. Campbell, J. Corder, A. Osborne, R. Paynter, F. S. Pope, A. M. Robertson, H. E. Stephens, L. W. Tiller (Secretary).

INTRODUCTION.

Fruit research in New Zealand continues to be carried on as a co-ordinated series of projects divided among the Plant Diseases Division of the Plant Research Bureau, the Cawthron Institute, the Horticulture Division of the Department of Agriculture, the Dominion Laboratory, and the Department of Scientific and Industrial Research. The investigations are centred chiefly at the Mount Albert and Huapai areas under the control of the Plant Diseases Division at Auckland; the Hawke's Bay Fruitgrowers' Association orchard at Havelock North; the Cawthron Institute orchards and associated areas, Nelson; the Government Research Orchard, Appleby, Nelson; and over a range of districts covered by the manurial experiments of the Horticulture Division.

The work largely centres round the apple, as the foremost fruit in New Zealand, but also deals with stone-fruits, small fruits, and citrus. For the most part the investigations have a distinct economic bias, and close contact is maintained with the problems of the industry, both directly and through the active co-operation of the New Zealand Fruit Export Control Board and the New Zealand Fruitgrowers' Federation.

The cold-storage aspect of fruit research is under the control of a special Cold Storage Committee, and is dealt with elsewhere in this report (see page 45).

During the year the Secretary of the Fruit Research Committee, Mr. W. M. Hamilton, left for England to assist the Department's Scientific Liaison Officer in London, and the secretaryship remained vacant until the return of Mr. L. W. Tiller from England in October. During the latter's stay in England close contact was established with English fruit research workers, and much information of potential value to New Zealand's fruit industry was secured.

APPLES.

Fertilizer Experiments.

Research Orchard.—Cox's Orange: Nitrogenous and phosphate-nitrogen-potash manurial treatments have continued to give growth increases in tree and fruit size, and this year also gave a crop-weight increase. Fruit size was greatest on trees receiving PNK treatment.

Dunn's Favourite: Nitrogen treatment has continued to promote vegetative growth, is now giving increases in crop weight, and is tending to reduce the incidence of skin-cracking at the stalk.

Delicious: Growth increases continue to follow the use of nitrogen, and the condition of the trees is still further improved by the addition of phosphate and potash. N and PNK treatments are now yielding crop-weight increases over untreated trees.

Jonathan: The use of nitrogen continues to induce marked growth and foliage development. Crop weights are also increased by the treatment, but only at the expense of a rather heavy reduction in the amount of overlying colour on the fruit. Trees that had received two heavy dressings of potash continue to show improved vegetative vigour, increased crop weights, increased fruit size, and very marked improvement of overlying colour.

Sturmer: Treatments, including nitrogen, are continuing to show all-round improvement in vegetative vigour, and this is accentuated by the inclusion of phosphate and potash. Nitrogen is

maintaining a higher fruit yield, and this is still further increased by the addition of phosphate, with PNK giving the highest yield of all. A number of weak trees have been markedly invigorated by the use of moderately heavy applications of sulphate of potash.

Cawthron Institute.—The fertilizer trials at Upper Moutere, Waimea West, and at the Annesbrook Orchard, Wakatu, continue to yield valuable data concerning the effect of specific manurial trials carried on over a period of years.

At Waimea West the effect of 1 lb. and 3 lb. dressings of ammonium sulphate per tree, in conjunction with a standard application of superphosphate and sulphate of potash, has been studied on the Cox's Orange variety. Growth of tree and yield of fruit have been greatly benefited on this soil type by the use of the 3 lb. dressing of ammonium sulphate, but improvement in this direction has been accompanied by a relatively large increase in the amount of internal breakdown in cool store.

At Upper Moutere the manurial trials with Jonathan apples demonstrate clearly the importance of a complete fertilizer for maintenance of growth, crop-production, and high quality of fruit. Trees from which phosphates have been withheld are inferior in growth and foliage development to those receiving a "complete" fertilizer. Potassic manures appear to be as important as nitrogenous manures when the trees come into full bearing.

The trials on the Dougherty variety at the Annesbrook Orchard confirm the value of phosphatic manure on this somewhat phosphate-deficient soil. The trees treated with phosphates only are showing no die-back, while many untreated trees are affected more or less severely with die-back.

Horticulture Division, Department of Agriculture.—A series of six trials was carried out in four districts—Auckland, Nelson, Motueka, and Marlborough—to ascertain if any difference could be detected between the effects of liquid injection into the soil and concentrated surface sowing of fertilizers. The tests were carried out with P and PK treatments, but no significant differences were observed except in one test in the Motueka district, where a plot receiving PK as a soil injection has remained superior to the other three plots.

In another series of experiments conducted in Auckland, Hawke's Bay, and Mapua a concentrated placement of fertilizer round the tree was compared with broadcast sowing. Treatments were P and PK as above, but no differences attributable to method of placement have been apparent. In the Mapua experiment, however, the potash-treated trees appear to have carried a greater density of foliage than those receiving no potash, irrespective of the method of placement. In a liming test on apples in the Motueka district there have been no apparent differences of any kind between limed and unlimed trees.

The test on the manuring of young trees in the Hawke's Bay area has failed to show any response to fertilizer treatments during the six and a half years since the experiment was commenced.

Rootstock Experiments.

Research Orchard.—An area of approximately 1 acre has been planted out as a comparative rootstock test using Northern Spy, and East Malling Nos. I, XII, and XVI, worked to Cox's Orange, Jonathan, Delicious, and Granny Smith varieties.

Cawthron Institute.—The trees at the Annesbrook Orchard continue to show the superiority of Northern Spy over Double Vigour and Large's Seedling as a stock for the Cox's Orange variety. The first two are vegetatively raised types and the latter is a seedling selection from seeds taken from a single Epps' Seedling tree.

In the case of the Sturmer and Jonathan, however, the Double Vigour and seedling stocks have both given higher fruit yields than the Northern Spy stock.

Plant Diseases Division.—Trials with apple varieties on East Malling and Northern Spy type stocks have been continued, both at Mount Albert and in several fruitgrowing districts of the Dominion. Stocks under test are East Malling Nos. I, XII, XIII, XV, and XVI and a selected Northern Spy. They have been worked with the scion varieties Cox's Orange, Jonathan, Delicious, Granny Smith, Statesman, and Sturmer.

Evidence accumulating from these trials indicates the partiality of scion varieties for certain stocks. It is probable, therefore, that no one stock will prove equally satisfactory for the chief varieties grown in New Zealand.

Inarching Experiments.

In order to ascertain the value of inarching in invigorating old and debilitated trees, work has been undertaken at the Research Orchard, Appleby, and by the Plant Diseases Division at the Huapai and Havelock North orchards. At Huapai two-year-old clonal stocks of a Plant Diseases Division selection (N/1/19) and Large's Seedling No. 1 were used to treat Jonathan apples, using three different methods of inarching. At the Research Orchard and at Havelock North vigorous East Malling types of stock have been used.

Standard Collection of Apple Varieties.

This collection is being prepared by the Plant Diseases Division in Auckland. Budwood of thirty apple varieties has been secured from local orchards with a view to providing a nucleus collection of standard varieties. The collection will be added to from time to time and should serve as a means of assessing the value of new introductions, behaviour of each to disease, &c.

Pruning Experiments.

In the Hawke's Bay area experiments have been laid down with a view to ascertaining the relative values of short and long lateral systems of pruning apple-trees.

At Huapai Orchard, where the trees were in an extremely impoverished and neglected condition, the entire orchard has been hard-pruned, the object being to bring the trees into good condition as rapidly as possible. The results are already most marked, and the orchard is now one of the most vigorous in the locality.

Plant Protection Experiments.

I. *Entomological Studies.*

(*a*) *Biological Control.*—This work is carried out by the Entomology Division of the Plant Research Bureau, located at the Cawthron Institute, Nelson. The major activities in this branch of fruit work have been the distribution of *Aphelinus mali* parasite to orchardists in different parts of New Zealand; further studies of the *Aphelinus* parasite, particularly in relation to overwintering; and studies of the dryinid parasite of the apple leaf-hopper.

In connection with *Aphelinus*, preliminary experiments carried out last season showed that the use of winter oil definitely increased the mortality of the overwintering *Aphelinus* on apple-trees. It is probable, however, that the reduction in the overwintering population of woolly aphis by the spray is proportionately much greater. A short investigation of the parasites of *Tortrix postvittana* was made by Mr. L. J. Dumbleton during a visit to Tasmania. The object was to determine what varieties were present and their relative importance, and, if possible, to collect and ship to New Zealand supplies of any parasite deemed to be worth introducing. Eleven parasites of the larvæ and pupæ were reared from the material collected. The total parasitism of the larvæ was not more than 15 per cent., and of this the tachinid *Voriella uniseta* Malloch contributed 7 per cent. The parasitism of the pupæ was about 20 per cent., of which *Chalcis* sp. and *Xanthopimpla rhopaloceros* Krieger each contributed 8 per cent. A small number of puparia of the two tachinids were brought back to New Zealand and flies emerged, but attempts to breed the parasites were unsuccessful. No emergence of the pupal parasites was secured from the material which was brought back.

The most promising of these parasites are judged to be the tachinid larval parasite *Voriella uniseta* and the two pupal parasites *Chalcis* sp. and *Xanthopimpla rhopaloceros* Krieger.

In connection with the ecology of *T. postvittana* a study of the influence of temperature on the development of the apple leaf-roller has been made, together with other investigations bearing on the seasonal cycle and method of overwintering of the species in the field.

(*b*) *Chemical Control.*—Work on the maximum effective viscosity of oils for control of eggs of the European red mite has been completed by the Plant Diseases Division.

II. *Mycological Studies.*

(*a*) *Mouldy Core.*—In the studies of this problem at the Cawthron Institute at least thirty different fungi associated with diseased tissue have been identified and their frequency of occurrence alone, or in conjunction with other fungi, assessed.

The Plant Diseases Division is conducting studies on Delicious apples from early, mid-season, and late pickings held in cool store to ascertain to what extent the fungous hyphæ present in the core cavity and calycine sinus develop into mouldy core. The percentage of infection did not increase with keeping up till July, although the degree of infection became greater. From August onwards the percentage of the disease increased steadily.

(*b*) *Eye-rot.*—At least twenty fungi of frequent occurrence in affected apples have been identified by the Cawthron Institute, and their power of invasion relative to that of the predominating fungus *Botrytis cinerea* has been determined. The relative percentage of the fungi under examination in comparison with *Botrytis* and other members of the group has likewise been assessed.

(*c*) *Silver-leaf.*—Young apple-trees grown at the Havelock North orchard have been inoculated with strains of the silver-leaf organism isolated from apple branches, and when the disease is established measures for its control will be tested.

(*d*) *Apple-canker.*—Two species of canker-forming fungi, *Physalospora obtusa* and *Nectria galligena*, have been inoculated into small trees at the Mount Albert area with a view to providing materials for testing the efficacy of several new types of wound dressings.

(*e*) *Crinkle of Granny Smith.*—In Hawke's Bay an endeavour is being made to ascertain if this disease is transmissible by grafting, which if successful would indicate the disease as being of virus origin.

(*f*) *Black-spot.*—The Cawthron Institute has maintained the usual notification service in regard to date of ascospore maturity for the benefit of Nelson orchardists.

III. *Spraying Experiments.*

At the experimental orchard in Havelock North a comprehensive series of spraying experiments, designed to modify and improve existing spray programmes, has been completed, and results are being tabulated and published in the *Orchardist*. Attempts have been made to find a better place in the programme for summer oils; to develop an oil for summer use which would be safe to apply with sulphurs or lime-sulphur; and to modify the current programme used for control of black-spot of pears.

Fruit russet is being studied in relation to modification of the spray programmes.

Modified spray programmes for control of black-spot and powdery mildew at the Huapai Orchard were rendered inconclusive by very low incidence of disease on check trees.

Spray injury was induced when Bordeaux mixture was employed subsequent to blossoming.

In a number of experiments on the control of bitter-rot (*Glomerella cingulata*) it was found that a copper spray was necessary, and that a 1½–3–50 Bordeaux in early January before any sign of appearance of the disease gave satisfactory control.

Bronze-beetle control by the use of lead arsenate in the Huapai Orchard was unsatisfactory where infestation was severe.

Excellent control of codling-moth was secured by lead arsenate, despite the fact that the check trees developed 100 per cent. infection. Applications, to be successful, must be made at proper times and with adequate equipment.

IV. *Physiological Studies: Cork Injury.*

Studies on the use of boron in relation to non-parasitic diseases of the apple have been continued by both the Plant Diseases Division and the Cawthron Institute.

Plant Diseases Division.—The study has been extended to cover the influence on storage-pit, and it has been found that boron compounds applied in various ways do not have any effect on the incidence of this disease in Cox's Orange. Studies on the permanence of soil treatments indicate that a dressing of ½ lb. per tree of either borax or boric acid may be relied on to give control of cork for a period of two years.

Cawthron Institute.—Investigations have shown that two 0·25 per cent. borax sprays—one early in November and the other three weeks later—have given efficient control of cork in both Nelson and Central Otago. So far no adverse effect on either foliage or fruit has followed the use of borax at the above strength in the usual spray combinations employed at this period.

In view of the fact that rasorite (or kernite), a hydrated sodium borate, has been suspected by some orchardists of causing damage when used in combination with other spray materials, the investigations have been extended to study the effect of borax and rasorite in an extensive list of spray combinations.

Borax used as a soil dressing round trees has been found to induce a marked increase in the susceptibility of Jonathan apples to internal breakdown in storage, 1 lb. and 3 lb. dressings being very marked in this respect. At present it is deemed desirable to restrict applications to not more than ½ lb. per tree. The matter is receiving further attention and is being extended to cover the effect of 0·10-per-cent. and 0·25-per-cent. borax sprays.

Experiments conducted in co-operation with the Department of Agriculture have shown that the use of borax is likely to have wide application in the Alexandra district, Central Otago.

Negative results have so far attended the attempt to control storage-pit and tree-pit by the use of borax compounds.

V. *Therapeutant Testing.*

The scheme for certification of therapeutants, inaugurated and controlled by the Plant Diseases Division, is now in active operation, and two certification lists have been published covering orchard sprays.

In the second list are recorded twenty-nine certified products offered by eighteen manufacturers or agents. The result has been most encouraging, and growers are freely using the service.

A further seven materials of a new type have been offered for biological testing. During the year advice regarding production of spray materials has been given to several manufacturers. Two were helped in improving the quality of their hydrated lime; three in the matter of improved oil emulsions; one in improving summer oil; one in preparation of a colloidal sulphur; two in improving lime-sulphur. Twenty-one samples of sulphur were examined on behalf of two agents.

Two hundred apple-trees of eight varieties have been planted at Mount Albert for the purpose of therapeutant testing and the improving of spray programmes. Other plantings for this work cover citrus, *Phylloxera*-resistant grapes, passion fruit, and hops.

STONE-FRUITS.

Fertilizer Experiments.

The Horticulture Division of the Department of Agriculture has carried out placement tests with phosphate and potash on apricots in Central Otago on exactly parallel lines to those carried out on apples, but no differences between treatments have become evident.

Standard Collection.

The collection of standard varieties has been commenced by the Plant Diseases Division, and work this year has been concentrated on types and varieties of apricots.

Silver-leaf.

Two hundred peach-trees have been set out at Mount Albert for the purpose of inoculation with the infective organism, and when it is established these will be used to test out measures of control.

Brown-rot.

None of the programmes tested in Auckland gave economic control of brown-rot of stone-fruits. The conclusion must be drawn after four years' work that where conditions favour the onset of this disease available sprays give inadequate control.

The investigations into the control of the disease in transit and store have shown that an economical treatment can be secured by dipping. Further work is necessary, however, before recommendations can be made.

The Cawthron Institute has maintained for the benefit of Nelson orchardists an ascospore maturity notification service similar to that for black-spot of pome fruits.

SMALL FRUITS.

Standard Collection.

Forty-five varieties of red and black currant, gooseberry, and raspberry have been introduced from East Malling Research Station and are being grown in quarantine at Mount Albert. They represent the full range of available varieties produced as pure lines. Trials will be commenced next year to ascertain if they are superior to varieties at present in the Dominion.

Strawberries.

An area of approximately ¼ acre has been planted to two varieties of strawberries which are being used for studies in root-rot. An additional two commercial varieties from Queensland and selections secured from East Malling are being grown for comparison.

Raspberries.

The Entomology Division at the Cawthron Institute has commenced a study of the raspberry bud-moth and the raspberry saw-fly.

(*a*) *Raspberry Bud-moth (Carposina adreptella).*—This native insect is the most serious pest of raspberries, and practically no information was available concerning its life-history and habits. A preliminary investigation now concluded has given valuable information on the biology of the pest without pointing the way to any economic method of control.

(*b*) *Raspberry Saw-fly (Priophorus tener).*—The work has been confined to observations on the biology of this recently established European pest. It was reported for the first time in 1936–37, its larvæ feeding on the leaves of the raspberry.

Passion Fruit.

An area of 100 plants of passion fruit has been set out for a study of grease-spot and its control.

CITRUS.

Fertilizer Experiments.

The Horticulture Division of the Department of Agriculture has carried out liming experiments on lemons in the Tauranga district for the past seven years, and plots which had 2 tons of lime per acre in 1930, followed by a further 2 tons per acre in 1935, produced in the two years following the latter treatment 374 lb. of fruit per tree, as against 300 lb. per tree for the no-lime plots. The difference is statistically significant. The data relative to quality and yield of cured lemons from the experiment are being summarized.

Root-stock Experiments.

Materials for citrus-stock studies have been planted out in the Mount Albert area of the Plant Diseases Division. Approximately one thousand stocks of sweet and sour orange, citronelle, and trifoliata have been set out. A number of each have been double-worked with the other stock varieties, about a score of combinations being available for budding next year.

Seedlings of four different types of Cook Island orange are being grown for use in rootstock investigations.

Insect Pests.

In co-operation with the Horticulture Division of the Department of Agriculture, the Plant Diseases Division is preparing a series of papers on citrus pests and their control, the first having been forwarded to the *New Zealand Journal of Agriculture.*

Bacterial Diseases.

(*a*) *Citrus-canker.*—This serious bacterial disease was found to be widespread in the citrus-growing areas of the North Island, except Hawke's Bay. The organism has been isolated and identified by the Plant Diseases Division as *Pseudomonas citri*, the cause of this disease in other countries.

(*b*) *Citrus-blast.*—This is a bacterial disease of recent origin, and specimens have been collected from Gisborne, Tauranga, and Auckland. The disease has been found to be caused by *Pseudomonas syringae*, the cause of a similar disease elsewhere.

Physiological Diseases.

Mottle-leaf.—At the instigation of Dr. M. M. Burns, Canterbury Agricultural College, investigations were undertaken by the Plant Diseases Division for the treatment of this physiological disease. It is widespread in the Auckland Province, and the symptoms resemble those recorded for the disease in the United States.

In America the disease has been found to be related to zinc deficiency, but in New Zealand the trouble has not responded to zinc treatments. As in preliminary work promising results were secured with manganese, a series of field trials has been laid down to test the effect of this element on a large scale.

Lemon-curing.

Since the commencement of this work at the Dominion Laboratory a total of four curing-runs has been performed in the air-conditioned cabinets erected for the purpose, and a large number of variations in conditioning have been investigated. This has involved the examination and individual measurement of some six thousand lemons and well over one hundred comprehensive analyses of representative parcels of fruit.

As a result of these experiments a wider understanding of the mechanism of curing has been attained, some excellent fruit has been turned out, and tentative optimal conditions of curing have been established.

The investigations have brought clearly to light, however, the necessity for very considerable improvement at the production end. Particularly is this so in regard to reduction of spore loading on the fruit during the growing, harvesting, and pre-curing period. If the fruit is not reasonably free from potential sources of infection it is not possible to accord it optimum curing conditions without risking high incidence of fungous disease.

Unfermented Fruit Juice.

Widespread interest has been aroused among the fruitgrowers of New Zealand as a result of the extensive developments in the manufacture of unfermented fruit juices on the Continent and its introduction into England. The product would appear to offer a valuable and profitable outlet for low-grade fruits for which there is at present no economic market.

In co-operation with a commercial manufacturer of this type of juice in New Zealand it has been possible for the Department of Scientific and Industrial Research to initiate a series of tests to determine the suitability of various methods of manufacture for New Zealand apple varieties. Six of the main varieties are being processed, and six different modifications of the process are being tried with each variety.

FRUIT COLD STORAGE.

Fruit Cold-storage Committee.—Messrs. J. A. Campbell (Chairman), H. G. Apsey, W. Benzies, F. R. Callaghan, J. T. Cross, W. K. Dallas, F. W. Grainger, J. L. Mandeno, Sir Theodore Rigg, A. M. Robertson, H. E. Stephens, L. W. Tiller, and H. C. Heays (Acting Secretary). Also, Mr. R. Sutherland rendered valuable service as a member of this Committee up to the day of his untimely death in December, 1937.

The Committee appreciatively acknowledges the helpful co-operation of and services rendered by both Dr. A. J. M. Smith, of the Cambridge Low Temperature Research Station, and Mr. N. L. Wright, the Scientific Liaison Officer in England; the overseas and the local shipping companies, including their officers and engineers; the New Zealand Fruit-export Control Board; the Fruitgrowers' Federation; the Horticulture Division of the Department of Agriculture; the Wellington Harbour Board; and the managing directors of certain cool-stores. Mr. L. W. Tiller, Fruit Research Officer, is worthy of special mention not only for the work he achieved while in England, but also for the comprehensive and informative reports which he has officially submitted since his return to New Zealand.

Information from Abroad.

As is usual, valuable information received from abroad regarding the handling, storage, and transport of food has from time to time been made available by the Department and has been most helpful to individual members of the Advisory Committee for their work in general.

Experimental Gas-store.

The small three-chamber experimental refrigerated gas-store, built early in 1937 adjacent to the Dominion Laboratory, has been operating throughout the year 1937–38 and has functioned splendidly. In the interests of fruit and vegetable storage research this store will, for an indefinite period, be carrying "all that it can hold," but the restricted capacity, to some extent, is likely to retard progress and limit the scope of the experimental work.

Experimental Consignments to England in the 1937 Season.

(1) *The Influence of Position on Tree on Incidence of Storage Disorders in Cox's Orange Pippins.*

Fruit was taken from two contrasting positions on the tree, one being fully exposed to sunlight and the other well shaded, and two pickings were made. Pit was practically the only form of wastage showing in the fruit on arrival in London, and this increased appreciably during the three weeks following discharge, while a considerable amount of breakdown and some fungus developed in fruit of the second picking. Conclusions are briefly as follows:—

(*a*) In both shipments pit was very much more severe in shaded fruits. This conflicts with the results of the previous two years' oversea experiments and with the findings of Long Ashton Research Station, but is in accord with an experiment carried out by the Research Orchard, Appleby, in 1935.

(*b*) Pit-development was less severe in the second picking than in the first.

(*c*) In the first shipment breakdown was rather more severe in the larger sizes of exposed fruit than in the corresponding sizes of shaded fruit. In the second shipment breakdown was equally severe in the two types of fruit.

(*d*) Fungus diseases were practically unaffected by position of fruit on tree.

(2) *Effect of Precooling on Incidence of Storage Disorders.*

Wastage in this experiment was similar in character to that noted for Experiment (1) above.

(*a*) In the first shipment there was no difference in pit incidence between treatments till the second examination, three weeks after discharge, when rather more pit was found in precooled than in non-precooled fruit.

(*b*) In the second shipment there was less pit in the precooled than in the non-precooled fruit at each of the two examinations.

(*c*) Comparing pit incidence in the two pickings, there was less pit in the second picking of precooled fruit, but more pit in the second picking of non-precooled fruit.

(*d*) Breakdown was unaffected by treatments in the first picking, but was more severe in non-precooled fruit of the second picking than in precooled.

(*e*) Fungus-development showed a tendency to be more severe in non-precooled fruit, but the figures are of doubtful significance owing to individual variability.

(*f*) Storage-pit, breakdown, and fungus disease were more severe in fruits of 150 count than those of 180 count.

(3) *Influence of Different Types of Wrapper on Incidence of Storage Disorders.*

Only one picking was dealt with in this experiment, and wastage consisted chiefly of storage-pit, with a small percentage of breakdown and a trace of fungus. Fruit was wrapped in plain, copper-sulphate-treated, and oiled papers, but no differences of any kind developed between treatments. The only consistent feature of the experiment was the well-established association of higher breakdown susceptibility with the larger fruit sizes.

Taking the group of experiments as a whole, pit susceptibility could not be correlated with position of the fruit in the case. In the oversea experiments of a previous year it had been found that fruits from the outside layer round the case developed more pit than inside fruits. This season this relationship held more or less true for the first examination, three days after discharge, but at the second examination, three weeks later, the position was reversed.

"No Dunnage" Demonstration Shipment.

In co-operation with the Cambridge Low Temperature Research Station, a demonstration shipment of apples (nearly fifty thousand cases) on the "no dunnage" system of stowage was carried to London by one of the modern vessels of the Blue Star Line, and proved completely successful in that the fruit, apart from the usual amount of bruising, was in excellent condition when examined after being discharged.

At selected stations throughout the hold electric thermometers were placed inside specially marked cases of apples (two varieties selected from the same orchard, picked and packed at the same time and of the same grade and size) and readings were regularly taken during the voyage. The maximum range of temperatures, after cooling, was approximately 1° F. on either side of the mean, while for four-fifths of the consignment the temperature was uniform to $\pm$ 0·5° F. of the mean.

With the omission of dunnage the close stowage enabled about three thousand extra cases to be carried in the hold.

The efficiency and reliability of the refrigeration plants and equipment, also the improvements in design and construction of the holds of the modern vessels, accentuates the shortcomings of many of the older vessels, to several of which the needed improvements probably could not be effected. As a result of observations during past seasons it is felt that ample evidence to justify a reasonable expenditure on effecting improvements to at least some of the ships in the latter group could be readily obtained by a co-operative effort in securing data regarding the actual distribution of or variation in temperature throughout the holds of the respective vessels when carrying fruit to England.

Dr. A. J. M. Smith's Investigations.

Arising out of the visit of Dr. A. J. M. Smith to New Zealand and Australia last season, several points of interest in connection with the transport of fruit overseas emerge from the preliminary report presented on this work:—

(1) In the large hold, stowed without dunnage, the "jacket" system of cooling has proved to give the most uniform range of temperature that has been recorded for a cargo of fruit, and it would appear that further experiment in the transport of fruit in such vessels is unnecessary.

(2) In some holds prolonged ventilation is necessary during the first two or three days of a voyage in order to guard against excessive accumulation of CO_2.

(3) The close correlation between the temperature of carriage of pears at 32° F., 34° F., and 37° F., and their condition on arrival has been given further emphasis.

(4) The need is shown for improvement in the design of indicating instruments, particularly because of the shortcomings of thermometers for use in a tube and of portable CO_2 indicators.

Cold Storage for Export Fruit and for Local Marketed Fruit.

The need for improved facilities in Wellington and in some other centres for the preshipment storage of our export fruit, and for the proper cold storage of fruit for the local markets, has been a matter of some concern to the Committee throughout the year. It has endeavoured from time to time, by correspondence and representative discussion, to keep closely in touch with some of the other parties who are directly interested, but, unfortunately, the solution of this important and difficult problem is still in the preliminary stage.

Those who are familiar with the existing conditions appreciate the need for adequate cold storage for fruit which has to be held in Wellington, or elsewhere, while awaiting shipment, and they also realize that if an appropriate modern cool store were provided the locally-stored export fruit would be in better condition when offered in the markets overseas.

At the same time, and in this regard, it is felt that the fruitgrowers in general may not be aware of the efforts of recent years which have been made in their interests, and perhaps they themselves do not yet fully apprehend the need for the early erection of an efficient cool store on the waterfront at Wellington. The condition in which export fruit opens up on arrival in Great Britain is dependent in large measure on the promptness with which it is brought down to correct storage temperature after picking. This entails emphasis on three phases of the export organization—

(1) Fruit must be handled expeditiously at the orchard and delivered to the inspection and assembly point in the minimum of time from picking.
(2) Fruit must be given a quick passage through the inspection and assembly point and delivered with the minimum delay to a cool store.
(3) There must be an efficient large-capacity store available, at a suitable point in the central and in the southern portions of the Dominion, capable of bringing the fruit rapidly down to the correct temperature of carriage.

Influence of Oiled Wraps on Apples.

To test the influence of oiled wraps compared with plain wraps on the keeping-quality of apples and with a view to determining whether the former were likely to be of economic benefit to the exporter, a trial of eight cases of each of eleven varieties of apples (88 cases in all), was undertaken. All the fruit was grown in the Nelson Province, and the different varieties came from different orchards. The results indicate that, except for the control of superficial scald in susceptible varieties (Granny Smith and Rome Beauty in this series), the use of oiled wraps did not beneficially influence the keeping-quality or the general appearance of the other nine varieties in this experiment—viz., Cox's Orange Pippin, Jonathan, Dunn's Favourite, Lord Wolseley, Ballarat, Statesman, Sturmer Pippin, Delicious, and Dougherty. Their universal use therefore would appear to be more a matter of choice than otherwise.

The Control of Superficial Scald on Granny Smith Apples.

Experiments on the storage of Granny Smith apples with a view to effecting some improvement in the out-turn from the commercial stores were begun locally in 1934 and have been extended each season since then, but are still incomplete.

The experiments on this variety of apple, undertaken in Auckland during the past season (1937), confirm the conclusions of earlier trials—viz., locality of the orchard is a significant factor, the less mature fruit develops scald earlier than the more mature, and oiled wraps have a controlling effect. In addition, this year's trials indicate that the fruit which was cooled almost immediately after picking was more discoloured than that whose storage was purposely delayed.

Use of Copper-sulphate-treated Wraps in the Control of the Spread of Grey Mould (Botrytis Rots) in Winter Cole Pears.

All this fruit (fifty-four cases in all) was stored in Wellington at 30° F. to 32° F. within four days of picking, and came from Canterbury, Nelson, and Motueka districts. Half of each lot of the pears was wrapped in plain wraps and the other half in copper-sulphate-treated wraps, while both corrugated all-round linings, and smooth-surface-paper linings with shredded paper at top and bottom, were used in the respective cases.

Much of the fruit which lay in contact with the corrugated wrappers was badly stained, while the plain lining-paper by comparison did not have the same effect.

Very little grey mould was observed in either the plain or the copper-sulphate-wrapped lots—only one pear in the latter and a maximum of 3 per cent. for one lot of three cases for the fruit which was in plain wraps.

From the standpoint of control of grey mould the experiment was not conclusive, and this work is being extended during the current season (1938).

The pears held their condition throughout the period of trial, which terminated on the 6th September, and the fruit was marketed at very satisfactory prices.

Relation of Nutrition to Cold-storage quality of Apples from the Research Orchard, Appleby.

(*a*) *Cox's Orange.*—After two months' storage, fruit from trees which received nitrogenous manure (ammonium sulphate) developed a high percentage of internal breakdown in comparison with fruit from untreated or phosphate-potash trees. The use of potash and phosphate additional

to the nitrogen reduced breakdown incidence by half. In another experiment these effects of nitrogen and potash were again in evidence. None of the treatments had any effect on storage-pit. Storage troubles were accentuated by the fact that the trees were in their off-year of bearing.

(*b*) *Dunn's Favourite.*—The increase in breakdown susceptibility induced by the use of 2 lb. or 4 lb. ammonium sulphate per tree is now less than it was initially, although still evident.

(*c*) *Jonathan.*—The use of 2 lb. and 4 lb. ammonium sulphate, additional to normal phosphate and potash, continues to give marked and proportionate increases in susceptibility to breakdown and to fungous diseases. Jonathan-spot, however, has been unaffected by the nitrogen treatments. Potash has reduced breakdown and fungous incidence, but, on the other hand, has markedly increased Jonathan-spot and has also induced a slight amount of deep scald.

(*d*) *Sturmer.*—Nitrogen by itself has given a relatively high percentage of breakdown and fungous disease with this variety. The use of phosphate additional to nitrogen has reduced this adverse effect, and the use of phosphate plus potash has eliminated it altogether. In another experiment in which potash was used at varying rates it was found that it effected a reduction in breakdown and fungous trouble. Storage-pit was unaffected by treatments.

CO_2 Gas-stored Apples.

Separate experiments on Washington and on Ballarat seedling varieties of apples were undertaken in the 1937 season, and are also in hand for similar fruit at the present time (1938 season).

In the former trials the fruit was held at temperatures of 36°, 40°, and 44° F., with the respective atmospheres containing 6, 9, and 12 per cent. carbon dioxide and 15, 12, and 9 per cent. of oxygen, or, in other words, each variety was stored at three different temperatures and three different concentrations of CO_2 gas.

Unfortunately, both lots of fruit were initially "advanced" for maximum keeping-quality in cool storage, and this forward condition was reflected to some extent in the results.

The Washingtons after twelve weeks' storage were in all cases affected by brown heart, but to the least degree at the 6-per-cent. concentration of CO_2 at 40° and 44° F.

The Ballarats were held for sixteen weeks, at which time all lots showed brown heart, and again the damage was slight at 6 per cent. CO_2 and at temperatures of 40° or 44° F.

At the latter temperature only 4 per cent. of the Ballarats were affected by brown heart, but, on the other hand, internal breakdown was serious, while at 40° F. internal breakdown was only slight and 15 per cent. of this group of Ballarat apples were slightly affected by brown heart.

On the whole, the gas-stored sound fruit was (1) firmer, (2) less mature, (3) more juicy, and (4) of better flavour than the corresponding lots of control apples in air.

Cool Storage of Asparagus.

Small experimental shipments of New-Zealand-grown asparagus in the 1935 and 1936 seasons proved that this vegetable could be delivered in London in a reasonably good condition, and this partial success was followed up by a series of experiments in the Department's cool-store during the time it was not required for apples.

The main conclusions regarding this trial are :—

(1) Good-quality asparagus may be kept at 33° F. and at a fairly high relative humidity, for about six weeks.
(2) Quality and weight are maintained best by wrapping each bundle in cellophane and standing it upon damp sphagnum moss.
(3) The interval of time between cutting the stalks and their cool storage should be the shortest possible.
(4) Only tight-headed, firm, and otherwise well-grown sticks should be stored.
(5) The asparagus which was stored in an atmosphere of 5 per cent. CO_2 and 16 per cent. oxygen was better than that kept in air storage, but it is not yet clear whether this improved condition was due to the carbon dioxide or to the higher relative humidity.

These conclusions, however, require to be confirmed by further research, as the asparagus used was not of first-class quality.

Storage of Green Peas.

During January and February of this year (1938) some experiments on the cool storage of green peas of mixed varieties and of fair average quality and purchased in the local market were carried out at 34° F. and 37° F., and the following information was obtained from those stored in their pods :—

(1) The storage temperature of 34° F. gave the better results.
(2) Containers of tin and also of wood were used, and the latter were the better. The higher relative humidity of the peas held in the tins encouraged sprouting and fungal growth.
(3) The control of relative humidity is important, but in these experiments was not wholly effected : if too high, sprouting and fungal damage occur, while if too low the pods dry out and wilt considerably.
(4) The peas should be picked when of a fresh green colour, and should be stored as soon as possible thereafter. In such circumstances they will keep in cool storage for at least four weeks.
(5) Storage in an atmosphere of 10 per cent. CO_2 was beneficial ; it checked mould-growth and retarded the loss of flavour.

Shelled peas did not keep well for more than two weeks under the conditions tried in these experiments, which were similar to those outlined for peas in the pods.

Research and Experimental Work in 1938 Season.

No experimental or demonstration shipments of fruit are being undertaken during the 1938 season, as it was felt that the regular and special consignments over an unbroken period of several years just passed have proved the efficiency of the comparatively new "jacket" construction and cooling system for the holds of vessels engaged in the overseas transport of our fruit and for other exported foods, and they have also as surely stablished the shortcomings of some of the older vessels and have served in fairly comparing the various systems of stowage.

Nine groups of separate experiments on fruit are, however, being undertaken locally, some of these being check tests and some others are extensions of work begun in past years.

The respective groups are:—

(*a*) To test the relative influence of all-round wrappers on the staining of Winter Cole and Winter Nelis pears.

(*b*) To test the influence of copper-sulphate-treated wraps in controlling the spread of grey mould on Winter Cole pears—three separate groups, one lot at Hastings and two lots at Wellington.

(*c*) Demonstration of the conditions required for successful storage of pears of different varieties.

(*d*) Control of scald on Granny Smith apples and to obtain a measure of the keeping-quality, both involving maturity at time of picking, delayed storage, and oiled wraps versus plain wraps.

(*e*) The effect of fertilizer treatment upon keeping-quality of Cox's, Dunn's, Jonathan, Delicious, and Sturmer apples; also in the first-named variety from the individual tree standpoint and in relation to bitter-pit.

(*f*) Influence of position on the tree and incidence of bitter-pit in Cox's; also respiration tests of specimen fruit from outside and from inside positions on the tree.

(*g*) Extension of the gas-storage trials on Washington and Ballarat apples from the same orchards in Nelson as for the 1937 season.

(*h*) Preliminary work in connection with the gas storage of Sturmer apples in case lots.

SOIL SURVEY: EIGHTH ANNUAL REPORT.

Land Utilization Committee.—Sir Theodore Rigg (Chairman), F. R. Callaghan, A. H. Cockayne, R. P. Connell, E. J. Fawcett, Dr. L. I. Grange, Professor W. Riddet, W. Robertson, R. B. Tennent, Dr. I. W. Weston, F. J. A. Brogan (Secretary).

The land utilization survey of Hawke's Bay, comprising soil, pasture, and farm managenent and farm practice surveys by the Soil Survey Division, the Plant Research Bureau, and the Department of Agriculture, respectively, has made rapid progress towards completion during the year. During the period under review about 1,100 square miles were mapped by the Soil Survey Division, making the total area covered to date over 4,000 square miles. In the coming season the survey will be completed by a rapid reconnaissance of 300 square miles of high country in the north-western survey districts, and a more detailed survey of 650 square miles near Wairoa, Woodville, and between Weber and the coast. Soil maps of the district which have been completed are now being drafted for printing. The pasture survey under the Direction of the Grasslands Division of the Plant Research Bureau has also been rapidly extended, and a total area of 1,900 square miles had been covered by the end of the year. Pasture maps of several of the completed districts are being drafted for printing. The survey of farm management and farm practice in the Hawke's Bay Province has been carried out by the Fields Division of the Department of Agriculture under the immediate supervision of Mr. R. P. Connell, Land Utilization Officer, and a report on the progress made is contained in the annual report of the Department of Agriculture.

In North Auckland the soils of the south-western part of Whangarei County and neighbouring areas in Hobson and Otamatea Counties (an area of 600 square miles) were mapped, the total area surveyed to date being 2,600 square miles. The Department of Agriculture assisted in the work of relating farm problems to the soil types. A report on the work in the Whangarei County is being written up for publication.

Report by Director (Dr. L. I. Grange).

The chief activities of the Soil Survey Division during the year were:—

(1) The regional survey of Hawke's Bay Province (by I. J. Pohlen, H. S. Gibbs, and J. D. Raeside).

(2) The regional survey of North Auckland (by N. H. Taylor and C. F. Sutherland).

The Hawke's Bay Province covers an area of approximately 5,000 square miles, most of which has now been mapped. In the past season the pumice soils north and west of Napier have been classified. Soil maps for publication on a scale of 120 chains to the inch are now being drafted.

The North Auckland survey now covers about half the province, and steps are being taken to write an account of the soils in the Whangarei County.

Other field activities included :—

(1) *Survey of Heretaunga Plains* (by H. A. Hughes and L. Hodgson).—This was continued from last season, and the mapping of all except the old Ahuriri Lagoon is completed. A detailed account of the soils and orchards is being drafted and will be published shortly.

(2) *Survey of about 33 Square Miles on the Western Side of Akaroa Harbour* (by C. S. Harris and A. C. Harris).—It is thought that the main soil types on the peninsula have been included in this area, and top-dressing results obtained by the Department of Agriculture in the portion surveyed can be applied by them to other parts.

(3) *Survey of Wairua Plains, 90 Square Miles in Area* (by C. S. Harris and K. S. Birrell).—This work was undertaken primarily to provide some of the data required by the Public Works Department in their task of reporting on the feasibility of irrigating the plains.

(4) *Survey of Pakihi Soils at Westport*, covering an area of 120 square miles (by C. S. Harris).—As is well known, the soils on the terraces rising to a height of 700 ft. above sea-level east and south of Westport are very infertile and have, in general, a pan which causes subnormal drainage. On the badly drained part development is practically limited to the experimental block of the Cawthron Institute at Sargeant's Hill. With the aid of air maps the soils have been divided into several types. From the description of the different kinds of soils, together with information prepared by other Departments, it will be possible to say which of these offer a reasonable chance of development.

(5) *A Rapid Survey of the Pumice Soils of the Gisborne District* (by the Director, L. I. Grange).

(6) *A Preliminary Survey of Flax Soils* (by N. H. Taylor and J. K. Dixon).

A large number of chemical analyses have been made of soils collected by the pedologists in the course of all the surveys, and these added considerably to our knowledge of the various soil types. They were carried out at Cawthron Institute by Dr. J. K. Dixon, Messrs. A. C. Harris, L. Hodgson, and L. Corder; at the Dominion Laboratory by Messrs. F. T. Seelye and L. H. Davis; and during the latter part of the year by Mr. K. S. Birrell at the Fairlie Terrace Laboratory The chemical work at the Cawthron Institute is summarized by the Director (see p. 65.). At he Dominion Laboratory fusion analyses of soils and clay fractions were made, and at the Fairlie Terrace Laboratory plant nutrients in the soils of Wairau Plains and the Gisborne district were determined.

Two papers were published in the *N.Z. Journal of Science and Technology:* "The Soils and Agriculture of Western Samoa" (W. M. Hamilton and L. I. Grange), and "Phosphate Fixation in some New Zealand and Pacific Island Soils" (K. S. Birrell.)

HAWKE'S BAY SOIL SURVEY: PROGRESS REPORT.

By I. J. Pohlen, H. S. Gibbs, and J. D. Raeside, Pedologists, and J. K. Dixon, A. C. Harris, and K. S. Birrell, Soil Chemists.

Introduction.

During the 1937–38 season genetic soil types were mapped in Hawke's Bay over an area of about 1,100 square miles between Napier and Wairoa, and in the vicinity of the Wakarara Range. The total area mapped is now over 4,000 square miles, and the coming season will see the completion of the project with a rapid reconnaissance of 300 square miles of high country in the north-western survey districts, and a more detailed survey of 650 square miles near Wairoa, near Woodville, and between Weber and the coast. For the greater part of these last localities geological maps are available.

Air photographs taken by the Air Department of the district between Napier and Waipukurau have been made into mosaics, and by means of these greater detail is being added to the soil maps of the 1935–36 season. About 200 square miles of this work has been completed.

Description of Area mapped, Topography, Geology, Climate and Vegetation.

The geology of the area was practically unknown before the present survey, but a reconnaissance of the volcanic ash-shower region had been made for soil purposes. The Wakarara Range and adjacent rolling country form part of the topographical unit described in the last report as the *western ranges and rolling country.* Hard, highly contorted, and shattered rocks (argillites and greywacke) give rise to the ragged, steep-sided range with its slopes scarred by erosion, and in places scrub-covered. The adjoining foothills and plains, formed of ancient alluvium derived from similar rocks, are still partly covered with fern and scrub, or rarely, with small patches of forest. The natural fertility of all the soils is low except where forest formerly grew or where hills of mudstone soils are exposed.

The Napier-Mohaka district is also divided topographically into three units: (1) Western ranges and dissected country; (2) central easy rolling country broken by deep gorges; (3) coastal belt of steep country.

(1) *The western ranges and dissected country* within the area described are formed of tilted, highly-dissected beds of Tertiary sandstones, mudstones, and limestones which are coated, except on very steep slopes, with the Taupo pumice ash shower that gives rise to the "bush sick" soils of this district.

A few elevated rolling areas have survived the general dissection. Erosion is not so pronounced as on the southern continuation of the belt near Kuripapanga. Rainfall ranges from about 55 in. to 70 in. Where it is over 60 in. rimu-matai forest takes the place of fern and scrub and imparts a higher natural fertility to the soils, which are otherwise extremely poor. Access to the area is poor, and the steep or elevated rolling, fern, and scrub-clad landscape is rarely varied by paddocks in permanent pasture.

(2) *The central easy rolling country* is a belt about four miles wide trending north-east and centred on the Napier–Wairoa main road between Tutira and Putorino. The contour is again determined by gently tilted sandstones and mudstones with a little limestone or conglomerate, broken by deep gorges, and covered by the Gisborne shower * (and earlier pumice ash shower ejected from Taupo). The rainfall ranges from 50 in. to 60 in. Practically all the soils are reputed to be "bush sick." The new Napier–Wairoa railway runs through the middle of this belt, containing many thousands of acres of easy rolling ploughable soils, the great bulk of which is in fern and scrub. These soils are of low natural fertility, but have an excellent physical condition.

(3) *The coastal belt* of moderately steep to steep country is formed of strongly dissected beds of mudstones, sandstones, and limestones. The coating of volcanic ash in this area was originally thin and has now been almost completely removed, so that the soils are derived from the underlying rocks and bush sickness is not recorded. Rainfall is less than 50 in. and pasture has replaced the former fern cover. The fertility of the soils in the natural state is relatively much higher than that of the other belts, but as a rule they are not ploughable.

In general, it may be said that in the Napier-Wairoa area the country is largely covered by a blanket of volcanic ash, thick towards the west and north-west, but gradually thinning eastwards until in the coastal area it has disappeared; that the fertility of the soils increases as the volcanic-ash deposit becomes thinner; and that most of the ploughable country lies in the middle portion of the district.

Classification of Soils.

In earlier reports the normal soils of Hawke's Bay—*i.e.*, soils other than those derived from limestone or volcanic ash—were tentatively called podsols. Podsols are soils that are well leached of their fertility elements, and those soils on which this process is far advanced generally present some difficulties in their development. But Hawke's Bay soils are treated somewhat unfairly in being so classed, for if one or two of the plant-foods which are low are supplied they can be ranked as very suitable for pasture. The soils are not well leached owing to their original high lime content and are tentatively placed in "New Group." Following the American classification, stages are recognized in the group according to the amount of leaching the soil has undergone. The names formerly given to the soils are placed in brackets.

Description of Soil Types.

New Group.

(*a*) *Recent* (skeletal podsol) soils have profiles consisting almost entirely of unweathered parent material. They are so youthful that clay or other material has not had time to be washed down from the surface to the subsoil, and no horizons can be recognized in the vertical profile other than, say, discolouration of the topsoil by humus. They are thus developed only on recently deposited alluvium in valley-bottoms or on steep hillsides where periodic slipping allows constant renewal of the soil profile. In the area discussed they are developed from mudstone rocks on very steep hill slopes or valley walls, so that, although common throughout the area, they occupy only a small acreage on the map.

(*b*) *Young* (immature podsol) soils are a little more weathered than recent soils. A small amount of clay has been washed down into the subsoil, which is slightly more compact. They are also developed on steep country from mudstone of sandstone rocks. They occupy about 15 square miles in the Tutira-Putorino district, and about 5 square miles in other areas. The mudstone soil is of high natural fertility, having a base saturation† of over 60 per cent., and is near neutrality in reaction, but is subject to constant slipping and in low rainfall areas dries out badly. The sandstone soil has not previously been described. A profile is:—

6 in. heavy sandy loam, black, free.
On very heavy sandy loam, creamy-yellow, more compact.

It is derived from marine pumiceous sandstone and is much less fertile than the mudstone type. It dries out to a greater degree.

(*c*) *Immature* (mildly podsolized) soils are moderately weathered, and have a distinct clay accumulation in the subsoil, which is often fairly compact. They have developed sufficiently to enable the processes associated with the New Group to be detected in the soil profile by field and chemical evidence, as indicated in the last annual report. A leached, somewhat greyish or yellowish, horizon appears below a humus topsoil.

Immature soils are most common in the coastal belt, where they occupy about 150 square miles west and north of Napier. The main soil type is developed on moderately steep unploughable slopes from marine pumiceous sandstone. A profile is:—

6 in. sandy loam (heavy), greyish-black.
8 in. sandy loam (heavy), creamy-grey to light brown.
On sandy clay loam, dull yellowish-brown.

This type occurs on country not as steep as the immature type developed on the same parent rock. It is low in natural fertility (though much higher than the ash soils), the available phosphate being low, although the percentage base saturation is fairly high. It dries out badly, however. Sheet and other forms of erosion are active, and will be discussed later. Because of their marked influence on

* See p. 58 for the definition of the Gisborne Shower.
† Soils with a base saturation of 60 per cent. are generally regarded as very fertile.

pasture, it was necessary to delineate roughly on the maps certain phases or, rather, complexes, mainly composed of this type. In one such complex limestone outcrops are abundant, and the sandstone which overlies the limestone and surrounds the outcrops contains more lime, so that the resulting soil is more fertile. Again, profiles of pure pumice sands are encountered, and in some area are so numerous that a poorer phase is recognized. In the Matapiro district the normal type is most common, and this is considered to be better country (pH=6·2, percentage base saturation 71 per cent.) than that near the coast north of Napier, where the poorer phase containing numerous sand profiles is mapped.

(*d*) *Semi-mature* (weakly podsolized) soils have, as a rule, compact subsoils with high clay accumulation, and more free sandy topsoils. In dry weather the subsoil is a hard pan, but in wet seasons the pan does not appear to be cemented. They are best developed in the coastal belt north of Napier, where they form rolling ridges left by the close dissection of the land-mass, and in the Greenmeadows - Bay View area west of Napier where about 70 square miles have remained without important dissection. The main type is the one derived from marine pumiceous sandstones. A profile is :—

6 in. sandy loam (heavy), greyish-black.
9 in. sandy loam (heavy), creamy-grey.
9 in. sandy clay loam, yellowish-brown, compact.
On pan of sandy clay loam on sandy clay, yellow.

On phases where the slope is very gentle to flat this pan forms a thick siliceous "case-hardened" band when exposed to air. The subsoil is sometimes calcareous. As a rule, the type is of fair natural fertility. Data for a typical profile are given below :—

Sample.	Locality.	Depth (In.).	Topography.	Horizon.	Stage and Parent Rock.	pH.	Available		Percentage Base Saturation.	Clay.
							Phosphate.	Potash.		
2105 ..	Ohiti Road	0–6	Rolling to steep	A_1	Semi-mature (derived from marine pumiceous sandstone)	6·0	0·003	0·021	62·1	17·2
2106A		7–12				6·8			62·5	19·5
2106B		13–18				7·1			76·8	25·8
2106C ..		18–24				7·3			59·7	26·5

There is evidence of the shift of clay in the profile. Phosphate is low, but the base saturation is relatively high. Phosphate top-dressing is indicated. The rolling country in the Matapiro area twelve miles west of Napier belongs to this type (pH about 6, and percentage base saturation near 60 per cent.), and is better than the phase north of Bay View which contains numerous profiles of pumice sands.

(*e*) *Sub-mature and mature* (moderately podsolized) soils are fully weathered and have a dense compact clay subsoil or cemented hard pan. They are the end-product under existing conditions. They are not common in the area described, but occur in small areas on the easy rolling to flat phases of the semi-mature soil described above. These phases are well leached and have a hard silica pan which remains permanently cemented.

Certain other soils of the New Group surveyed in previous seasons include those in the Wanstead district, seven miles north-west of Wallingford, developed on moderately steep to rolling slopes derived from a heavier calcareous mudstone. Owing to the high original lime content the soils are still in the young state and relatively fertile, although for practical purposes they are not as valuable as the better-drained, warmer soils at Raukawa. Data for a typical profile are :—

Sample.	Locality.	Depth (In.).	Topography.	Horizon.	Stage and Parent Rock.	pH.	Available		Percentage Base Saturation.	Clay.
							Phosphate.	Potash.		
2099 ..	One-half mile south-east of Elsthorpe turnoff, Tukituki River Road	0–6	Rolling to steep	A_1	Immature (derived from calcareous mudstone)	5·7	0·009	0·032	81·0	46·5
2100A		8–12	,,	A_2		5·7	0·007	0·019	80·7	55·6
2100B		13–18	,,	A_2		5·5	0·003	0·013	96·7	55·7
2100C ..		18–23	,,	A_2		5·2	..	..	93·5	55·3

Phosphate is low, but the percentage base saturation is very high. The pH values are low considering the base saturation. Phosphate top-dressings are needed. A few miles east of Wallingford the Weber soil type is developed on slightly coarser rocks on gently rolling hills. Leaching has progressed to a slightly greater extent than on the Wanstead type and the soil is better drained. Similar base-saturation figures are given for this type, although the pH is higher.

The field characteristics of the soils in the Wakara district were fully described in the last annual report. A typical chemical profile for a young soil developed from greywacke on steep slopes is given below :—

Sample.	Locality.	Depth (In.).	Topography.	Horizon.	Stage and Parent Rock.	pH.	Available		Percentage Base Saturation.
							Phosphate.	Potash.	
1945 ..	Ngamoko, west of Norsewood	0–6	Steep ..	A	Young (derived from greywacke)	5·6	0·009	0·015	17·8
1946A ..		12–18	,, ..	B	,,	5·7	0·005	0·011	4·4
1946B ..		18–24	,, ..	C	,,	5·4	0·005	0·004	3·0

Phosphate is low, and the percentage base saturation indicates a rather low reserve of bases, especially as the lower depths are noticeably deficient.

As shown by the following analyses, the fertility of the easy country is somewhat similar to that of the steep country. According to the analyses both lime and phosphate dressings are required :—

Sample.	Locality.	Depth (In.).	Topography.	Horizon.	Stage and Parent Rock.	pH.	Available		Percentage Base Saturation.
							Phosphate.	Potash.	
1869 ..	Yarrow Stream Road	0–6	Rolling	..	Semi-mature (derived from ancient greywacke alluvium)	5·8	0·008	0·031	16·16
1870A ..		12–18				5·7	0·0005	0·036	29·48
1870B ..		19–25				6·2	Trace	0·013	35·65
1870C ..		29–34				6·3	0·00	0·009	56·23

Pumice Soils.

The pumice volcanic ash bush-sick soils which were grouped with the immature brown loams in the last annual report are here simply described as pumice soils. Most important in extent is the Taupo pumice series which occupies about 350 square miles of forest, fern, or stunted scrub country in the western area. Two-thirds of this area is occupied by rugged, steep, or moderately steep, unploughable slopes, much of which was formerly in forest. These forest types have a good natural fertility, but the fern and scrub soils are very poor. Only a few square miles are in good pasture and, as with all these light volcanic soils, particularly on steep slopes, great caution must be exercised in their management lest wind or water erosion should gain a hold. The rolling Taupo pumice soils, which occupy about 70 square miles, half of which was formerly in forest, resemble in fertility the steeper types. The topsoils pH figures lie between 5·0 and 6·0, while the base saturation is low, indicating a need for liming. A profile of the forest type is :—

6 in. sandy silt to sandy silt loam, blackish-grey, fluffy.
8 in. fine pumice sand, greyish-buff, free.
12 in. gravelly sandy loam, dark grey or blackish-brown with light-yellow pumice gravel, free.
12 in. heavy silt loam, pale yellowish-brown.
On heavy silt loam, compact, greyish-brown.

The Gisborne pumice shower covers the central rolling country of the Napier-Wairoa district, a belt of about 200 square miles trending north-east, about eight miles wide, and centred on the Tutira–Mohaka main road. About 130 square miles is mapped as rolling ploughable country; the rest is moderately steep and unploughable. A profile on the rolling country is :—

6 in. coarse pumice sandy loan, greyish-black, free.
8 in. gravelly pumice sandy loam, creamy-yellowish-brown, very free.
4 in. gravelly pumice sand, yellowish-cream, very free.
On heavy silt loam, golden-brown, compact.

As the texture indicates, this type dries out badly. Like the Taupo ash, it is low in cobalt and is reputed to be bush sick. The pH is near 6·0 and there is about 40 per cent. base saturation. Its vegetation is fern or tall scrub, indicating a slightly better fertility than the Taupo ash, and the great bulk of this soil type is still under its natural cover. Though subject to wind-erosion under certain conditions, this type is not as severely affected as the Taupo ash. The moderately steep Gisborne soil is very similar to the rolling type as regards soil properties.

Eastwards the ash showers become thinner and give place to a zone where the ash is less than 2 ft. thick and rests upon an older soil derived from marine mudstones, sandstones, or limestones. The resulting soils are not as fertile as the underlying ones which are exposed nearer the coast, but are a great deal better than the true ash soils. Flat and rolling types are well developed near the mouths of the Mohaka and Waikare rivers. A profile is :—

8 in. silty sandy loam, dark brownish-black.
10 in. very sandy loam, chocolate-brown, free.
10 in. coarse loamy sands, white, loose.
12 in. heavy sandy loam, white, with yellow streaks, compact.
On fine muddy sandstone, creamy-yellow.

The plant-roots appear to be able to derive a portion of their food supply from the buried soil, and it is perhaps for this reason that these soils are not bush sick. They do not dry out as badly as true ash soils because they are not as well drained. Similar soil types are developed on steep or moderately steep country and are better drained though unploughable.

Soil Conservation.

A description of the wind and water erosion on light volcanic soils has been given. During the past season a good deal of attention has been paid to the more common types of erosion, these being :—

(1) Sheet erosion.
(2) Slipping and slumping.
(3) Gullying.

(1) *Sheet erosion* is the progressive removal of topsoil over wide areas under favourable conditions of run-off and open vegetative cover. It is of relatively great importance on the Hawke's Bay hill country, and is indicated by an open sward and a bare appearance of the pastures on steeper slopes in dry weather. Sheet erosion must continue on an open sward,

and already two or three inches of the humus-bearing topsoil have been removed from certain soil types over widely scattered areas. The young and immature soil types derived form pumiceous sandstone and extending west and north of Napier are suffering severely in this way. So also are moderately steep soil types in the Wallingford district.

(2) *Slipping and Slumping.*—The recent torrential rain in Hawke's Bay has emphasized the seriousness of this problem. Sometimes the topsoil slips off a clay subsoil and at other times soil and subsoil slip, exposing the bare rock. In both kinds of slipping the scar is difficult to heal unless the rock exposed is shattered and is rich in plant nutrients. In by far the greater number of cases the slipping during the recent rains has been detrimental on the farms on which it occurred.

(3) *Gullying* in Hawke's Bay is not as severe as in other districts. It follows on erosion of type (2) when increased run-off cuts into loosely consolidated parent material and gouges out deep channels in the hillsides. If the problem of preventing the exposure of bare surfaces by slipping or other erosion—*e.g.*, wind—is not solved, gullying may in the future assume serious proportions.

Increased flooding is the obvious natural outcome of erosion, for erosion produces bare soil or rock surfaces from which run-off is greatly increased. An example is the flooding and havoc which recently took place in the Esk Valley, the Tutaekuri Valley, and in the valleys of other main streams of the area described. In Hawke's Bay a disaster of this sort occurs approximately every second decade, while in nearly every decade major floods are recorded. Rivers have built up their beds by many feet, and with increased erosion in the hill country the "old man" floods must inevitably increase in size and number. On the soil maps the soil types that are subject to increasing erosion have been delineated, and this information should be of value should any action on the problem be taken.

HERETAUNGA PLAINS.

By H. A. Hughes and L. Hodgson.

The work of preparing a detailed soil map of the Heretaunga Plains is now nearing completion, and the following is a brief account of the soils and their characteristics.

The soils of the plains have been divided into ten series, which in turn have been divided into twenty-seven types. A description of the types will be given in the complete report on the plains.

The soils of the Twyford Series are derived from material deposited by the Ngaruroro River when following one of its earlier courses across the plain. They lie at a slightly higher elevation than the surrounding soils and are situated roughly in the western centre of the plains. The sub-types, which cover a fairly large range, vary from stony gravels to good silt and sandy loams. This series is generally very fertile, except where the stony gravel sub-types are encountered. The types have a very low moisture-holding capacity and dry out rapidly; the period of growth, which is governed by the amount of rainfall, is very short. The silt and sandy loam sub-types have a much higher moisture-holding capacity, and are generally very fertile and easily cultivated.

The available phosphate and potash figures indicate a high availability of plant nutrients. The phosphate status is maintained even into the subsoil, indicating a natural fertility. The pH values vary considerably and are worthy of further study. Soluble salts below 0·1 per cent. are not likely to be deleterious to plant growth.

Twyford Series.—Typical Analysis.

Sample No.	Depth.	Available		pH.	Soluble Salts.	Texture.
		Phosphate.	Potash.			
	In.				Per Cent.	
1965 ..	0–6	0·037	0·033	6·5	0·072	Fine sandy loam.
1966A ..	12–18	0·045	0·015	6·4	0·057	,,

The Paki Paki Series, which bounds the Twyford Series on the southern margin, lies at a slightly lower elevation. Some of the sub-types are only moderately fertile and suffer severely from drought conditions. The subsoils consist mainly of fine pumice sand with occasional large lumps. In the lower-lying areas, where a heavy clay loam topsoil is found, the types become much more fertile.

The level of phosphate and potash is rather lower than in the Twyford Series. The pH values are just over 6·0, and soluble salts are important in the profile.

Paki Paki Series.—Typical Analysis.

Sample No.	Depth.	Available		pH.	Soluble Salts.	Texture.
		Phosphate.	Potash.			
	In.				Per Cent.	
1989 ..	0–6	0·018	0·017	6·0	0·145	Sandy loam.

The Ngatarawa Series is found in two localities, Ngatarawa and Te Mata. The soil characteristics are similar in both cases, being sandy loam to free loamy sand overlying stony gravel at an average depth of 18 in. The soils of this series dry out rapidly. The available potash and phosphate is low, and the analyses indicate that with sufficient moisture phosphate dressings might be applied with advantage. In reaction the soils are acid, being well below neutral.

NGATARAWA SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.
		Phosphate.	Potash.	
	In.			
2457 ..	0–6	0·012	0·026	5·7
2458 ..	9–15	0·003	0·010	6·3

The Havelock Series does not cover a very large area and does not vary to any extent except in texture. The subsoils consist of a particularly heavy clay, in some places forming a shallow pan. The topsoils also are fairly heavy and do not break down well when cultivated.

The available potash is fairly low, especially in the subsoil, and the available phosphate, although high in the topsoil, drops markedly in the subsoil, suggesting that added phosphates have been retained in the topsoil. The pH values vary somewhat.

HAVELOCK SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Soluble Salts.	Texture.
		Phosphate.	Potash.			
	In.				Per Cent.	
1983 ..	0–6	0·037	0·010	6·7	0·077	Sandy loam.
1984A ..	6–12	0·004	0·007	6·5	0·011	,,
1984B ..	12–18	Trace	0·005	6·6	0·084	Clay.

The Hastings Series covers a fairly large area, with a large range of sub-types. These sub-types also vary considerably, owing to such external factors as high water-table and deposits from different rivers. The topsoils in the heavier types present some difficulties in cultivation and require seasonable conditions to be right, before breaking down to a good tilth. The lighter-textured types, on the other hand, break down fairly well. This series is particularly well supplied with available potash and phosphates, while the pH values range from 5·2 to 7·2.

HASTINGS SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Soluble Salts.
		Phosphate.	Potash.		
	In.				Per Cent.
2459	0–6	0·046	0·053	6·0	0·053
2460	9–15	0·042	0·026	6·3	0·033

The Pakowhai Series is found near the present Ngaruroro River and does not cover a very large area. It is derived from flood deposits of that river and does not vary as much as some of the other types. The whole series is very fertile, but is subject to repeated flooding. This series is associated with good phosphate and potash figures, while the pH tends to be near neutral or higher—perhaps sometimes too high for apples.

PAKOWHAI SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Texture.
		Phosphate.	Potash.		
	In.				
1671	0–6	0·040	0·066	6·0	Silt loam.
1672B	12–18	0·031	0·030	7·4	,,

The Kaiapo Series is also somewhat scattered and varies considerably in texture. The limiting factor in these soils is the presence of a high water-table. This hampers the work of cultivation and during very wet period the soils become very water-logged. The soils are very fertile, being high in phosphates. Better drainage in this series seems essential.

KAIAPO SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Texture.
		Phosphate.	Potash.		
	In.				
1484	0–6	0·046	..	5·2	Clay.

The Turamoe or peat series covers a fairly large area in the southern portion of the plains. This series, like Paki Paki, has a pumice subsoil and is divided into types according to the depth of peat. The moisture-holding capacity is very low, this being probably due largely to lack of consolidation. Medium phosphate and potash figures are found while the pH is low.

TURAMOE SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Texture.
		Phosphate.	Potash.		
	In.				
2251	0–6	0·031	0·018	4·8	Loamy peat.

The Farndon series does not cover a very large area and is of fairly recent origin, being deposited mainly by the Tutaekuri River. The soils are only moderately fertile, and where the texture is open dry out badly. Only medium phosphate figures are found, while the potash values vary. The pH values are invariably high and may be associated with a poorer growth of apples. Soluble salts may be high enough to affect growth adversely. Further data are necessary on this point.

FARNDON SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Soluble Salts.	Texture.
		Phosphate.	Potash.			
	In.				Per Cent.	
1967 ..	0–6	0·016	0·014	8·3	0·083	Fine sand.
1968A ..	6–12	0·017	0·019	8·2	0·114	Fine sandy loam.
1968B ..	12–18	0·018	0·017	8·3	0·066	,,

The Meeanee Series occurs in the north-eastern portion of the plains, and is derived from deposits of the Tutaekuri River. It lies at a very low elevation, being only a few feet above mean sea-level, and a large area until recently was subject to tidal influence. The soils are well supplied with phosphate and potash, but they are neutral to slightly alkaline in reaction and some of the sub-types have a high chloride or salt content which limits their use for agricultural purposes. On the saline types salt-tolerant plants should be grown, as difficulties of drainage may preclude the normal use of these soils for many years.

MEANEE SERIES.—TYPICAL ANALYSIS.

Sample No.	Depth.	Available		pH.	Soluble Salts.	Texture.
		Phosphate.	Potash.			
	In.				Per Cent.	
1977 ..	0–6	0·046	0·061	7·2	0·801	Clay loam.
1978B ..	12–18	0·015	0·050	8·2	0·664	..

NORTH AUCKLAND SOIL SURVEY: PROGRESS REPORT.

By N. H. TAYLOR and C. F. SUTHERLAND.

During the 1937–38 season the soils of the south-western part of the Whangarei County and neighbouring areas in Hobson and Otamatea counties (an area of 600 square miles) were mapped in fair detail. Both the Whangarei and the Bay of Islands counties and parts of the adjoining counties of Mongonui, Whangaroa, Hokianga, Hobson, and Otamatea have now been covered by the soil survey. The total area surveyed is approximately 2,600 square miles.

During the year Mr. E. B. Glanville, of the Department of Agriculture, assisted in the work of relating farming problems to the soil types as mapped by the soil survey, and it is hoped that a full report of the work in the Whangarei County will shortly be published.

In co-operation with the Department of Health, work has been undertaken in relation to the health of children living on markedly different types of land. As cow's milk is the most important part of the child's diet produced locally, preliminary samples of milk have been collected for spectroscopic analysis in order to obtain some knowledge of the minor elements contained in milk ash.

During December Miss L. M. Cranwell, botanist to the Auckland Museum, spent a week in the field tracing the relationship between the native vegetation and the soil types developed beneath them.

Mr. J. C. Neill, Assistant Director of the Plant Diseases Division, made a mycological analysis of five North Auckland soils. The results showed this to be a promising line of research, and it is hoped to continue it as soon as laboratory facilities are available.

Soils.

The soils over a large part of the area mapped (approximately 270 square miles) are derived from the Whangarei sandstone. Rolling to moderately steep hills carved from this sediment occupy the greater part of Tangihua Survey District and extend into neighbouring districts of Mangakahia, Maungaru, Tokatoka, Matakohe, Ruakaka, and Waipu. A wide range of soils has developed, depending largely on the angle of slope of the surface and the type of forest cover and, to a certain extent, on lithological differences in the sandstone formation itself.

Type A.—Where the sandstone is argillaceous the surface of the ground is slumped and hummocky due largely to mass movements which have taken place beneath the original dicotylous forest cover. The topsoils are dark, grey-brown clay loams and sandy clay loams, and the subsoils brown and grey-flecked clays. Although the land is difficult to plough, on account of the uneven surface, these soils are fairly fertile and are used extensively for dairying and grazing. They respond well to slag and to lime and superphosphate top-dressing.

Type B.—Where the sandstone is more arenaceous the hillsides have not slumped so readily and are consequently smoother in outline and in places steeper than where underlain by the argillaceous sandstone. Most of the land of this type has been covered by a dicotylous-podocarp forest mosaic with taraire dominant in the valleys and rimu and totara on the ridges. Where the bush has been removed slips have developed on the steeper hillsides. The soils are grey-brown clay loams and the subsoils brown and grey-flecked clays and sandy clays. These soils are less fertile than those of type A, but the drainage is better and they have been successfully used for sheep and cattle grazing. Little top-dressing has been practised on this soil type, and much land felled forty to fifty years ago is now reverting to bracken fern and manuka.

Type C.—Over smaller areas covered with kauri forest the topsoil is a grey silt loam and the subsoil a poorly drained, compact, flecked clay. This soil is less fertile than type B, and without top-dressing the pasture readily reverts to manuka.

Type D.—Lower in the scale of natural fertility are the submature and mature podsols which cover the low rolling country. These are gumland soils which formerly supported kauri forests, but now are covered with low manuka scrub, wiwi, and *Drachophyllum*. The topsoils are grey structureless loams and sandy loams; the subsoils grey compact clays with humus and iron pans developed in the more mature phases. As with other gumlands, these soils, where well cultivated and manured with lime and phosphates, can be made to support good pastures, but at present comparatively little of the land covered by this type is being farmed.

Type E.—Areas of easy rolling country covered with sticky grey and grey-brown clays and supporting stunted scrub and fern represent the eroded phases of type D. The loamy grey topsoil has been washed away, leaving the grey clay subsoil exposed to form the parent material of a new soil. This soil type, being both infertile and difficult to work, is little used by farmers. Attempts made to grass it have met with but little success, and ploughed hillsides are in many places channel-eroded.

A similar range of soils derived from argillaceous limestone and calcareous mudstone covers parts of Motatau, Tokatoka, Matakohe, Hukatere, Otamatea, and Waipu survey districts. Where the soils are young the effect of the parent material is evidenced by a fertile soil, but where the residual clay overlying the limestone is thick and the area has been covered with podocarp and conifer forests, the soils are infertile and resemble those derived from less calcareous sediments.

Near Maungaturoto and in other places with an average rainfall of 50 in. or less per annum a fertile lime humus (rendzina) soil forms beneath the dicotylous forest wherever the limestone of the hillsides is close to the surface. A typical profile in such localities is :—

10 in. dark, grey-brown, heavy clay.
2–3 in. grey and brown flecked, heavy clay.
On white argillaceous limestone.

Fragments of limestone occur throughout the whole profile, and in many places pea-like manganese nodules are to be found in the lower half of the profile. These soils have a high natural fertility and are used for sheep and dairy farming. Owing to the heavy texture of the soil, drainage is poor and the soil poaches during wet spells.

Near the Motatau where the rainfall is 70 in. and over, the humus-bearing topsoil is rarely more than 3 in. to 6 in. deep, even where the limestone is close to the surface, and the flecked grey and brown heavy clay occupies a much greater part of the profile.

Other hill soils, such as the brown granular clays derived from dolerite rock and submature podsols developed on siliceous claystones, have been described in previous reports. Where as in parts of Motatau Survey District these submature podsols cover moderately steep hills the land appears to have little, if any, agricultural value.

Meadow Soils.

From Kerekopuni to Ruawai meadow clays have been mapped over 47 square miles of flat land bordering the left bank of the Wairoa River. Upstream from Dargaville these flats are narrow and discontinuous, but downstream they are larger and at Ruawai they are about eight miles long and four miles across.

The soils on the main flats are grey-flecked clays with a marked crumbly structure. Raupo and other swamp vegetation is said to have been the main cover in the past, though certain areas supported Kahikatea and mixed bush. On lower areas close to the foothills the topsoils are fertile peaty loams and peaty clays; deep peaty loam soils cover only small areas and in the foothill re-entrants.

Drainage is the chief soil problem on these flats. Because of the heavy texture the soils are difficult to drain, and during wet weather they poach badly with even moderate stocking, many farmers being forced to shift their stock on to neighbouring hill lands during the winter.

These clay meadow soils are the complement of the podsolized soils of the adjacent hills and should be used in conjunction with them, for each tends to grow grass when the other is not producing.

Soil Conservation.

Attention has been paid to the problem of soil conservation on the hill lands and the results of some of the work has been published by one of the writers (N. H. Taylor) in the *New Zealand Journal of Science and Technology*.

It is necessary to build a stable grass soil on the hills in order to protect them from deterioration. An example from the hills near Whangarei shows this clearly. Part of the clay hillside with a 22° slope was covered with good paspalum and part with poor danthonia pasture which was frequently burned. Beneath the paspalum had been built a layer of brown humus 2 in. to 3 in. thick, whereas beneath the sparse danthonia cover the profile was similar to that of a treated forest soil.

With a poor pasture cover the general process of deterioration in North Auckland appears to be first the removal of topsoil by sheet erosion, followed by shallow slipping induced by wider fluctuations in soil moisture, and finally destruction of the slipped ground by channelling.

FOREST LITTERS.

By N. H. Taylor and J. K. Dixon.

Farmers have long been able to estimate the quality of the soil by the forest trees growing upon it. For example, such trees as puriri and kohekohe are regarded as signs of good land, whereas kauri trees indicate land of definitely poorer quality.

During the course of the North Auckland soil survey this correlation of forest trees with stage of soil leaching, even where the underlying rock is the same, has been very apparent and has been one of the problems studied.

Three main types of forest floor are recognized. Under dicotylous trees (such as puriri, kohekohe, and taraire) a loose litter of dead leaves directly overlies the mineral soil. Under podocarps and related trees (such as rimu, totara, and miro) the litter does not decompose so rapidly and the intermediate stage of decomposition is shown by the powdery humus layer which separates the layer of fresh litter from the mineral soil below. Under kauri (a conifer) this intermediate layer is much thicker and resembles a greasy peat.

Analyses of the forest-floor samples, although incomplete, show the litter of dicotylous trees to contain more lime and potash than does the litter of the kauri. The alkalinity of the litter ash (*i.e.*, the excess of basic over acidic constituents) agrees with the field evidence in placing the trees in the following order: puriri, taraire, rimu, kauri. The puriri produces the most fertile soils from a given parent material, and the kauri the least fertile.

PUMICE SOILS OF THE GISBORNE DISTRICT.

By L. I. Grange.

In December, 1937, the writer made an examination of the pumice soils of East Cape Peninsula in order to provide basal soil data for the experiments on anæmia in sheep that are being carried out in that district.

The map in Bulletin No. 32 of the Department of Science and Industrial Research shows the Taupo pumice extending east as far as Matawai, but the present survey disclosed the fact that this ash shower does not extend into the Gisborne district—it probably does not reach much beyond Lake Waikaremoana. The ash that covers the Gisborne district is the product of an eruption from Lake Taupo, which immediately preceded the eruption of the Taupo pumice. It is given the name Gisborne Shower, a typical section of which is:—

7 in. black sandy silt.
8 in. grey-brown gravelly sand.
7 in. creamy-grey gravelly sand.

This means it is a light-textured soil with a gravel layer in its subsoil.

The shower extends from the Taupo pumice boundaries north to a few miles beyond Matawai, to within a short distance of Gisborne, and to the Mangaheia Valley, ten miles west of Tolaga Bay. The area covered by the Gisborne Shower covers almost all the local farms on which bush sickness has been reported.

Analyses made by Mr. K. J. McNaught, of the Department of Agriculture, show that the soils are low in total cobalt content, but are higher in this element than those derived from Taupo pumice. The soils are low in phosphate and are distinctly acid.

WAIRAU PLAINS SOIL SURVEY.

By C. S. Harris and K. S. Birrell.

General.

In June, July, and August of 1937 the area mapped comprised all the plains' land on the south side of the Wairau River between the Blenheim–Picton railway-line and the Wye Stream, thirty-five miles from Blenheim, together with the lower eight miles of the Waihopai Valley and a number of fans along the foot of the Wither Hills, the total being roughly 58,000 acres. Attention was confined to those parts already contoured at 10-foot intervals by the Public Works Department in connection with the irrigation projects.

Rainfall and Irrigation.

Some of the mean annual rainfall figures are as follows: Erina, 37 in.; Waihopai, 32 in.; Renwicktown, 28 in.; Blenheim, 26 in.; Spring Creek, 30 in. Although the rainfall is not particularly low, except at Blenheim and Renwicktown, the porous nature of the soils, hot north-west winds, and high evaporation cause serious droughts in some years. Spring Creek district appears to receive an underground seepage from the Wairau and does not suffer to any extent. Lack of sufficient moisture in most years is the limiting factor to higher production and various methods of irrigation are being considered by the Public Works Department.

Soil Series.

Hillersden.—From the Waihopai to the Wye there are three main river terraces, the highest and oldest of which, consisting of silt loams on gravels, together with some of the Waihopai Valley, contains small areas with a tendency to pan formation. (The lower terraces in the upper Wairau are included in the Waurau Series.) There are numerous gravel ridges on all terraces. These soils are the most acid on the plains and, according to chemical tests, show the greatest need for lime. The available potash, although low, may be adequate, but phosphate appears to be deficient, those types in the Waihopai Valley being lower in available phosphate than those of the Wairau Valley. The cover is chiefly brown-top, danthonia, and a little sweet vernal, the main weeds being matagauri, manuka, and fern. A good deal of the area is farmed in conjunction with the hills. Oats are grown for green feed and chaff, but no grain crops are grown. Wool, mutton, and store sheep and lambs are the main sources of income, and in good seasons some lambs are fattened.

Wairau.—All the soils in the upper Wairau, except those on the highest terrace, are included here. The soils nearest to the river are mainly 3 in. of sandy loam on gravels, while the higher ground back from the river consists of silt loam and sandy loam resting on sands. The phosphate status is high as is usual with recent alluvial greywacke soils, but the available potash is rather low. These soils are less acid than the Hillersden Series, but still show the need for lime. This series is farmed in conjunction with the Hillersden Series and, being of somewhat higher fertility, is partly used for growing supplementary feed crops. The pasture is slightly better than that on the Hillersden Series.

Fairhall.—Soils developed on the Fairhall fan, adjacent small fans, and a small area at Renwicktown have been classed under this heading. The profile varies a great deal, in places silt loams and sandy silt loams resting on gravels at a depth of 6 in. to 24 in., while in others there is about 6 in. of heavy silt loam resting on clay loams and clays. Gravel ridges are common. Chemical analyses indicate a moderate need for lime, while the available potash figures are average to good and the available phosphate fairly high. The wetter parts of this series are of lower fertility and are more acid. The fertility is low, partly owing to dryness, and very little cropping is done, most of the area being confined to sheep.

Taylor.—The Taylor fan has given rise to silt loams which vary in depth from 2 in. on the southern higher ground to 18 in. on the lower northern margin of the fan. They rest on gravels. The acidity here is lower than on the Fairhall Series, but in phosphate and potash status the two series are similar. Sheep-farming is the main pursuit, but a little cropping is done and there are one or two small apple orchards. Subterranean clover is being tried out on the dry shallow types, the results so far being excellent. The indications are that it would also prove very good on the more gravelly parts of the Fairhall, Omaka, and Hillersden series and in the Opawa River bed.

Omaka.—The Omaka River, flowing north across the Wairau Plains, has deposited gravels, sands, and finer sediment along its banks. The profiles vary from gravelly sandy loam on gravels at 2 in. to 8 in., sandy loam on sands, to 36 in. of silt loam. Analyses indicate moderate acidity and available phosphate is high, but the potash figures are only fair.

There is a fair amount of cropping, these soils ranking in fertility about the same as the Rapaura Series. Where the farms include lands on the Fairhall and Omaka series, supplementary feed crops are usually grown on the latter.

Rapaura.—The area east of the Waihopai River grades rapidly into more fertile country, until on the eastern side of Renwicktown the cropping area begins. At this point blue borage, a really troublesome weed, makes its appearance. Following the Wairau River there is a strip, constituting the Rapaura Series, running east from the Wairau bridge for about two miles, bounded on the south by the Opawa River. In this region the soils consist mainly of sandy silt loams and sandy loams on gravels, but there

are some extensive gravel ridges. The soils, being for the most part sandy, gravelly, and shallow, and therefore well drained, dry out badly in the summer and autumn. This area would probably respond best of all the plains to irrigation, and there seems no reason to suppose that under irrigation along with top-dressing, the production could not be greatly increased. Conditions are somewhat more acid than on the Opawa Series. The available potash is slightly lower than in the Opawa Series, but available phosphate is of the same order though not so consistently maintained in the subsoil. Holdings would average about 200 acres. Mixed sheep and crop farming is carried on. The pastures rapidly deteriorate if the plough is not kept going, but top-dressing, at present almost unknown, may help in the maintenance of good permanent pasture. Some excellent malting barley is grown, the yields reaching as much as 70 bushels or 80 bushels per acre at times, but the average would be about 40 bushels. Oats, garden peas, red clover, white clover, and a little wheat (usually for seed) are also grown. Old ewes are brought in, mated to black-faced rams, and sold fat with their lambs. Store lambs are brought in. Lambs are fattened off their mothers and off clover, but a little rape is also grown for fattening.

Spring Creek.—From Selmes Road east to Spring Creek the soils are heavier and damper, drainage being a problem because of the lack of fall. Gravel ridges are seldom in evidence. A common profile is about 24 in. of silt loam on sandy loam or sands. The Spring Creek Series includes some of the most fertile land on the plains. The acidity is approximately the same as for the Rapaura Series and the available potash is of the same order, but the available phosphate is very slightly higher. The pastures are better, but the farming is similar to that at Rapaura. Dairying is also carried on to a limited extent, more cream being sent in from the mixed cropping farms here than at Rapaura. Store lambs are fattened as on the lighter soils to the west. The carrying-capacity without top-dressing but with additional feeding is about four ewes per acre. Top-dressing is carried on to a small extent, 2 cwt. to 3 cwt. of super being used, but the practice is an innovation and is still in its experimental stages with most farmers.

Opawa.—A strip following the Opawa River from about Hammericks Road to the railway-line consists of very highly fertile soil deposited in some cases within the lifetime of old inhabitants. The profile is usually silt loam down to a depth of 36 in. or more. In places sands are met with at 24 in. from the surface, but there are no gravel ridges. This is the least acid of all the series, while the available potash is adequate to good, and the available phosphate figures are high. Holdings are small and the farming is similar to that at Spring Creek, but there is also some market gardening.

Peat.

One mile north-west of the new aerodrome there is a patch of peat several feet deep about 120 acres in extent, completely surrounded by a strip of 6 in. of peaty loam on clay loam of about the same area. On the inner part logs and stumps come up thickly as the water is carried away by the co-operative drain. The surface is dry, open, and springy to walk upon, but there are small wet patches. The pasture is mainly rye-grass. The outer part is mostly dry and firm to walk over. Very good crops are raised on the peaty loam, including peas and red clover, and the pasture is excellent.

Note.

Near the sea there is a considerable area of land which has been built up by the Opawa River. For some distance back from the sea the river is tidal, and at times when heavy rains coincide with very high tides salt water floods over the paddocks. Samples have been taken, and a map prepared showing the areas affected and the degree of salinity. The part nearest the sea is not farmed, but at least 3,600 acres of land continuously farmed is fairly badly to very badly affected.

PAKIHI SOILS OF WESTPORT.

By C. S. Harris.

Introduction.

Field-work on the pakihi soils was commenced at the end of October, 1937, and completed in May, 1938. About three-quarters of the area was photographed by the New Zealand Aerial Mapping Co., the assembled photograph, on a scale of 6 in. to a mile, coming to hand at the beginning of February. They were extremely useful, making it possible to fix many boundaries accurately and rapidly. Previously it had been found necessary to run chain and compass traverses at convenient intervals in order to form a basis for mapping soil type boundaries, as practically no landmarks were present. Unemployed labour was used to some extent for this purpose.

The total area surveyed was roughly 120 square miles, most of which was "pakihi" land, extending from Charleston north to Waimangaroa.

Climate.

Mild temperatures prevail, but there are cold winds during the winter. The annual rainfall during the last ten years has averaged nearly 79 in., each month averaging 6 in. to 7 in.

Parent Material.

Over the greater part of the area sandstone or granite gravels, originally deposited by the sea, constitute the parent rock, and give rise to "pakihi" land. On the remainder the soil is formed from recent alluvial material, sand dunes, or from small patches of limestone, and for the most part give rise to much better soils than the "pakihi."

ERRATUM.

SOIL SURVEY REPORT.

The paragraph on page 64 under the heading of "General" has been placed in the wrong context, and is intended to be the concluding paragraph of the section on the Pakihi Soils of Westport, pages 60–61. It should be read immediately after the paragraph entitled "Foulwind Series" on page 61.

Addison Series.

Addison soils occur chiefly along the main road from Charleston to Waimangaroa and include the high terraces along the foot of the mountains. The general drainage is northward to the sea, and the topography flat to very gently rolling, giving rise to ridges and hollows of very faint relief. The soils have been formed from disintegrating granite gravels. At Sargeant's Hill, a common profile is :—

4 in. to 6 in. black peaty loam.
12 in. clay loam.
1 in. fine quartz gravel.
½ in. to 1 in. iron pan.
On cemented granite, greywacke, and quartz gravels.

From the Buller Bridge to the junction of the Nelson and Greymouth roads the soils are usually up to 3 ft. in depth, but from the junction towards Greymouth the pan is usually less than 1 ft. from the surface, and there is no clay layer. In many places there is no soil at all, the fine quartz gravels coming right to the surface.

On all types in this series the depressions are wetter and have a more peaty top. The Addison soils are all badly drained, partly because a pan lies beneath, and partly because the topsoil absorbs and retains moisture. Yellow-pine logs and branches embedded in the soil indicate the type of vegetation once carried. The present cover is chiefly pakihi rush and umbrella fern. Umbrella fern thrives best on the wetter types, while pakihi rush is the chief species on the shallower, better-drained areas. Associated with these, and occurring mostly in the wet spots, are numerous low-growing mosses, and occasional poor stunted type of flax-bushes; but on the drier parts flycatchers, danthonia, and stunted, flattened manuka appear.

The high level terraces are similar to Virgin Flat except for the 700 acres, known as Caroline Terrace, where the profiles are more like those at Sargeant's Hill.

Wilson Series.

The soils are formed from northerly-trending, dry, sandstone ridges, lying between the sea-coast and the Addison soils, bordering the Westport–Greymouth Road. These sandstone ridges are nearly parallel to each other, and between each two lies a strip of wet flat land, largely built up by detritus washed down from the ridges. On the dry ridges themselves there are small, wet depressions giving a similar profile to that obtained on the flats. Almost everywhere there is an iron pan about ¼ in. thick, resting upon the sandstone.

On the ridges the soils range typically from 6 in. to 20 in. of moist sandy loam or sands on an iron pan. Many exposed small knolls of sandstone have no soil upon them, the pan and parent substance being at the surface. The original cover was chiefly rimu, kahikatea, beech, and totara, and the best was milled for timber, but some ridges carried no bush.

The commonest profile on the flats is 18 in. of sandy loam resting on sands, but in places there is a pan at 18 in. to 27 in. from the surface.

Pakihi fern is not as abundant as on the Addison soils, but there is more danthonia, pakihi rush, and gorse in dry places, and more sphagnum and other mosses in wet areas.

Buller Series.

Along the banks of the Buller River and beside some of the larger streams there have been deposited in recent times gravels, sands, and silts, from which have been formed highly fertile silt loams and sandy loams of varying thicknesses, resting on gravels. These soils are well drained, except for about six square miles of swampy land in the Nine-mile Valley, south of Westport, where rushes and second growth have come in thickly, and some bush is left standing. This wet strip would yield good land, but drainage and clearing would be costly. Analyses of samples from this locality indicate slightly acid conditions.

Tauranga Series.

In very recent times a thin strip of sandhills has been formed along most of the sea-coast. The higher dunes, back from the sea, have a dull-grey top about 10 in. in thickness, resting on pale-grey sand. The original cover was chiefly ribbonwood, wineberry, and fuchsia and cabbage-trees. These high dunes are well consolidated and fixed, a good pasture of mixed species growing well. The low dunes near the sea have only about ½ in. to 1 in. of black topsoil on loose pale grey sands. Marram-grass and lupins form the chief cover of these loose dunes, but there are some grasses, clovers, and flatweeds.

To the east of Westport, along Utopia Road, the soils are formed from slightly older sands, and being exposed to the leaching action of rain for a longer time have lost some of their plant nutrients and in places a pan has been formed.

Foulwind Series.

This series has been formed from limestone which occurs chiefly at Cape Foulwind. The usual profile is chocolate-brown clay loam or clay topsoil resting on a darker-brown clay subsoil. Small pieces of limestone occur throughout the profile and the parent substance comes to the surface in places. The crumb structure is excellent and very good garden and orchard crops were grown when the sawmills were working. Heavy bush containing a high percentage of rata once flourished, but little remains, most of the area now supporting a good mixed pasture.

REPORT ON BANKS PENINSULA SOIL SURVEY.

By C. S. Harris and A. C. Harris.

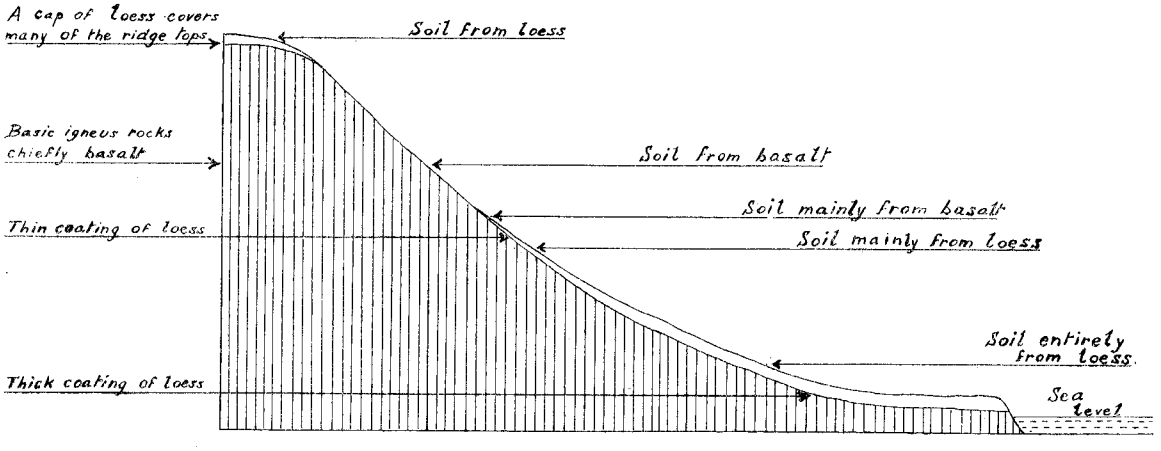
Introduction.

During April and May of 1937 part of Pigeon Bay and Akaroa survey districts was mapped on a scale of 20 chains to an inch. The area, totalling 21,000 acres, consists roughly of the slopes on the western side of Akaroa Harbour, from Duvauchelles Bay through Wainui to Timutimu Head.

Topography, Parent Material, Rainfall.

Apart from small areas of flat land in the bays, the country is made up of gentle slopes near the sea merging into very steep and rugged topography near the tops, which run up to 2,000 ft. or more above sea-level. The main streams drain towards the east into Akaroa Harbour. The rainfall on the lower slopes is about 40 in. and increases with altitude.

The underlying rock consists mainly of basalt over which has been spread a mantle of wind-blown dust (loess). On the lower, gentler slopes and on the easy ridge-tops the mantle of loess is many feet deep, but over the greater part of the steep upper slopes the loess is absent. Between the high, steep basalt slopes and the low, gentle loess slopes there is a transition zone where the parent material is partly loess and partly basalt. The following cross-section of a typical hillside gives an idea of the general distribution of loess and basalt and the soils derived from them :—



Section through hillside showing distribution of soil derived from loess and basalt in relation to topography.

Small flats have been formed in some of the bays by loess and basalt detritus washed down from the hills above. There are also two very small strips of flat in Barrys and Duvauchelles Bays where the soils have been formed from raised sea-beaches with a thin covering of alluvium.

Soils.

Owing to the soils being young, the parent material is the dominant factor in soil classification ; other important factors, however, are the steepness of slope and type of native plant cover.

Chemical data included in the description of the different soil types for the most part correlate well with field evidence and substantiate data that have been gained previously from farmers' and Department of Agriculture trials.

A. *Soils derived from Loess.*

1. *Pawson Silt Loam.*—This type, which occurs usually on the low, gentle slopes, has a light to very dark brown silt loam topsoil resting on pale yellowish-brown silt loams. The texture is fairly free down to a depth of 27 in., where it becomes more compact. A certain amount of slipping occurs.

The original cover was heavy bush—mainly totara with some kowhai, akeake, black-pine, and white-pine. Some of the best cocksfoot paddocks on the Peninsula are on this type. At its best the pasture is composed of cocksfoot, rye-grass, and clovers ; while at its worst Yorkshire fog, crested dogstail, cocksfoot, rye-grass, clover, timothy, and a little sweet vernal are the main species.

2. *Brough Silt Loam.*—The topography is the same as for Pawson silt loam, but the topsoil is black and the subsoil is not as compact, and more slipping occurs.

Very heavy kanuka (up to 24 in. to 30 in. in diameter) originally covered most of this type, although some smaller areas which carried manuka and mountain-flax are included. The pasture is very poor, being pure danthonia or danthonia with some brown-top and sweet vernal. Hair-grass, Yorkshire fog, a little clover, mosses, and flat-weed are often present also, while cocksfoot does not thrive at all. Chemical analyses indicate that the potash supply is fairly satisfactory and that there is need for lime and heavy dressings of phosphate. The figures show that lime, phosphate, and potash content is lower than that in the Pawson soil, and on this evidence indicate the need for heavier dressings.

3. *Bossu Silt Loam.*—At high altitudes on gentle, smooth-surfaced slopes this is the commonest type. The usual profile is :—

6 in. black to brownish-black silt loam.
6 in. very dark blackish-yellowish-grey silt loam.
On brownish-yellow silt loam ; fine, dry and powdery.

The present cover consists of about 50 per cent. tussock with danthonia, Yorkshire fog, and flat-weeds and occasionally some rye-grass.

B. *Soils derived from Basalt.*

These soils, which have been classed as brown loams, occur on the highest, steepest, and most rugged country. All have a good crumb structure.

(1) *Stewart Brown Loam.*—A typical profile is :—

6 in. dull dark chocolate-brown silt loam.
12 in. dark chocolate-brown clay loam.
9 in. chocolate-brown clay loam.
On basalt.

The depth of soil varies from 6 in. to 24 in. and lumps of basalt occur throughout the profile. The original cover was mainly totara, with konini dominant on sheltered, warmer, well-drained faces. The pasture is chiefly rye-grass and Yorkshire fog, with a little timothy and cocksfoot in sheltered spots. Almost a pure rye-grass pasture is found in some of the warmer paddocks, but the sward is fairly open. Available potash is present in fair supply. Phosphate, however, is much higher than in the other types and would almost indicate no great need for phosphate if it were not for the fact that brown loams, derived from basalt, usually fix phosphates in the soil. If phosphates are required, basic phosphates will probably give the best returns. The lime status is similar to that of the Pawson silt loam.

2. *French Brown Loam.*—The topsoil is shallower than that of Stewart brown loam and is black or brownish-black in colour. The present cover consists of blue and silver tussocks with a considerable amount of flat-weeds, a fair amount of Yorkshire fog, and traces of cocksfoot and sweet vernal.

C. *Soils derived from a Mixture of Loess and Basalt.*

Summit Silt Loam.—The loess covering is from 4 in. to 48 in. in thickness, and irregular pieces of basalt occur throughout the profile. The mixing of loess and basalt is caused by slipping and by shedding down of rock from above, and a good deal of variation in soil occurs ; but for present purposes several types, mapped separately, may be here classed together. An average profile is :—

6 in. dark chocolate-brown to brownish-black silt loam.
12 in. dark yellowish-brown to dark chocolate-brown heavy silt loam to clay loam.
On dark yellowish-brown to dark chocolate-brown clay loam.

The original cover was chiefly bush consisting of broadleaf, black-pine, white-pine, titoki, ngaio, five-finger, and akeake ; but smaller areas with a black topsoil were originally covered with kanuka, manuka, and mountain-flax. Where the soil is formed chiefly from basalt the bush contained a fair proportion of totara but little broadleaf. Pastures on the Summit silt loam are not quite as good as those on the Pawson silt loam. The available phosphate is the lowest for the types examined, but the general fertility level, apart from this, as shown by chemical analysis, is similar to that of the Pawson silt loam.

D. *Soils derived from Alluvium.*

Barrys Silt Loam.—These soils have been formed in the larger bays. Gravels do not often occur at less than 36 in. from the surface, except at Wainui. On the flat at French Farm Bay an old soil is frequently met with at 22 in. below the surface. The soils at Duvauchelles Bay, Barrys Bay, and French Farm Bay give on the average the Barrys silt loam profile :—

6 in. to 12 in. dark brown silt loam.
On brown silt loam.

As the parent material on the Wainui flat contains more basalt and brown loam, the soils are somewhat heavier, but gravels occur at 12 in. to 24 in. There are also two very narrow strips following the sea in Barrys Bay and Duvauchelles Bay which consists of 14 in. of alluvial silt loam on uplifted old sea-beach.

The original cover was scattered light bush consisting of black-pine, white-pine, and some ribbonwood, kanuka, and totara. There is a good mixed pasture of rye-grass, cocksfoot, crested dogstail, clovers, and Yorkshire fog.

Farming.

A rough division may be made into—

(1) The land to the north of Wainui, which is devoted chiefly to dairy-farming : and
(2) The land to the south of Wainui, which is devoted to sheep-farming only.

Very little top-dressing is done because of the high cost of transport. The easy slopes of the loess types might be top-dressed by machine, but the remainder would have to be done by hand, which here is heavy and costly work. Observational top-dressing trials by the Department of Agriculture had been put down long before the soil survey was made, and these are now being extended to take in types on which there were no plots. Deterioration in the pastures is said to be quite marked over a period of years, and to offset the drain imposed on the soil by heavy stocking and seed-production

the subject of top-dressing is becoming progressively more important, especially as erosion gains its greatest hold where the fertility is not maintained at a high enough level to ensure that a vigorous sward covers the ground.

(1) North of Wainui much of the high country is used for dairying because it is run in conjunction with the lower and warmer areas. The cows graze on the higher country during the warm weather—*i.e.*, October to April—and are then brought down to the lower paddocks, where they are generally wintered on cocksfoot roughage. The cocksfoot is grazed in June, July, and August and shut up for seed in September, the cows soon afterwards going to higher altitudes. In this way the maximum use is made of the high cold areas, and of the cocksfoot-seed paddocks which would deteriorate in seed-production under heavy grazing, and at the same time the need for winter hay is largely obviated. Cocksfoot thrives very well on the Pawson silt loam, Summit silt loam, and on sheltered parts of Stewart brown loam type. The highest country south of Stewart's Peak is used for sheep-farming only.

(2) South of Wainui, farmers have been in the habit of buying in two-tooth ewes, but some are now breeding their own. English Leicester and Southdown rams are used. In a good season 50 per cent. of the lambs may be sold fat, half of these being off their mothers. The remainder go away as stores. A few dry cattle are run as scavengers and to break down fern and scrub, but no dry sheep are kept.

General.

The Addison and Wilson soils are usually referred to as "pakihi" land, which is characterized by a cover of pakihi rush and fern, a very poor drainage, the presence of a pan, extreme acidity, and a very low content of lime and phosphate. The supply of potash is satisfactory, but nitrogen, though a good supply is present, is not available to the plant because of the sour condition of the soil. The surface presents a desolate appearance and is exposed to winds from all points of the compass.

Attempts to bringing the pakihi into pasture have not been successful until the last few years. One or two farmers have established good pastures, and the Cawthron Institute Experimental Farm at Sargeant's Hill has shown that, without cultivation but with suitable top-dressing and seed-mixtures an excellent pasture can be grown on the Sargeant's type of pakihi land. The question of what trees to plant for shelter and how to grow them is an important one and requires more investigation if any of the land is to be settled.

Much of the greater part of the area surveyed is pakihi land and it is this that has to be considered from the point of view of development. Other more fertile series are already being farmed, though some of these are not producing to their maximum.

The Addison series has been divided into a number of types, and these, together with the Wilson types will be carefully appraised in a detailed report. Those having a shallow depth of soil on the gravel, as at Virgin Flat and Addisons Flat, can definitely be classed as unsuitable for development. At Sargeant's Hill there are about 1,200 acres to 1,300 acres, and between the Buller Bridge and the intersection of Greymouth and Nelson main roads another 1,200 acres to 1,300 acres of land, suitable for development.

On the Wilson Series no attempt has yet been made to establish a pasture, but probably the same methods as at Sargeant's Hill would be successful on the dry ridges. Unfortunately, however, the wet patches, which are numerous and large, present great drainage difficulties, as there is very little slope. In the cut-over area towards Cape Foulwind, which constitutes the major part of this series, there is the additional problem of getting rid of the logs and stumps at a cost low enough to warrant its being brought in.

FLAX SOILS.

By J. K. Dixon and N. H. Taylor.

In company with Dr. J. S. Yeates, of Massey Agricultural College, visits were paid in September, 1937, to a number of typical flax areas in the Manawatu, Bay of Plenty, Waikato, and Wairarapa districts with the object of correlating growth of flax with soil conditions. At each location Dr. Yeates acquainted the writers with data relating to quality, growth, and variety of flax (*Phormium tenax*). Owing to the brief and preliminary nature of the investigations the conclusions outlined below must be regarded as tentative only and are useful mainly in indicating possible lines of research if the project is taken further.

Drainage.

(1) Flax grows well on fertile, well-drained soils, as well as on fertile ground-water soils (soils in which the water table rises within the zone of soil formation).

(2) Other soil factors being equal, the flax-growth on the ground-water soils is poorest where the water-table approaches nearest to the surface. Peats, in general, whether drained or not, are not associated with good flax.

(3) No absolute height can be given at which the water-table should stand for good flax-growth. The fertility of the soil and the state of aeration and fluctuation of the ground-water all bear upon this point. On the mineral ground-water soils the zone over which the water-table fluctuates can be gauged by the zone of mottled subsoil that separates the topsoil from the bluish colours of the permanently water-logged subsoil. On peaty soils this evidence is difficult to collect, and the only satisfactory solution in these areas would be to collect ground-water data regularly throughout the year.

(4) The strong growth of flax on the banks of running streams suggests that rate of movement of ground-water and or aeration are important factors in good flax growth.

Fertility.

(1) The more fertile the soil the more vigorous and healthy is the flax. Good alluvial soils in particular appear well suited to flax.

(2) The fact that flax will grow naturally on an area is not evidence that it can be grown satisfactorily for milling.

(3) In a number of areas the height of the water-table was not sufficient to explain the poor growth of flax observed. Soil samples subjected to chemical analysis for available P_2O_5 and K_2O (1 per cent. citric soluble), pH, carbon, nitrogen, and C/N ratio indicated that lack of phosphate was likely to be an important factor in these cases.

Phosphate fertilization is not an accepted method in flax culture, but in view of Sir Theodore Rigg's success in inducing good growth of flax by the means of phosphates on the poor pakihi soils of the West Coast (private communication) it can be concluded that the more extensive use of phosphates is justified. The use of such phosphatic fertilizers may be the means of utilizing areas for commercial flax-production that have hitherto not been regarded as payable propositions. In planting fans phosphate placed in the hole is likely to be most effective, especially when the phosphate fixing power of the soil is high.

(4) In the following table have been set out some figures typical of good and poor flax soils :—

No.	Locality.	Available		pH.	Carbon.	Nitrogen.	Carbon Nitrogen Ratio.	Growth of Flax.
		Phosphate.	Potash.					
2181	Mungaroa	0·004	0·014	3·3	50·4	1·57	32·0	Poor.
2165	Tahuna	0·002	0·025	5·3	1·9	0·21	9·0	,,
2175	Roto Aira	0·009	0·02	6·3	2·6	0·17	15·3	,,
2177	Massey College ..	0·035	0·03	5·1	2·4	0·22	10·9	Good.
2157	Maori soil, Maungatapu	0·068	0·083	7·6	5·8	0·42	13·8	,,
2179	Martinborough ..	0·049	0·03	6·9	1·6	0·13	12·3	,,

From the above it will be seen that available K_2O, pH, C, N, C/N do not appear to vary significantly, but there is considerable difference in phosphate figures.

A distinction needs to be drawn between soil conditions necessary for the growth of swamp flax and conditions necessary for the growth of selected Maori varieties. The selected varieties appear to need more fertile and better-drained soils for satisfactory growth. The best flax seen grew on pumice land near Tauranga, where Maori cultivation had raised the soil fertility (Sample 2157).

CHEMICAL WORK AT THE CAWTHRON INSTITUTE, PERIOD 1937–38.

Sir Theodore Rigg, Officer in General Charge.

Introduction.

During the past year routine analyses of soil samples collected by the pedologists in connection with soil surveys now in progress in Hawke's Bay, North Auckland, Banks Peninsula, and Westport have constituted the most important part of the work undertaken in the chemical laboratory. The analyses have included determinations of available plant food, base status, and texture.

The data obtained by the chemists have been of considerable value to the pedologists in classifying the soils of the different districts and in delimiting their boundaries.

In view of the fact that soil classification in the surveys has not been finalized by the pedologists, it is not possible at this stage to correlate the data with the soil types and to discuss the results in detail. Certain aspects of the chemical work on the Hawke's Bay and North Auckland soils are, however, presented in separate statements by Dr. Dixon, and are appended to this report.

In addition to the routine analytical work associated with the conduct of the soil surveys, special investigations have been carried out on tobacco soils of the Nelson district and on Phormium soils in the North Island.

In co-operation with Mr. N. H. Taylor, special studies have been undertaken concerning the influence of forest litters on soil type and the role of compound soil particles in the aeration and drainage qualities of the land.

Westport Soils.

In collaboration with the pedologists, laboratory studies have been made on typical samples representing different types of pakihi land and the recent alluvial soils of Westport.

All soil samples from the pakihi lands have shown the characteristic features of mature humus-iron podsols. The A horizon of these soils is greatly leached of lime and phosphate and is markedly acid, having a pH value ranging between 4·0 and 4·6. The B horizon likewise has a poor lime status, but iron and organic matter are present in notable amounts.

The following chemical data for a typical pakihi profile on the Buller Gorge Road illustrate the characteristics of these podsols :—

Depth in Profile. (Inches).	Horizon.	Available Phosphoric Acid.	Base Exchange Capacity.	Total Exchangeable Basis.	Base Saturation.	pH.	Iron Oxide.	Loss on Ignition.
		Per Cent.	m.e.	m.e.	Per Cent.		Per Cent.	Per Cent.
0 –1½	A_0	..	16·7	1·5	9·0	4·6	..	12·79
1½–6½	A_1	0·002	11·7	0·4	3·4	4·7	Trace	7·85
6½–18½	A_2	0·006	11·3	0·2	1·8	5·0	1·44	4·71
18½–34½	A_3	0·007	5·4	0·2	3·7	5·0	0·95	2·30
34½–38½	B_1	0·008	30·3	0·1	0·3	5·0	3·90	14·91
38½–45½	B_2	0·003	10·3	0	0	5·1	9·65	6·05
45½ + ...	C	0·025	2·2	0	0	5·2	2·90	1·74

Under the high rainfall of the West Coast leaching proceeds very rapidly, and open-textured soils in particular quickly develop the characteristics of typical podsols. The consolidated sands adjoining the sea-beach in the Sergeant's Hill locality, despite their very recent origin, already show great exhaustion of bases and phosphate, with pan formation in the B horizon.

The alluvial soils of the Buller and Orowaiti river systems, on the other hand, are well supplied with available phosphate. These soils are acid, with pH values ranging from 4·8 to 5·5. On the more recent flats there is no indication of iron-movement and pan formation.

An interesting feature of the pakihi lands is the occurrence of cobalt-deficiency among calves when grazed on pastures established on these soils. The cobalt content of the soil is less than 0·5 p.p.m. During the past season the use of cobalt drenches and cobalt licks has given great benefit to stock grazing the development area of the Lands Department.

Soils of the Banks Peninsula.

A series of soil samples was received from the pedologist in charge of the survey in Banks Peninsula, and the samples have been examined in the laboratory for texture, plant-food, and base status. The data show that the soils of all types are acid and unsaturated in regard to bases. Soils which have been associated with forest cover have a much higher base status than those associated with tea-tree. Some of the best soils have a base saturation of 36·5 per cent., against 15 per cent. for the poor types.

The data for plant-food status reveal wide and irregular differences in both available phosphate and potash. The brown loams of basaltic origin have high phosphate figures in contrast to the tea-tree soils of loess derivation which have a very low phosphate status. The infertility of the latter soils appears to be connected with low base and phosphate status.

Tobacco Soils.

It has been long suspected that irregular growth of tobacco seedlings in the beds of Nelson growers has been influenced in certain cases by the manurial treatment of the soils. The use of lime, wood-ash, and fertilizers in excessive amounts has been noted on different occasions by officers of the Cawthron Institute, and has been associated with poor growth of tobacco seedlings.

At the request of the tobacco Research Committee, and in co-operation with Mr. J. M. Allan, Tobacco Research Officer, soil samples from a series of seedling beds in different parts of the Nelson district were examined with a view to securing more definite information concerning the manurial practice adopted by growers in the treatment of seedling beds.

Determinations of available plant-food and pH were made on a set of fifty-five samples collected by the Tobacco Research Officer. The analytical results show that there are great variations in the plant-food supply and in the reaction of the seedling beds. The range of pH values in the top 0–3 in. of soil was 5·8 to 8·2, with an average value for fifty-five soil samples of 6·4. Twelve samples of soil had values of 7·0 or greater. As tobacco is considered to grow best under acid-soil conditions, these high pH values suggest that actual harm to seedlings may result from excessive applications of wood-ash and lime.

The percentage of available potash in the soils varied from 0·009–0·074, with an average figure for forty-samples of 0·024 per cent. The analytical data indicate that in certain cases little if any potassic manures are used by growers, while in other cases the figures suggest that excessive amounts of manures are being used.

Figures for available phosphoric acid were invariably high, indicating that all tobacco-growers were using liberal amounts of phosphatic manures in the treatment of the seedling beds. The percentages ranged from 0·035 to 0·114, with an average figure for fifty soils of 0·083 per cent.

Soluble Salts in New Zealand Soils.

In continuation of their studies of soluable salts in New Zealand soils, Messrs. Dixon and Harris have examined soils at Wakapuaka, Nelson, and at Blenheim which have been affected by sea-water flooding. Determinations of the soluble salts in soil associated with the growth of *Salicornia*, *Juncus*, buckshorn plantain, and grasses have been made. It was found in the soils of both districts that sodium had entered the clay complex and had been retained despite great reduction in the amount of soluble salts as a result of leaching by rain.

In the case of Wakapuaka soils, high content of soluble salts detrimentally affected pasture establishment. In the Blenheim soils the presence of sodium bicarbonate adversely affected the growth of lucerne and other crops.

Survey of New Zealand Flax Soils.

In co-operation with Dr. Yeates, of Massey College, and Mr. N. H. Taylor, of the Soil Survey Division, an inspection was made by Dr. Dixon of several typical flax soils in the North Island. Flax appeared to grow most luxuriantly on well-drained alluvial soils. It was noticed that soils with impeded drainage and peaty soils were associated with poorer stands of flax. Chemical analyses of a selected number of soils suggested that poor flax-growth was connected in certain cases with a low phosphate status of the soil. In view of the great importance of phosphatic manures for flax on the pakihi soils of Westport, which are very deficient in phosphate, it seems probable that phosphatic top-dressings would prove profitable on a number of the flax plantations of the North Island.

Potash Responses in Taranaki.

In the annual report for 1934–35 attention was drawn to the low potash status of a large number of soil samples collected in North Taranaki. With few exceptions soil samples obtained from the area lying north of a line drawn between Stratford and Cape Egmont and extending to Ohairo in the north gave available potash figures of less than 0·020 per cent. for the 0–3 in. depth of soil. The figures for the southern sector of Taranaki were generally much higher, particularly in the Patea locality. Some samples, however, were found with figures for potash below 0·020 per cent., making any generalization concerning the value of potassic manures in the southern sector very difficult. As a result of the analytical data obtained for Taranaki soils it was suggested that a response to potassic manures for pasture treatment was probable throughout the whole of the northern sector of Taranaki. In view of this suggestion, based on the chemical results, it is interesting to note that the field trials with potassic manures conducted by the Department of Agriculture have shown, with few exceptions, marked potash response for pastures in North Taranaki, enabling a general recommendation to be made to farmers concerning the value of potassic manures.

Compound Soil Particles.

During the past few years attention has been drawn by the pedologists to a discrepancy between the observed free drainage qualities of soils classed as brown and red-brown loams, and the laboratory classification based on the usual methods of mechanical analysis. It was suggested that the unexpected free drainage qualities of these soils resulted from the formation of compound soil particles.

Laboratory studies have therefore been made with a view to determining percentages of water-stable soil aggregates in selected soils. The wet sieving method of Bouyoucos was tested and was found satisfactory for routine analysis. The results of texture analysis by this method gave a much better correlation between the laboratory classification and the field properties of the soils.

The brown and red-brown loams with high iron clays contained comparatively high percentages of water-stable compound particles, thereby accounting for their good drainage qualities.

Studies of soil aggregates are being extended to other types of soils with a view to determining their influence, if any, on soil-erosion.

Influence of Forest Litter on Soil Type.

It has long been known that the plant covering of land profoundly affects soil formation and that different types of plant cover are associated with distinct types of soil—*e.g.*, typical podsols are developed under a forest cover, while black earths are developed under a grass cover.

It is of great interest, therefore, to determine the relationship between different species of New Zealand trees and the soils with which they are associated. With a view to securing information on these relationships, forest litters have been examined in the chemical laboratory. The chemical results show that there is a considerable difference in ash composition of litters associated with the puriri, taraire, rimu, totara, kauri, and nikau. The alkalinity of the ash of the litters correlated well with field observations concerning the fertility of the soils associated with these trees.

General.

Considerable time has been spent in comparing different methods of extracting plant-food from soils. The use of 1-per-cent. citric acid for the extraction of available phosphoric acid has been compared with buffered acetic and sulphuric acids at strengths giving pH values of 2, 3, and 5 respectively.

The phosphoric-acid estimations on the solutions obtained with the different extracting liquids showed a fairly good correlation in the case of citric acid and sulphuric acid (pH 2), but the correlation with the other strengths was not satisfactory.

As noted by other investigators, replacable potash estimations gave a very satisfactory correlation with available potash figures obtained with 1-per-cent. citric acid. In a comparison of hydrochloric-acid and citric-acid extraction, the potash figures did not show a satisfactory correlation.

Dr. J. K. Dixon has remained in charge of the Soil Laboratory during the past year and has been responsible for the conduct of a great deal of the work. He has been ably assisted by Mr. A. C. Harris, M.Sc.; Mr. L. Hodgson: and Mr. J. T. Corder. Miss E. B. Kidson, M.Sc., was granted a year's leave of absence for study overseas. Since her return to New Zealand she has been seconded to cobalt investigations relating to stock ailment in Southland and in Ashburton County, Canterbury.

AGGREGATE ANALYSIS.

By J. K. Dixon.

In making mechanical analyses of the soil the amounts of clay, silt, sand, &c., are determined without regard to the particles of crumb size which are evident in many soils on cultivation. These particles or aggregates are ground up to find out how much clay, &c., they contain. But they cannot be neglected, for their presence or absence may make all the difference between a good and poor soil for agricultural uses.

A method described by Buoyoucos (*Soil Science*, Vol. 40, p. 481, 1935) was therefore applied in the Soil Laboratory at the Cawthron Institute, in order to find out the proportion of aggregates of different sizes in a number of New Zealand soils. A striking example of the difference in structure between two soils which on mechanical analysis appeared similar is the case of the basalt soil and claystone soil of North Auckland. The former is a clay, but an aggregate analysis showed that it contained 25 per cent. of particles greater than $\frac{1}{12}$ in. in diameter, whereas the latter, a clay loam, contained only 2 per cent. of particles greater than $\frac{1}{12}$ in. in diameter. The basalt soil, although a clay, therefore gives a much better tilth than the claystone soil, owing to the presence of so many more aggregates.

The detailed results of this work will be published elsewhere.

RADIO RESEARCH.

Advisory Committee: Professor James Shelley (Chairman), Professors P. W. Burbidge (Auckland), D. C. H. Florance (Wellington), R. Jack (Dunedin), F. W. G. White (Christchurch), Squadron-Leader E. M. F. Grundy (Air Department), Captain G. H. Heal, N.Z.S.C., Army Headquarters, Messrs. E. H. R. Green (Post and Telegraph Department), J. R. Smith (National Broadcasting Service), and Dr. M. A. F. Barnett (Department of Scientific and Industrial Research).

During the year a Radio Research Committee was set up with the following objectives:—

(*a*) To co-ordinate the radio-research activities of the Broadcasting, Post and Telegraph, Defence, and Aviation Services and of the several University Colleges.

(*b*) To establish liaison with the radio-research organizations in other parts of the Empire, notably with the Australian Radio Research Board, so that research in the Southern Hemisphere may be carried out in the most profitable way.

(*c*) To promote the development of radio research in New Zealand in its scientific aspects and with special reference to local geographical and meteorological factors in this country.

The first meeting of the Committee was held on the 28th May, 1937, when it was decided to confine the research work, in the first place, along three main lines. These will be treated in turn below, although it is too soon to be able to report in any detail on the results obtained.

(1) *Ionospheric Investigations.*—The ionosphere, or ionized region of the upper atmosphere, plays a predominant part in the propagation of wireless waves over any considerable distance, and work on this subject takes a leading place in radio-research investigations all over the world. The effects vary in different places, and there is at present a serious lack of information relating to the Southern Hemisphere. Active research work on different aspects of this problem has been started both at Canterbury College under the supervision of Professor White, and at Victoria College under Professor Florance. A full-time assistant, Mr. C. J. Banwell, has been appointed at Christchurch and a part-time worker at Wellington. Following the practice in other countries, automatic equipment is being obtained by means of which more or less continuous records can be obtained of changes in the ionosphere at one place, at least, in New Zealand. Such changes are closely related with solar activity, magnetic storms and aurorae, and the sub-committee concerned is keeping closely in touch with work being carried out in New Zealand in these allied fields.

(2) *Research on the Reception of Distant Signals.*—Measurements of the variations of intensity, the direction of arrival and elevation, and the polarization of incoming short-wave signals from overseas are of considerable importance to New Zealand, whether looked at from the purely scientific point of view or from the more practical aspect of, for instance, the best location and arrangement of aerials for receiving or transmitting short-wave signals from or to England. Such work is of particular interest because New Zealand is so near the antipodes of England. It is perhaps worth mentioning, for instance, that the shortest route for radio waves from Auckland to London passes almost over the North Pole, while from Dunedin it passes near Panama.

A start has been made on some preliminary measurements at Auckland, where a part-time worker has been appointed under Professor Burbidge. To develop this research fully, however, requires the construction and use of apparatus involving a highly specialized technique, and the Committee is at present endeavouring to find a man whose qualifications would enable him to take charge of the work and bring it to a successful conclusion. It should be mentioned that the British Radio Research Board has asked the Department to undertake this type of investigation and has offered to co-operate by arranging for special transmissions.

(3) *Research in connection with the Propagation of Waves over the Earth.*—This work, which involves the measurement of the attenuation of local signals as the distance from the transmitter is increased, is a problem of direct interest in the technical development of radio broadcasting. The actual

technique of field-strength measurement has now been more or less standardized, but local differences in terrain and topographical peculiarities make it essential that such data should be obtained in each country where broadcasting is being developed. Mr. G. Searle has been seconded for this investigation and has been working under the supervision of Mr. J. R. Smith, engineer of the National Broadcasting Service. A good start has been made on measurement of field-strength contours of North Island broadcasting-stations, and, in particular, of 2YA. A considerable amount of work has also been carried out to determine the distortion in the field produced by obstacles of various types—hills, trees, buildings, fences, &c. Some very interesting results have also been obtained relating to the standing wave effects which are induced in the electric-power and telephone-reticulation networks.

TOBACCO RESEARCH.

Advisory Committee: Dr. E. Marsden (Chairman), Sir Theodore Rigg, Mr. J. A. Campbell, Mr. L. J. Schmitt, Mr. I. Hamilton, Mr. C. C. Nash, Mr. J. F. Balck, Mr. B. T. Rowling, Mr. F. A. Hamilton. Tobacco Research Officer and Secretary, Mr. J. M. Allan.

During the year a Tobacco Research Association was established along lines similar to those adopted in the Research Associations already established in the wheat, dairy, wool, and leather industries.

In December, 1935, representations were made to the Hon. the Minister in Charge of Scientific and Industrial Research by the Nelson Provincial Tobacco Growers' Association that, in view of the increasing prevalence of disease in tobacco-plants and the necessity of experimenting with types and varieties suitable for culture in New Zealand, consideration be given to the establishment of a Tobacco Research Station in the Nelson province.

Following this and other representations the Secretary of the Department of Scientific and Industrial Research and the Director of the Cawthron Institute met the Tobacco Growers' Association executive at Motueka on 3rd February, 1936. It was agreed that—

(*a*) The Motueka-Riwaka District was the most suitable district in New Zealand for the establishment of a research station with tobacco culture as its main object.

(*b*) The activities of such a station could be extended to cover the requirements of the hop and small-fruits industries.

(*c*) The requisite finance could be supplied by the industry and the Government by an arrangement similar to that under which the existing Research Associations for other industries were financed. The simplest method of finance and collection would be the setting-aside of portion of the levy defined in the Tobacco Industry Act, by Order in Council, to use for this purpose.

In April, 1936, the Council of Scientific and Industrial Research discussed tobacco-research schemes, and approved the proposals for a Research Association.

The establishment of the Tobacco Control Board by Act of Parliament in 1935, with funds at its disposal to defray the cost of administration and other work of the Board, suggested that the Board might actively assist in the establishment of tobacco research and in the provision of funds for this purpose. Accordingly, negotiations were opened with the Board, which decided to make a grant calculated at the rate of $\frac{1}{8}$d. per pound on the 1935–36 season's crop and a further grant calculated at the same rate in respect of the 1936–37 crop. The Board also intimated that it would be prepared to make further grants on a similar basis up to and including the 1939–40 crop.

In January, 1937, advantage was taken of the visit of Professor A. E. V. Richardson and Dr. B. T. Dickson, of the Commonwealth of Australia Council for Scientific and Industrial Research, to discuss the need for tobacco research in New Zealand. After visiting the Motueka-Riwaka area they strongly emphasized the necessity for the immediate establishment of a research station in the district.

At the request of the Department of Scientific and Industrial Research and the Cawthron Institute, Sir Theodore Rigg visited Australia in April to study tobacco culture and obtain information on the organization of tobacco research.

The first meeting of the Tobacco Research Committee was held at Riwaka on 11th June. At this meeting Sir Theodore Rigg presented his report, and the Committee agreed to the general proposals outlined therein. It was decided to secure a suitable area of land, preferably in the Motueka-Riwaka district, and to invite applications for a specialist officer who would take charge of the work located at the Research Station. In addition, it was decided to recommend to the Minister in Charge of Scientific and Industrial Research that a grant of £500 per annum from the funds available for tobacco research be made to the Cawthron Institute for the investigation of certain aspects of tobacco-seed and mosaic investigations, as well as studies relating to the nutrition and quality of tobacco.

Proposals for a more detailed survey of tobacco soils were discussed by the Committee, and Sir Theodore Rigg was empowered to make the necessary arrangements to have the work done.

At the next meeting of the Committee Dr. Marsden reported that Mr. J. M. Allan, B.Sc. Agr., M.D.A., formerly of the Council for Scientific and Industrial Research, Australia, had been appointed Tobacco Research Officer to take charge of the work at the Research Station. Mr. Allan took up his duties at the end of November, 1937, and immediately proceeded to make contact with the industry.

A sub-committee was appointed to arrange for the lease of an area of approximately 20 acres for the tobacco-research station. An agreement to lease approximately 18½ acres of land at Motueka was finally made, possession to be given on 1st May, 1938.

Research Activities.

During the period under review the main lines of research work have been in connection with—

(1) Tobacco-seed diseases.
(2) Control of mosaic disease.
(3) Chemical investigations relating to tobacco soils and the quality of tobacco-leaf.

In addition, a survey has been made by the Tobacco Research Officer of the general conditions under which tobacco is grown both in the Nelson district and at Pongakawa, Bay of Plenty. Arrangements were also made for the selection and production of tobacco-seed of the main varieties grown in the Nelson district.

In the conduct of the research work Dr. K. M. Curtis, in co-operation with Mr. J. M. Allan, has been responsible for the work on tobacco-seed diseases and mosaic-control investigations.

The chemical work has been conducted at the Cawthron Institute under the general direction of Sir Theodore Rigg and Dr. H. O. Askew.

Report of Tobacco Research Officer.

On arrival of the Tobacco Research Officer in Nelson at the end of November arrangements were immediately made to co-operate with the tobacco investigations being conducted by the Cawthron Institute and to secure a first-hand knowledge of the conditions ruling in the Nelson tobacco industry, particularly in regard to problems which required investigation.

Disease Investigations.—In co-operation with Dr. K. M. Curtis, records of the percentage of mosaic were made in a large number of tobacco fields, and carefull consideration was given to the different factors which might operate in the dissemination of the mosaic virus. In addition, several small experiments were made to determine the means of transference of the virus in the tobacco-seedling bed.

Plants of the supposedly mosaic-resistant Porto Rican tobacco variety, Ambalema, are being raised in a glasshouse at the Cawthron Institute to determine resistance to the disease and in the hope of developing a suitable resistant commercial variety by crossing with the at present favoured susceptible varieties.

A tobacco disease prevalent in the Nelson district this season is believed to be the virus disease ring spot. It was found on occasional plants in a large number of crops and affected up to 5 per cent. in a few crops. Ring spot is seed-borne and is transferred by handling, in the same way as mosaic.

In one crop a fair percentage of plants was found affected with a serious stalk-rot, believed to be "black leg" or "hollow stalk" caused by *Bacillus aroideae.*

Seed-production.—To prevent the introduction from other countries of serious tobacco diseases—*e.g.*, blue mould, wildfire, &c.—which are seed-borne, it is considered desirable to encourage the use of locally grown seed. The Tobacco Research Committee agreed to the proposal that the Research Officer should select seed from growers' crops and tend, clean, and disinfect it for next season's requirements. The tobacco-manufacturing companies were invited to co-operate in an experiment for the use of local seed. All have agreed to grow at least part of their requirements next season from the seed so selected.

Pongakawa Tobacco Area.—The tobacco-growing area at Pongakawa, under the control of the State Forest Service, was visited at the end of the season. An area of 43 acres was under production, from which a yield of approximately 35,000 lb. of leaf was obtained. The maximum yield was not realized owing to serious storm damage earlier in the year. The leaf harvested contained a high proportion of bright grades; body and texture were good, and the quality of the leaf generally was comparable with much of that grown in the Nelson Province. The soil is a light pumice type and should be suited to tobacco culture. Rainfall and climatic conditions generally also appear to be favourable. One disadvantage is lack of permanent water-supply in close proximity to the area.

The area of suitable soil in the valley is approximately 200 acres, but it is typical of other valleys in the locality, giving quite a large area in aggregate.

Review of the Nelson Tobacco Industry.—Harvesting of the crop was practically complete by the end of March. The season was an exceptionally good one—it is claimed to be the best for several years. Although somewhat delayed by prolonged wet weather at the latter end of the season, the harvest was finished earlier than usual and escaped all danger from frost and hail which frequently curtailed its completion in other seasons. Some trouble was experienced among the "air-drying" growers where the excessive humidity caused "shed burn" in crowded sheds, but the trouble was accentuated by unsatisfactory buildings. Yields of leaf were high and the quality exceptionally good.

The mosiac disease was more prevalent than usual, high percentage of infection having occurred in a large number of crops, in some cases over 90 per cent. being recorded. Fortunately, however, growth conditions were such that, despite the high precentage of infection, symptoms tended to be masked and the reduction in yield and quality was considerably less than under conditions less favourable to vigorous growth.

Mosaic Investigations at the Cawthron Institute.

During the 1937–38 season a large-scale experiment was conducted by the Cawthron Institute to determine the relative importance of glasshouse, seedling-bed, and field in the dissemination of tobacco mosaic. The two major tobacco-manufacturing companies co-operated with the Institute by supplying the seed of eight varieties and selecting the growers to whom the seedlings were subsequently distributed.

In all, approximately 1,000,000 seedlings were raised in a non-tomato glasshouse, in which the soil had been sterilized with steam and the walls with formalin. In the glasshouse every precaution was taken to prevent infection, including the prohibition of smoking, frequent sterilization of the workers' hands, arms, and implements, the use of special aprons, &c.

The seedlings were distributed to forty-six growers and were pricked out into the beds in accordance with their usual routine. In three beds the soil was sterilized with formalin prior to pricking-out to determine whether such treatment would reduce the percentage of mosaic.

The beds were inspected just prior to transplanting into the field, and the number of seedlings showing mosaic symptoms was recorded. Although a few infected seedlings were found in many beds, the highest record did not exceed 0·7 per cent.

Records in the field were taken approximately four weeks and eight weeks after transplanting. As controls for the experimental plants a similar number of other plants, of the same variety and growing under similar conditions, but derived from another source, were also recorded. The record unit was 1,000 plants in rows selected at random through the fields. At the time of the first field record the percentage of mosaic varied from 0 per cent. to 50 per cent. There was a general increase in most cases at the second recording, and in a few there was more than 90 per cent. infection.

In all, 83,438 plants were recorded. There were comparable lots of experimental and control plants. There was little difference in the amount of infection in the experimental and control plants—viz., 7,851 infected in 42,826 experimental plants, as compared with 7,581 in 40,612 control plants. Expressed as percentages, these figures are 18·33 per cent. and 18·67 per cent. respectively.

The conclusions arrived at from the experiment are as follows:—

(1) Under this season's conditions the raising of tobacco-seedlings in a non-tomato glasshouse did not prevent the development of mosaic in the seedlings in the seedling-bed.

(2) Where formalin was used for the treatment of beds prior to the pricking-out of tobacco-seedlings grown in a non-tomato glasshouse no mosaic was found at the bed-stage. This, however, did not prevent the appearance of mosaic in the field after the transplanting.

(3) There was no evidence that raising tobacco-seedlings in commercial tomato glasshouses was responsible for any increase in the amount of mosaic in the crop.

(4) While the percentage of mosaic in the seedling-beds does not appear high, the subsequent increase in the disease between bed and field indicates the importance of the bed-phase (in its wider sense, from pricking-out to transplanting) in the multiplication of the disease.

(5) Handling and cultural operations after the planting in the field, while spreading mosaic, were of less importance than the equivalent operations at the bed-phase, owing to such secondary field infection taking place too late to seriously impair the development of the crop-leaves.

Chemical Investigations.

At the Cawthron Institute a start has been made with soil and plant analyses relating to tobacco-culture. A set of sixty soil samples collected by the Tobacco Research Officer from the tobacco-seedling beds throughout the district has been examined in the soil laboratory for available plant-food and soil reaction. Information secured from growers earlier in the season suggested that a great variation in manurial treatment of tobacco-beds occurred in different parts of the district and that in certain cases actual harm was being done by excessive manurial treatment. The analytical data indicate that in certain cases liming and the use of wood-ash is excessive and that the use of potassic manures is haphazard.

The range of pH values in the top 0 in. to 3 in. was 5·3 per cent. to 7·7 per cent., with an average value for forty-one soil samples of 6·4. There were six soil samples with values as high as 7·0 or higher. As tobacco is considered to grow best under acid soil conditions, these high pH values suggest that in certain cases actual harm to tobacco-seedlings has resulted from excessive applications of lime and wood-ash.

The percentage of available potash in the top 0 in. to 3 in. of soil varied from 0·009 to 0·051, with an average figure for forty samples of 0·023. In certain cases the figures indicate that little, if any, potassic manure is used in the manurial treatment of the tobacco-seedling beds, and that in other cases the amount of potassic manure is unnecessarily high and possibly detrimental to young seedlings.

With few exceptions, the figures for available phosphoric acid in the top 0 in. to 3 in. of soil were high, indicating that phosphatic manures are used by all tobacco-growers in the preparation of the seedling-beds. The percentage of available phosphoric acid varied from 0·035 to 0·114, with an average figure for thirty-nine soils of 0·081 per cent.

With a view to correlating quality of tobacco-leaf with chemical composition, experience of the methods developed by Dr. Earl in Australia is being obtained. This work is necessarily only in its preliminary stages and results will not be available until next season. In the meantime samples of leaf from different varieties and at different growth-stages have been secured with a view to more intensive work during the winter and spring.

Insect Pests.

The Entomology Division of the Plant Research Bureau has recently reported the occurrence of two serious pests of stored tobacco in one factory—viz., the tobacco-moth (*Ephestia eleutella*) and the cigarette-beetle (*Lasioderma serricorne*). Growers' bulking-sheds may possibly be a source of infection, as well as manufacturers' stores.

WOOL MANUFACTURERS' RESEARCH ASSOCIATION.

ANNUAL REPORT FOR THE YEAR ENDING 31ST MARCH, 1938.

Wool Manufacturers' Research Association Committee.—Mr. J. Evans (Chairman), Mr. W. R. Carey, Professor H. G. Denham, Mr. T. E. Donne, Mr. H. Lee, Dr. R. O. Page, Dr. E. Marsden (Secretary).

Director.—Professor F. G. Soper.

A preliminary meeting of the Committee was held on 22nd July, 1937, at which general organization, staffing, and location of headquarters was discussed. By the 20th October an agreement had been reached with the University of Otago for the housing of the research staff within the Chemistry Department of the University, for full use of the library, and for the assistance of certain Departments of the University, as needed, more particularly those of chemistry and of bacteriology. Further, a Research Chemist, Mr. R. V. Peryman, M.Sc., and a Secretary-Typist, Miss F. D. Davies, M.H.Sc., had been selected, and applications had been called in England, Australia, and New Zealand for a Textile Research Officer. Mr. Peryman and Miss Davies took up their duties at the end of November.

Dr. S. Townend was appointed as Textile Officer, following reports received from an English Selection Committee. Dr. Townend, who has had English and American wool research experience, will take up the appointment on 1st May, and will spend some time in Great Britain and on the Continent before leaving for New Zealand.

Visits were paid by the Director during August and October to eleven New Zealand woollen-mills, and lines of work were discussed. Arising out of these visits, work was started on the raw-wool scouring process. A close study of this has been made by Mr. Peryman in three mills, and detailed reports, with recommendations, have been submitted to the mills concerned. As a direct result of work done on raw-wool scouring one mill has been able to effect a large saving in scouring-material and improvement of the scoured wool. This work is proceeding, and approximately one week is being spent with each mill in testing the process, examining the water-supply, and studying faults in the dyeing and finishing of yarn and cloth. Simultaneously, analyses of the amount of alkali in the scoured wool have been carried out in the laboratory.

In addition to this study of raw-wool scouring, various service problems have been submitted by the mills, involving diagnosis of stains, of the cause of rotting of certain bathing-costumes, and of the formation of holes. The foreign matter in a sample of zeolite from a water-supply has been examined, and a method of cleansing the zeolite tested.

In co-operation with the Bacteriology Department of the University, work has been started on the relation of scouring methods to resistance to bacterial attack, and this work is to be extended in the future towards further examination of the protection against such attack, an important problem in connection with swimming-costumes.

Bulletins have appeared monthly dealing with some general item of interest. Subjects covered to date have been: unshrinkable wool, scouring, and protection against moths. It is noteworthy, and not generally realized, that woollen goods can now be processed at relatively low cost in such a way that, though quite odourless, they are immune from moth-attack. Moth eggs and larvæ placed in contact with the cloth fail to develop and no damage results.

In concluding this report of the initiation of the New Zealand Woollen Manufacturers' Research Association, reference must be made to a most important asset—the spirit of whole-hearted co-operation shown towards it by the various woollen-mills.

SOCIAL SCIENCE RESEARCH BUREAU.

ANNUAL REPORT FOR THE YEAR ENDING 31st MARCH, 1938.

Social Science Research Committee.—Mr. Evan Parry, LL.B. (London), Barrister and Solicitor, (Chairman); Mr. F. B. Stephens, M.A., B.Com., Department of Internal Affairs (Vice-Chairman); Dr. C. E. Beeby, M.A., Ph.D., Director, New Zealand Council for Educational Research; Professor H. Belshaw, M.A., Ph.D., Professor of Economics, Auckland University College; Dr. Elizabeth Gregory, M.H.Sc., Ph.D., Home Science Department, University of Otago; Dr. Elizabeth Gunn, M.B., Ch.B. (Edin.), Director of School Hygiene, Department of Health; Mr. E. H. Langford, M.A., Private Secretary to the Hon. the Minister of Scientific and Industrial Research; Mr. George Lawn, M.A., Economic Adviser and Director, Reserve Bank; Dr. E. Marsden, M.C., C.B.E., D.Sc., F.R.S.N.Z., Secretary, Department of Scientific and Industrial Research; Mr. T. H. McCombs, M.P., M.Sc., A.I.C.; Dr. D. G. McMillan, M.P., M.B., Ch.B.; Professor R. W. Souter, M.A., Ph.D., Professor of Economics, University of Otago; Dr. W. B. Sutch, M.A., B.Com., Ph.D., Secretary-Economist to the Hon. the Minister of Finance and Marketing; Mr. D. O. Williams, M.A., Director Bank of New Zealand; Mr. Ormond Wilson, M.P., M.A.; Mr. G. E. F. Wood, M.A., Census and Statistics Office; Mr. W. T. Doig, M.Com., Secretary and Executive Officer.

The Social Science Research Bureau has now been established for just over a year, and the progress made during that period has been very satisfactory. Apart from its own research projects, which are outlined below, the Bureau has been able to provide an information service for students, research workers, and others interested in social and economic research, and the fact that a large number of requests from both New Zealand and overseas for advice and information have been received is proof that a long-felt need in the field of social science research is being met. With the object of providing further information for those people interested, the Secretary has prepared a bibliography of social and economic research in New Zealand, which will be published as a bulletin.

During the year the Bureau has been indeed fortunate in securing, through the generosity of the Carnegie Corporation of New York, the services of Professor J. H. Kolb, Professor of Rural Sociology, University of Wisconsin, United States of America, who is acting in an advisory capacity

for a period of six months. Professor Kolb's advice and constructive criticism have been of great value to the Bureau, and his wide experience in rural surveys has been particularly valuable in regard to our own survey of standards of living of dairy-farmers.

A brief description of the Bureau's work during the year follows.

The Unemployed.

A small sub-committee was set up early last year to inquire into the question of the extent of unemployability among those who were unemployed, and with the co-operation of the Labour Department a trial survey was made in Christchurch for the purpose of working out a technique to deal with the problem of classification. A brief report of the results of this survey was forwarded to the Labour Department, which has since carried on the inquiry in a more extensive manner.

Nutrition.

During the year a grant was made available to a Nutrition Sub-committee, comprising Professor Malcolm, Dr. Elizabeth Gregory, and Dr. Elizabeth Gunn, for the purpose of promoting research into some nutrition problems in the Dominion. Miss E. Wilson, M.H.Sc., who had been engaged upon dietetic work in England, was appointed to a research position at the Home Science Department, University of Otago, on 1st January, 1938, and she has now completed the first section of her work dealing with minimum adequate low-cost dietaries. Diets have been prepared for both summer and winter for families of different age composition, with a view to securing adequate nutritional requirements at a minimum cost. In order that these diets could be shown to be really practicable, they have been tested by a few families who have co-operated with Miss Wilson. Miss Wilson's report has been prepared for publication in the *New Zealand Journal of Science and Technology*.

The second section of the nutrition study will take the form of a survey of the actual dietaries of a group of industrial workers' families in the cities, this inquiry to follow the Bureau's survey of urban standards of living.

Owing to the establishment of the Medical Research Council early this year (1938), the work of the Bureau's sub-committee and of Miss Wilson has now been taken over by that Council as part of its scheme to co-ordinate nutritional research in the Dominion. Contact is being kept with the work in its relation to the other activities of the Bureau.

Survey of Standards of Living of Dairy-farmers.

The chief research project which was undertaken during the year—an inquiry into standards of living of dairy-farmers in New Zealand—has produced results of a very satisfactory nature. The detailed results will be published in due course, and the following is a brief summary:—

I. *Introduction.*

The following outline is presented in order to give an indication of some of the results of the survey of standards of living of dairy-farmers conducted by the Bureau with assistance from the New Zealand Branch of the Institute of Pacific Relations. A wide range of data has been collected and analysed, but owing to limitation of space in the annual report of the Department, and owing to the fact that much of the data is not yet analysed, it has been impossible to give a detailed treatment and interpretation of all the results, but it is intended to publish them in the near future. The data were collected between September, 1937 and February, 1938.

The schedule used in this survey was first given a trial test with a group of approximately forty dairy-farmers and amended in accordance with this experience. The field workers were given a course of instruction both in the office and in the field, and were then sent out to their respective districts. Family budget forms were also supplied to the wives of the farmers interviewed, and data have been secured concerning the actual household expenditures of a large number of families. During the course of the inquiry a very satisfactory and helpful response was given by farmers' organizations and farmers themselves, and the Bureau is greatly indebted to those people who so generously assisted in this survey and who, by their unfailing courtesy and co-operation, made the study possible.

In the selection of the farm, those where sheep or agricultural farming was a major source of farm income were excluded. It may therefore be assumed that the survey covers purely dairy-farms. A strict and unequivocal definition of a dairy-farm is, however, difficult to arrive at; hence a fundamental difficulty is encountered in attempting to check the representative character of this sample as compared with others. The present sample compares very closely in respect of (*a*) total size of farm, (*b*) area devoted to dairying, (*c*) size of herd, (*d*) total butterfat, with that taken in a recent investigation by the Department of Agriculture. When allowance is made for the inevitable inclusion of many mixed farms and small farming units in the larger sample of approximately twenty thousand dairy-farms surveyed last year by the Government Statistician, the fit is also remarkably close in those data which are common to the two surveys.

In this report none of the data collected in regard to the farm, its area, stock, and production have been given, the stress being laid rather on the farmer, family living, and family life and activity. The results below relate only to the North Island farms covered, the analysis of the Southland figures being not yet completed.

II. *The Areas surveyed.*

(*a*) *North Auckland:*—

(i) Kaitaia—the area adjacent to Kaitaia and stretching four miles north and south and ten miles east.

(ii) Dargaville—a circular area round Dargaville with a radius of about five miles, and a further area stretching approximately sixteen miles down the east side of the Hobson Peninsula.

(*b*) *The Waikato :—*

(i) Ngarua—the area lying between Morrinsville, Waihou, and Waharoa.

(ii) Te Kowhai—the area between Frankton, Whatawhata, and Ngaruawahia.

(iii) Putaruru—the area surrounding Putaruru and enclosed roughly by lines drawn from Lichfield in the south-east to Arapuni in the west, to Tirau in the north, and to Mangatapu in the east.

(iv) Otorohanga—a circular area adjacent to Otorohanga but to the east of it, with a radius of about four miles.

(v) Te Awamutu—the area surrounding Te Awamutu stretching to Pirongia in the west, Kihikihi in the south, about six miles to the north, and eight miles to the east.

(*c*) *Taranaki :—*

(i) Lepperton-Inglewood—the area stretching eight miles north of Inglewood to Lepperton, six miles north-east to Everett Park, and three miles south to Maketawa.

(ii) Manaia South—the area between the Main South Road and the coast stretching from Hawera to Kaupokonui.

(iii) Manaia North—a belt two miles wide lying north of the Main South Road and stretching from Hawera to Kaupokonui.

(*d*) *Manawatu :—*

Awahuri—the area surrounding Awahuri with a radius of approximately five miles.

(*e*) *Southland :—*

The area surrounding Edendale but stretching from Mataura to Morton Mains, Seward Downs, and Wyndham.

III. *The Farmer and His Family.*

It will be noticed in some of the tables given below that the total number of cases discussed differs from that given in other tables. This is due to the fact that complete information was not secured for certain sections of some schedules. Analysis has been made so as to secure for each section of the schedule the maximum number of reliable cases.

(*a*) *The Farmer :—*

(i) Tenure Group : Of the 448 North Island farmers giving information as to tenure and complete occupational history, 295 (66 per cent.) were owners, 80 (18 per cent.) tenants, 51 (11 per cent.) share-milkers, and 22 (5 per cent.) managers. The tenure classification of these farmers among the four major areas is as follows :—

TABLE I.—TENURE GROUPS.

Tenure Group.	North Auckland.	Waikato.	Taranaki.	Manawatu.	Total, North Island.	
	Number.	Number.	Number.	Number.	Number.	Per Cent.
Owners ..	61	143	77	14	295	66
Tenants ..	9	28	23	20	80	18
Share-milkers ..	8	31	10	2	51	11
Managers ..	5	8	8	1	22	5
Total ..	83	210	118	37	448	100

(ii) Age : The average age of all farmers was 45 years, owners being the highest (46 years) and share-milkers the lowest (40 years). The farmers were distributed in the age groups as follows : 40–44 years 17 per cent. of the total ; 15 per cent. were in the group 45–49 years ; 14 per cent. 30–34 years ; 14 per cent. 35–39 years ; and 12 per cent. 50–54 years.

(iii) Occupational History : One of the interesting sections of the information concerning the farmer is that dealing with his occupational history. Details of the occupations followed by the farmers since leaving school as well as analyses of dairy-farming experience were obtained from 448 farmers. Non-dairying experience was classified on the basis of the 1936 New Zealand census.

TABLE II.—OCCUPATIONAL HISTORY FOR MAIN TENURE GROUPS.

Occupational History.	Number of			
	Owners.	Tenants.	Share-milkers.	Managers.
Total number in group*	295	80	51	22
Whole life engaged in dairying	87	21	13	9
Whole life not engaged in dairying—				
Agricultural and pastoral	86	25	14	8
Commercial	52	17	7	3
Industrial	107	29	22	5
Transport	30	11	12	2
Others	32	4	5	..

* Because several persons had experience in different occupations, the individual items do not add up to the total shown.

An interesting point is that, of the 375 present owners and tenants, 56, or 15 per cent., have been share-milkers at one time or another; whereas, of the 51 present share-milkers, 17, or 33 per cent., have at one time been owners or tenants of dairy-farms.

The average number of years on the present farm is shown in Table III for the four tenure groups in the major areas.

TABLE III.—YEARS ON PRESENT FARM.

Tenure Group.	North Auckland.	Waikato.	Taranaki.	Manawatu.	Total, North Island.
All farmers	15	11	12	16	12
Owners	17	12	13	16	14
Tenants	7	12	10	16	12
Share-milkers	3	4	5	9	4
Managers	14	5	12	14	10

(*b*) *The Family*:—

(i) The Homemaker: The "homemaker" is defined, for purposes of this survey, as the person chiefly responsible for the domestic work of the household. For the 448 farmers whose occupational history has been dealt with above there were 445 homemakers, 374, or 84 per cent., of the total being wives. In only 19 cases was the farmer his own homemaker, while the daughter managed the home in 13 instances, and the mother in 13 other cases.

(ii) Wives: of the 374 wives shown as homemakers, 343 gave ages, the average age of these being 41 years. Share-milkers' wives averaged 33 years of age.

(iii) Household and Family Composition: The average size of households* covered in this study is 5·02 persons, and that of families† 4·09 persons. The composition of households and families, by districts, is shown in the following table:—

TABLE IV.—HOUSEHOLD COMPOSITION.

	Districts.				Total, North Island.
	North Auckland.	Waikato.	Taranaki.	Manawatu.	
Number of households ..	82	208	118	37	445
Total number in household ..	449	1,076	550	157	2,232
Average size of household ..	5·48	5·17	4·66	4·24	5·02
Total number in families ..	365	850	469	137	1,821
Average size of family ..	4·45	4·09	3·97	3·70	4·09

IV. *Family Living.*

(*a*) *Housing and Domestic Equipment.*—An essential part of the study is an enumeration of the domestic facilities available in homes covered by the survey. This collection of data will, when fully analysed, assist materially towards providing an objective *picture of living-conditions*. Already some interesting results have emerged from the preliminary survey of the material collected; some of these are briefly referred to below under appropriate headings:—

(i) Construction of Dwelling: Of the 462 dairy-farmers' dwellings in the North Island concerning which data were available, all but 7 were constructed of wood.

(ii) Water-supply and Drainage: Running water (chiefly from tanks) was attached to 433 dwellings (94 per cent. of the total), while the field drain was the most typical drainage system, 237 dwellings (51·3 per cent.) having this type of drainage. Cess-pits or sumps served 120 dwellings, while in 73 cases there were septic tanks. In 31 instances there was no drainage.

(iii) Domestic Equipment: Electricity was available to 413 dwellings out of the 462 concerning which data were collected, and in all but 42 cases electricity, where available, was connected to the dwelling. Of these 413 dwellings having electricity connected, 354 had an electric iron (77 per cent.), 133 an electric vacuum cleaner (28·8 per cent.), 113 an electric range (24·5 per cent.), 107 an electric hot-water cistern (23·2 per cent.), 55 an electric washing-machine (11·9 per cent.), 19 an electric sewing-machine (4·1 per cent.), and 18 an electric refrigerator (3·9 per cent.).

Three hundred and eighty-one (82·5 per cent.) dwellings had a radio and 291 (63 per cent.) a telephone installed. A high-pressure hot-water service was installed in 336 dwellings, the remaining 126 having only a low-pressure service or no service at all.

* "Household" means all persons living in the house, including employees, &c. † "Family" means farmer, wife, and their children living in the house.

(*b*) *Family Expenditure.*—Provision was made in the field schedule for the collection, by the personal-interview method, of statistics of annual expenditure on items for which payments are not regularly distributed throughout the year. These data are intended to supplement a more detailed analysis of family expenditure which is being made from the collection of household budgets kept by homemakers for one summer month and one winter month. A complete analysis of family expenditure is not possible until the budgets for the winter month now coming to hand are analysed and the results correlated with those from the analysis of the budget collection made in the summer. The analysis of the completed schedules is, however, sufficiently far advanced to permit of the presentation of the following data:—

(i) Expenditure on Clothing: Average estimates of expenditure on clothing in respect of persons of varying ages have been compiled from the field schedules. The following table shows the results of this analysis

Table V.—Clothing Expenditure (to the Nearest Shilling).*

Age Group.	Males.		Females.	
	Number of Cases.	Average Annual Expenditure.	Number of Cases.	Average Annual Expenditure.
	Unmarried Persons.			
		£ s. d.		£ s. d.
Under 3	35	3 4 0	33	3 5 0
3–5	39	2 19 0	40	3 19 0
6–8	65	4 16 0	49	4 15 0
9–11	61	5 2 0	48	6 5 0
12–14	62	6 7 0	49	7 17 0
15–17	55	10 2 0	55	9 19 0
18–21	37	12 6 0	29	14 10 0
22–25	23	15 7 0	21	13 15 0
26–59	59	12 17 0	37	11 6 0
60 and over†	52	10 19 0	28	10 9 0
	Married Persons.			
Under 26	7	10 9 0	18	10 8 0
26–59	326	11 14 0	319	12 10 0

* Expenditure recorded in this table includes only that from the family income—that is, any income accruing to the farmer and his wife. It is possible that some children incurred other expenditure not recorded here.
† Unmarried and married.

In comparing the averages shown in the table, care should be taken to observe the number of cases from which an average is drawn, since, with a small number of cases, a single abnormal figure will markedly affect the average.

The average annual expenditure on the clothing of the farmer and persons dependent upon him and living in his home is £35 19s. (see footnote to Table V).

(ii) Some other Items of Expenditure: The average annual expenditure per family on medical and dental services, on life insurance, and on holidays as returned to the field officers is as follows—

Table VI.—Showing some Items of Expenditure.*

	Number of Families.	Number incurring Expenditure under each Heading.	Average Annual Amount per Family.	
			All Families.	Families incurring Expenditure.
			£ s. d.	£ s. d.
Doctor's expenses	462	308	8 6 0	12 9 0
Hospital expenses	462	94	3 0 0	14 15 0
Dentist's expenses	462	290	3 9 0	5 10 0
Life insurance	462	284	12 0 0	19 10 0
Holiday expenses	462	310	11 13 0	17 7 0

* The same qualifications apply to this table as apply to Table V.

V. *Family and Community.*

The life and activities of the farmer and his family are governed partially by their means of transport and the accessibility of various centres with libraries, schools, clubs, theatres, and so on.

(*a*) *Transport.*—The motor-car is the most important means of transport to-day, and it is of interest to note that, of the 462 cases investigated, 361, or 78 per cent., were in possession of a motor-car.

(*b*) *Distance from Services.*—The average distances (in miles) of the families included in this study from various services, &c., is given below.

TABLE VII.—DISTANCES (AVERAGES) FROM VARIOUS SERVICES.

	North Auckland.	Waikato.	Taranaki.	Manawatu.	Total, North Island.
Number of dwellings	84	208	129	41	462
	Miles.	Miles.	Miles.	Miles.	Miles.
Distance from primary school	2·5	2·2	2·4	2·1	2·3
Distance from post-primary school ..	5·1	7·0	10·3	8·2	7·7
Distance from hospital	6·9	22·0	10·3	9·6	14·9
Distance from family doctor	6·3	9·4	5·3	8·5	7·6
Distance from nearest doctor	5·9	7·0	3·4	6·6	5·5
Distance from dentist	5·8	7·3	5·3	8·1	6·5
Distance from public library	3·8	5·9	3·4	5·8	4·8
Distance from general store	3·7	4·2	2·5	2·7	3·4
Distance from dance-hall	3·1	2·2	2·3	2·9	2·5
Distance from picture-theatre	3·7	6·3	3·3	6·2	5·0
Distance from post-office	3·4	4·2	2·9	2·5	3·5

VI. *Conclusion.*

This outline of the results of the survey of the standards of life of dairy-farmers by no means gives the complete picture which the final analysis and tabulation of the data will make available. A considerable proportion of the material has not yet been analysed, and, in particular, the results of the family-budget inquiry are not yet available. As stated above, it is hoped at an early date to publish the results in full.

This study has been comprehensive both in the sense of securing from individual families a wealth of useful material and in covering families in many parts of the Dominion. Closer attention could now be given to more intensive regional research in which soil, pasture, farm-management, and standards-of-living surveys are closely linked. Significant relationships could then be studied as to the possibilities for regional developments.

SURVEY OF STANDARDS OF LIVING OF URBAN WORKERS.

A start has been made on a survey similar to that conducted in rural districts of standards of living of two groups of urban workers: (*a*) Tramway employees, and (*b*) boot and shoe operatives. An inquiry as comprehensive as that undertaken in regard to dairy-farmers will be made, and the schedule to be used has been drawn up and field workers appointed. The nutrition survey mentioned above forms part of this project.

CONCLUSION.

The organization and promotion of scientific inquiry in a field hitherto comparatively neglected presents many difficulties—breaking new ground is never easy for the social scientist—and a new research department dealing primarily with human problems and human material must secure the ready and willing co-operation of the people with whom it is dealing. Social science research can rarely rise above the ability of the people to appreciate its value and its significance. Greater appreciation of this type of work has steadily developed in other countries—in the United States, for example, it is a significant fact that since 1931 the total grant from foundations for research in the social sciences has for the first time in history exceeded the amount spent for physical sciences.

If the development and work of the Bureau during the past year can be taken as an indication of the possibilities for useful social science research in New Zealand, the future prospects are very favourable. The response given by the people concerned has been sympathetic and real, and the interest in the work and objects of the Social Science Research Bureau has greatly increased.

RESEARCH SCHOLARSHIPS.

Two National Research Scholarships of an annual value of £100 were awarded during the year. The holders of the scholarships and the researches upon which they are engaged are as follows:—

Mr. S. C. B. Gascoigne, M.Sc. (Auckland University College): "The Variation of Frictional Electric Charges with the Pressure of the Surrounding Medium."

Mr. T. H. Kennedy, M.Sc. (Otago University, Dunedin): "Synthesis of Methyl Isopropyl Phenanthrenes, with Special Reference to the 1.6 Compound which is believed to be Iso-retene."

PUBLICATIONS.

Monthly publication of the *New Zealand Journal of Science and Technology* was continued during the year, and the following departmental bulletins were published:—

No. 55: "The West Nelson Earthquakes of 1929," by J. Henderson.
No. 56: "Fourth Annual Report of the Wheat Research Institute."
No. 57: "Report of Inter-departmental Committee on Silicosis."
No. 58: "Farm-management Survey, Plains Area, Ashburton County," by J. R. Fleming.
No. 59: "The Manufacture of Sodium Chlorate: A Possible Electrochemical Industry for New Zealand," by S. H. Wilson.
No. 60: "Petroleum in New Zealand," by J. Henderson.

The editing and printing of the report of the Auckland (1937) meeting of the Australian and New Zealand Association for the Advancement of Science, which was undertaken by the Department, was completed.

IMPERIAL AGRICULTURAL BUREAUX.

The Imperial Agricultural Bureaux were established to act as clearing-houses for the interchange of information between research workers in eight branches of agricultural science throughout the various parts of the British Commonwealth. In New Zealand co-operation with the Bureaux is maintained through the Department of Scientific and Industrial Research, and liaison with the individual Bureaux is effected through official correspondents appointed to deal with specific inquiries. Mr. Nevill Wright, Scientific Liaison Officer of the Department in London, is Chairman of the Executive Council of the Imperial Agricultural Bureaux.

The Bureaux have continued to be of very great assistance to agricultural research workers in New Zealand through their regular publications and special reports, as well as by supplying information in response to specific inquiries.

During the year the free distribution list of Imperial Agricultural Bureaux publications in New Zealand was carefully revised by the Department, in order to ensure that the publications would reach all the research institutions and individual research workers who would obtain the maximum benefit from them. In revising the lists, the principle that the publications should go to institutions rather than to individuals was closely adhered to. Attention is also being given by the Department to the recommendation of the British Commonwealth Scientific Conference and the Executive Council of the Imperial Agricultural Bureaux that steps be taken to secure wider publicity for the Bureaux publications. The following is a list of the official correspondents of the Bureaux in New Zealand :—

Bureau.	Official Correspondent.
1. Soil Science	Sir Theodore Rigg, Director, Cawthron Insitute, Nelson.
2. Animal Health	Dr. C. S. M. Hopkirk, Officer in Charge, Veterinary Laboratory, Department of Agriculture, Wallaceville.
3. Animal Nutrition	Dr. I. J. Cunningham, Veterinary Laboratory, Department of Agriculture, Wallaceville.
4. Plant Breeding and Genetics	Dr. F. W. Hilgendorf, Director, Wheat Research Institute, Christchurch.
5. Pastures and Forage Crops	Mr. E. B. Levy, Director, Grasslands Division, Plant Research Bureau, Palmerston North.
6. Horticulture and Plantation Crops	Mr. J. A. Campbell, Director, Horticulture Division, Department of Agriculture, Wellington.
7. Animal Breeding and Genetics	Dr. F. W. Dry, Massey Agricultural College, Palmerston North.
8. Agricultural Parasitology	Dr. C. S. M. Hopkirk, Officer in Charge, Veterinary Laboratory, Department of Agriculture, Wallaceville, and Dr. D. Miller, Cawthron Institute Nelson (joint correspondents).

MISCELLANEOUS GEOPHYSICAL SURVEYS.

ASBESTOS DEPOSITS, D'URVILLE ISLAND.

By W. M. Jones.

Some geological and magnetic observations were made by the writer (8th to 13th May) in the vicinity of Black Beach, where the Asbestos Mining Co. has recently been prospecting.

Geological.—An extensive mass of ultrabasic rock, now largely serpentinized, has here been intruded into the Palæozoic sedimentaries—argillites and sandstones. The contact has been partially exposed by erosion, and many large blocks of argillite, altered near the contact into a hard close-grained rock formerly quarried by the Maoris for implements, appear at the surface in direct contact with serpentine ; asbestos has been developed, as cross-fibre up to ½ in. long, in more or less parallel veins in a zone of the serpentine, up to a few feet in thickness, adjoining the surface of separation. This has not happened in every case, especially where there has been shattering of the serpentine, and as many of the contacts have been obscured by rubble or drift material, a reliable estimate of the consistency with which the fibre-bearing zone has been formed requires surface prospecting in the form of removing the obscuring material at as many points as possible. As the serpentine body extends continuously from Black Beach across to the south-eastern inlet of Port Hardy—nearly a mile—with the sedimentaries on either side and residual blocks also on top, there is evidently a large area of the surface of contact, much of it not difficult of access. No intrusions into the serpentine itself were observed.

Magnetic Observations.—Very large variations of vertical intensity were found over the serpentine, with a total range of about 10,000 gammas, such as had previously been found over the asbestos-bearing serpentines of the Upper Takaka Valley, and the general boundaries of the serpentine body could no doubt be located by magnetic survey if they should be required in the future.

Disturbances of both declination and dip were also apparent from the behaviour of the compass-needle. In the one case measured, a differential variation of declination of 2° was found between the two ends of a line 4 chains long. The actual anomalies of declination were not measured, but may be considerable. It is interesting that disturbance of the compass has been suspected by airmen flying over this neighbourhood.

While the presence of such large anomalies of vertical intensity, both here and at Upper Takaka, does not necessarily indicate workable deposits of magnetite ore, it is always possible that such may exist in association with the numerous igneous intrusives of the Nelson Province, either as magmatic segregation or as impregnations, and that magnetic survey may call attention to them.

MAGNETIC OBSERVATIONS IN THE ONEKAKA-PARAPARA DISTRICT.

By W. M. Jones.

A few weeks were spent in a reconnaissance survey of the magnetic properties of the country in the Onekaka-Parapara district containing the iron-ore and other mineral deposits, variations of vertical intensity being measured with a Schmidt Balance of Askania construction. The results are summarized as follows:—

(1) The limonite ore-bodies themselves do not in general produce disturbances of more than a few tens of gammas in the vertical intensity, and in view of greater disturbances due to other causes it does not appear feasible to trace their concealed extensions directly by magnetic survey.

(2) On the other hand, a range of disturbance of over 1,000 gammas was found at Onekaka. Passing over the floor of the quarry from east to west, a continuous increase of 150 gammas in four chains was measured, while a few chains to the south a highly disturbed area was located, the variations amounting to as much as 800 gammas over half a chain. This indicates that the disturbing body is very close to the surface. The maxima observed were not over exposures of ore, but over crystalline limestone which does not itself contain appreciable quantities of magnetite. A suggested explanation is that an intrusive of a basic or ultra-basic igneous rock here approaches very near the surface. If this is so, its immediate proximity to the ores may be important as regards their structure and possibly their genesis. Alternatively, the possibility of magnetite or martite at a little depth in the ore-bodies is to be considered, although this would be difficult to fit in with conceptions of the ores as low-temperature replacements of limestone.

Another magnetic "high" of 140 gammas was found on the Ngarino Ridge, and smaller disturbances on other parts of the Washbourn and Tukurua Blocks. The igneous rock adjoining the Parapara deposits is acidic, and could not be expected to produce strong magnetic disturbances.

(3) Farther afield, in the Collingwood-Bainham-Takaka districts, a number of areal anomalies of hundreds of gammas are already apparent from the scattered readings taken to date. In some cases these are directly connected with exposed bodies of basic or ultra-basic igneous rock, and indicate the extensions of these bodies below either the ancient sedimentaries of the Aorere and Mount Arthur Series, or the Tertiary and Recent sediments in the Takaka and Aorere Valleys. If we assume, as seems reasonable from the nature of these sedimentaries, that they are in general incapable of producing anomalies of more than 100 gammas, the other anomalies can also be attributed to igneous rock-bodies not reaching, or not yet discovered at, the surface. In view of the undoubted connection of some of these rock-bodies and the mineralization of parts of the area, information thus obtainable as to their distribution and structure might prove very useful.

The greatest disturbance so far recorded in this area is from the ultrabasic rocks exposed in the Rameka Valley, about four miles south-east of Takaka, where a negative anomaly of 2,000 gammas at the mill gives place to a positive one of 2,200 gammas at the mouth of the gorge. This disturbance continues in a diminishing degree across the Takaka Valley at least as far as Takaka, where it amounts to 400 gammas. The Doctor's Creek – Appo's Creek is also the site of a "high" of 500 gammas. The schist at one point was observed to have undergone alteration, with a vein of limonitic material which proved on analysis by the Dominion Laboratory to contain 52·4 per cent. of Fe_2O_3 and 3·9 per cent. of P_2O_5. This is of interest, as its position can hardly be reconciled with an origin by deposition from surface waters. Other patches of limonitic ore were mapped by Bell in this neighbourhood, and the close association both here and at the Onekaka-Parapara deposit, of igneous rocks with the iron-ores, suggests the former as the parent of the latter, although no doubt concentration and transportation by surface waters has also taken place.

GEOPHYSICAL WORK IN THE ROTORUA DISTRICT.

By C. M. N. Watson-Munro.

In connection with the visit to New Zealand of Dr. A. L. Day, late Director of the Geophysical Laboratory of the Carnegie Institute of Washington, for the purpose of making vulcanological studies, it was suggested by the Secretary that a magnetic exploration of the thermal regions would assist in determining the distribution of basic intrusions and their possible relation to thermal or volcanic activity. Accordingly, in January, February, and March, 1937, in association with Dr. Day, officers of the Dominion Observatory made a reconnaissance magnetic survey in the Rotorua district.

Observations taken in the Tarawera-Waimangu area indicated that the bulk of the basic material was distributed at the Tarawera end of the rift, from which much fragmental basic material was ejected during the latter stages of the 1886 eruption. In the thermal regions at Wairakei, Waiotapu, Tikitere, and Waimangu the values of magnetic vertical intensity were characterized by a drop of about 200 gammas below normal. These observations could not be explained by contour effects and were not sufficiently low nor accompanied by corresponding high values to be due to strong basic intrusions, and a possible explanation was that either the rocks had lost their magnetite content by propylitization or that the high temperatures below had prevented them from attaining their full

magnetic properties. In the thermal regions at Whakarewarewa a similar state of affairs existed, except that here conditions were modified by a dyke of material more magnetic than the rhyolite near Pohaturoa Trig.

In order to aid the interpretation of the results, measurements of the magnetic susceptibilities of the rhyolites and basalts were made. The Curie Point, at which they lost their magnetic properties, was determined to be just under 600° C.

RESEARCH ON LIGHT-WEIGHT CONCRETES.

During the year a special Committee was established to direct the experimental work now being undertaken by the Department of Scientific and Industrial Research on light-weight concrete and special cement mixtures, also to study and advise upon the technical information and literature regarding building-materials and methods of construction which is received by the Department from time to time from England and other progressive countries.

The personnel of the Advisory Committee is as follows: Mr. F. W. Furkert, C.M.G. (Chairman); Mr. H. C. Morton, New Zealand Institute of Architects; Mr. W. E. Aked, representing the Wellington City Engineer; Mr. C. W. O. Turner, Public Works Department; Mr. H. R. Climie, Housing Construction Department; Mr. L. R. L. Dunn, Dominion Laboratory, Department of Scientific and Industrial Research; Mr. H. C. Heays, Department of Scientific and Industrial Research (Secretary).

Samples of New Zealand deposits of diatomaceous earth, clay (including bentonite), pumice sand, and pozzolanic materials have been collected for preliminary analysis in the Dominion Laboratory to judge their probable suitability for concretes. Through the generous co-operation of a local company producing concrete products, several kinds of test specimens have been made in order to compare the physical properties of the various mixtures.

The physical tests being carried out comprise tensile, compression, and deflection tests, together with studies of thermal conductivity, curing-shrinkage, and moisture movement.

The data obtained from the preliminary group of specimens which were made in a mould 14 in. by 6 in. by 2 in.—and when cast therein were vibrated for a brief period—show that (1) during the first few days all the specimens expanded slightly; (2) that, after curing for ninety days in an atmosphere held constant at 65° F. and at 92 per cent. relative humidity, the density of the specimens of 1 : 5 concrete from crushed stone, graded sands, and portland cement was approximately twice that of similar 1 : 5 concrete of aggregate from a sieved natural deposit of pumice; (3) the loss of weight at ninety days of these specimens was 2 per cent. and 24 per cent. respectively; and (4) the then incomplete contraction as a percentage of the initial length was approximately three times as much in the pumice specimens as in the concrete ones.

Compressive tests, upon similarly vibrated cylindrical specimens 6 in. diameter by 12 in. long, after under-water storage in an open-air fresh-water tank for a period of twenty-eight days, were also made, and the respective average figures are

1 : 5 crushed stone concrete	5,638 lb. per square inch.
1 : 5 pumice concrete	823 lb. per square inch.

It is yet too early to make any statement in regard to the probable effects of including diatomaceous earth, bentonite, or pozzolana in concretes for building purposes, and this important work will of necessity be spread over a relatively long period of time in order to obtain significant and reliable results.

Some work on the thermal conductivity of a group of well-matured, specially designed and equipped, hollow, ice-filled, cylindrical specimens of various concrete mixtures was also undertaken during the year. By careful measurement of the e.m.f. induced in each of five thermo-couples, connected in series with their cold junctions in the melting crushed ice and their warm junctions suitably embedded at selected stations on the outer surface of the cylinder under test, the mean temperature of the outer layer was ascertained to within 0·1° C.

Under the conditions of test the following figures were obtained and give a comparative indication of the heat conductivities of the respective types of concrete specimens or, conversely, may serve to compare their insulating qualities:—

	Conductivity in B.T.U./hr. per sq. ft./inch/1° F.
1 : 5 concrete of ordinary crushed stone	5·1
1 : 6 pumice	2·5
1 : 8 pumice	2·2
1 : 10 pumice	1·7

The resultant effect of soaking the specimens in water for a period of sixteen hours was also ascertained and gave conductivity ratios for the dry and the wet condition respectively as follows:—

	Dry.	Wet.
1 : 5 crushed stone concrete	1 :	4·7
1 : 6 pumice concrete	1 :	6·7
1 : 8 pumice concrete	1 :	7·2
1 : 10 pumice concrete	1 :	8·5

The technical publications and journals which are received frequently by the Department are carefully perused so that, by selected extracts, the individual members may be kept well informed regarding developments and progress made in this particular sphere of activity in the building world, thereby facilitating the work of the Committee.

RESEARCH WORK AT CANTERBURY COLLEGE, LINCOLN.

Agricultural Engineering.

During the year progress was made in summarizing and studying the large mass of experimental data collected during the previous five or six years. The work aims at providing a few simple tests which will describe the most important physical properties of a soil. Experience with a particular soil in an irrigation or drainage scheme, in the subgrade of a road, in a bridge foundation, or cultivated in a field may be recorded, together with its behaviour in selected laboratory tests. Many of these tests have now been shown to be related by mathematical laws, while other relationships are still being sought. Because of the number of relationships there seems a good prospect of reducing the important tests to five or six. Among other things, it was discovered that the strength of a soil in tension was a constant fraction of its strength in compression, and that either tension or compression values of a soil could be calculated with fair accuracy from contours drawn on a graph showing mechanical analysis. This means that a mechanical analysis made in an hour by means of a hydrometer will show if the subgrade soil in a road is sufficiently tenacious or if other materials must be added to it before sealing. Formerly tension tests lasting from one day to six weeks were necessary. Swelling and shrinkage were also found to be related to the hydrometer tests, thus obviating the lineal shrinkage tests used by the Bureau of Roads, United States of America. A simple mathematical method of expressing the mechanical analysis of most soils by two numbers has been found, and this method of expression has now been adopted and extended by Argentine workers.

Considerable time has been given to soil-water studies, since moisture content and permeability influence scores of phenomena—*e.g.*, duty of water in irrigation, leakage of stop-banks, spacing of drains, and settlement of foundations. Laboratory tests to determine lower plastic limit, shear, angle of repose, and moisture equivalent have also been carried out.

Further information was collected relative to types of buildings suited to New Zealand farm conditions.

Entomology.

(*a*) *Diamond-back Moth Control.*—In co-operation with other officers of the Entomology Division of the Plant Research Bureau, work on the establishment of the *Angitia* parasite was carried on by Mr. L. Morrison, part-time Lecturer of the College. It was decided that activities along this line should be discontinued at the end of 1937.

(*b*) *Wheat-bug.*—Experimental work was undertaken to ascertain if any of the hemipterous insects from North Otago were responsible for the "sticky dough" condition of certain lines of wheat. The results showed conclusively that at least three different species produced the condition in wheat grown at Lincoln.

(*c*) *Porina and Grass Grub Survey.*—A survey of portions of Canterbury was made during the spring of 1937 to ascertain the position of these pests and to find the relative importance of each. Some preliminary trials were conducted to determine value of poisoned baits as a control for *Porina*. Data were collected on the numbers of *Porina* present in pastures in different districts.

(*d*) *Investigation of Failure of Wheat Crops.*—This work was carried out during September and October. The cause of failure of certain crops in widely separated crops in North Canterbury and Mid-Canterbury was shown to be stem-eelworm.

(*e*) *Pests of the Wheat Crop.*—A survey of wheat-growing areas in Canterbury and North Otago was carried out during the summer of 1937–38. It was shown that two pests of economic significance were attacking wheat—viz., hessian fly and stem-weevil. The former is significant in South Canterbury and North Otago. Stem-weevil is of lesser importance than hessian fly and is not restricted to any particular area. It has been shown that the sowing-down of grass with wheat or barley is largely responsible for the high incidence of hessian fly in South Canterbury. Here is an indication that certain varieties of wheat are more susceptible to infestation than others. A report on this survey has been forwarded to the Chief Executive Officer, Plant Research Bureau, Department of Scientific and Industrial Research.

Sheep and Wool.

Fleece-weighing.—The work of weighing the fleeces from all stud sheep has been continued and the position will soon be reached when it should be possible to examine critically the figures collected. It is essential in connection with this work to determine certain correction factors for the fleece-weights, and this can only be done when a large amount of data are collected and treated statistically.

Lamb Recording.—The weighing, tagging, and pedigree recording of all stud lambs has been continued, and, as in the fleece-weighing experiments, there is gradually accumulating a set of figures which should be of considerable genetical significance when subjected to statistical examination.

Fœtal Development.—During the year an honours degree student carried out an investigation into the rate of development of the fœtal lamb. This work has served to indicate most forcibly the necessity for improved feeding of the pregnant ewe for from four to five weeks prior to lambing. The work has drawn attention also to several other points worthy of further study. One of these is the question of fœtal atrophy, which may be more important in relation to the low fertility of New Zealand sheep than was realized previously.

Covering Sheep.—A preliminary experiment to study the effects of a cover protection on sheep was carried out during the year. The results indicate that not only is a heavier and better-grown fleece obtained, but the covered sheep were slightly heavier than the non-covered sheep. Probably

the greatest benefit from the covers was the relative absence of vegetable matter in the covered sheep. In the non-covered group several fleeces showed evidence of discoloration brought about by bacterial activity, but this was absent from the covered fleeces.

Pelt Research.—Arrangements were made during the fat-lamb-killing season for the Leather Research Chemist of the Department of Scientific and Industrial Research to obtain sample pelts from the various types of cross-bred lambs available from the College flocks.

Agricultural Economics.

Ashburton Farm-management Survey.—A condensed account of Mr. J. R. Fleming's farm-management survey of Ashburton County, including a map, is being published as a Bulletin of the Department of Scientific and Industrial Research, and is at present in the press. By arrangement with the Department of Scientific and Industrial Research and the Department of Agriculture, the detailed sections of the survey have been cyclostyled in the form of an appendix to the Bulletin.

Addington Stock Market.—A survey of some of the main features of this stock market is being carried out.

General.—The record of the course of prices of farm-products, the farm-account work, the College Bulletin work, and the study of recent world changes in monetary and production methods and in trade and market conditions, have been continued.

Farm Advisory Service.

The research activities of this Department have been confined mainly to a study of the application of existing knowledge to farm practice and the alterations necessary in present farm practice to enable the most economic use of new information. Attention has also been given to certain management aspects of hogget mortality; the establishment and management of pedigree cockfoot for seed-production; pasture establishment, management, and top-dressing; and other general farm-management problems. Attention has also been given to problems associated with the valuation of rural properties.

Farm Crops and Pastures.

The following activities are in progress:—

Root Crops.—(1) Variety trials with mangels and swedes are now in their second season. Yield data and, in the case of swede trials, records of the incidence of dry rot, brown heart, and insect attack are being compiled.

(2) Mangel-seed treatment: Trials with sulphuric-acid treatment and pre-germination of seed prior to sowing are in progress.

(3) Swede-seed treatment (for control of dry rot): Six treatments are now under investigation in association with I.C.I., Ltd.

(4) The effect of gyrotiller cultivation on yields of mangels and swedes.

(5) Farm-yard-manure yield trials with mangels and sewdes.

(6) Variety trials with white and yellow turnips. Yield and disease data are being collected.

(7) Trials with various potato treatments—vernalization, "Azeta," and various degrees of greening—and the collection of data on earliness and yield.

Cereals.—(1) Influence of gyrotilling on wheat and oat yields.

(2) Effect of various new grades of disinfectants on germination and yield (wheat and oats) in ordinary soil and in heavily disease-inoculated soil. (Results are being published in the *N.Z. Journal of Agriculture.*)

(3) Studies on the intensity of plant population in wheat fields, including irregularity of plant distribution, plant mortality, and influence of plant density on yield. (Results are being published in the *N.Z. Journal of Science and Technology.*)

Garden Seeds and Legumes.—Seed-disinfection trials. Effect on germination after treatment and after a period of storage; effect on nodulation in legumes.

Pasture Plants.—(1) Investigation of the value and utilization of *Phalaris tuberosa* as a pasture plant under Canterbury conditions. Records are being continued with eight fields under study.

(2) Liming trials on lucerne.

(3) Long-term effect of lime on pasture composition, and yield and nutritive value of herbage.

(4) Cocksfoot: Further improved strains of cocksfoot have been built up from offspring of C. 23 and sown for testing.

(5) Testing of cocksfoot strains:—

(*a*) A pasture-mixture trial, including certified Akaroa, certified Government stock seed (C. 23), and Government pedigree seed (C. 23) is being conducted.

(*b*) A strain trial of the following five strains of cocksfoot has been established: Certified Akaroa, C. 23 (orginal), C. 23 (first remove), C. 23 (second remove), C. 23 (new combination).

(*c*) In co-operation with the Department of Agriculture a pasture-strain trial has been laid down. This includes certified Akaroa, certified Plains and College C. 23 cocksfoot, and in addition all the available strains of perennial rye-grass, Italian rye-grass, white clover, and red clover.

(6) Various pasture trials :—
(*a*) A liming trial on new pasture sown with mother-seed rye-grass and wild white clover is in progress. The treatments range from ¼ ton up to 2 tons per acre.
(*b*) Costs and returns associated with the growing of certified perennial rye-grass, Italian rye-grass, white clover, Montgomeryshire clover, and cocksfoot for seed-production are under investigation.

Ashley Dene Trials.—The whole of the Ashley Dene block of 900 acres is being used as an experimental unit to investigate the possibilities of subterranean clover and associated crops on light land characteristic of large areas of Canterbury and other parts of New Zealand.

The following acreages of different experimental pasture have been sown :—

Subterranean clover	400 acres.
Lucerne	12 acres.
Certified Montgomeryshire clover	10 acres.
Certified rye-grass, certified Montgomeryshire clover, and certified white clover	Mixed pasture, 12 acres.
C. 23 cocksfoot and subterranean clover	10 acres.
Yorkshire fog and subterranean clover	10 acres.

The following specific experiments have been established :—
(1) Large-scale fertilizer and liming trial, 72 acres. Four treatments.
(2) Small-scale fertilizer trial. The trial is in the same field as the large-scale trial and includes the same four treatments which are used in that experiment. The correlation between small-plot and large-scale grazing trials will be determined.

Other trials at Ashley Dene include methods of establishing subterranean clover and ecological studies on subterranean clover.

Miscellaneous.—Other investigations in progress include an examination of the effect of time of baling on the quality of lucerne hay, and field manurial trials with barley and oats according to the method of Mitscherlich as modified by Stewart and Robertson.

Animal Problems.

The following problems are under investigations :—

(1) *Ewe-mortality*—
(*a*) Field investigations ; collection of field data.
(*b*) Milk-fever investigations.
(*c*) Sorrel-poisoning investigations. Further work on sorrel-poisoning carried out during the last twelve months has shown that losses from this cause are greater than was orginally suspected. Cases among wether hoggets and ewes in the autumn have also been brought to the notice of the College and relevant data were collected.

(2) *Lamb-mortality*—
(*a*) Collection of field data.
(*b*) The determination of the cyanogenetic-glucoside content of clovers grown under Canterbury conditions.
(*c*) Investigations to determine the efficiency of various treatments for the control of internal parasites are being carried out on several farms where severe losses of lambs have occurred.
(*d*) Pulpy-kidney investigations include inoculation experiments with lambs on rape, and attempts to induce pulpy kidney in lambs on rape by increasing the carbohydrate content of their diet. Systematic glucose and lactose drenches have been administered.

Liming Studies.

Liming studies are being conducted on four distinct soil types—viz., heavy clay loam at Moeraki Downs, stony silt loam comparable to the Seafield type, and on the Buccleuch and Springfield loams near Methven.

DOMINION LABORATORY.

The work of the year consisted almost entirely of chemical analyses and investigations undertaken for various Government Departments.

The numbers of samples received from the various Departments were :—

Wellington (main Laboratory) : Customs, 172 ; Police, 67 ; Geological Survey, 199 ; Main Highways Board, 160 ; Mines, 57 ; Health, 2,690 ; Post and Telegraph, 84 ; Research, 130 ; Public Works, 69 ; Soil Survey, 146 ; Railways, 32 ; Stores Control Board, 8 ; Agriculture, 25 ; Defence, 13 ; Prisons, 239 ; Government Printing Office, 20 ; External Affairs, 9 ; Plant Research, 86 ; Housing, 70 ; Public Trust, 28 ; Other Departments, 81 ; Miscellaneous, 442 : total, 4,827.

Auckland (branch Laboratory) : Auckland Hospital, 2 ; Customs, 1 ; Forestry, 2 ; Health, 5,210 ; Marketing, 3 ; Justice (Police), 186 ; Post and Telegraph 5 ; Public Trust, 65 ; Public Works, 54 ; State Advances, 9 : total, 5,537.

Christchurch (branch Laboratory) : Food and drugs (Health), 3,287 ; Justice (Police), 141 ; Other Government Departments, 30 ; Local bodies and miscellaneous, 22 : Total, 3,480.

Dunedin (branch Laboratory) : Health, 1,517 ; Justice (Police), 20 ; Agriculture, 11 ; Scientific and Industrial Research, 49 ; Post and Telegraph, 1 ; Internal Affairs, 1 ; Forestry, 2 ; Mental Hospitals, 2 ; University Medical School, 1 ; Miscellaneous, 4 : total, 1,608.

A total of 15,452 samples was received in the main Laboratory and the three branches.

Customs.

The usual variety of samples was examined for approximate composition as a guide in classifying for tariff purposes.

Police.

Wellington.—Of a number of exhibits examined in connection with cases of suspected poisoning, strychnine was found in one case, nicotine in another, and in a third, oxalic acid.

Samples of wine and other alcoholic liquors were analysed in connection with suspected " sly-grog " selling.

Blood, urine, and other materials were examined for alcohol in several cases of suspected intoxication.

In two cases of alleged arson, sacking and other materials were tested for inflammable liquids.

Caustic soda was found in a sample of milk in a case of attempted poisoning, and arsenic in dates in a case of attempted suicide.

Several exhibits were examined for poisons in connection with the deaths of a number of dogs.

Blood-samples were examined for carbon monoxide in three cases of gas poisoning.

Samples of various drugs were analysed in several cases of suspected attempts to procure abortion.

Numerous exhibits, consisting of green paint and other materials were examined in two cases of house-breaking, and in a number of these exhibits a special search was made for traces of gelignite.

Auckland.—In four of the cases of poisoning investigated, veronal, lysol, oxalic acid, and strychnine respectively were found.

In the case of death due to poisoning by absorption of carbolic acid through the skin, traces of phenol were recovered from the liver. The victim had accidentally used liquefied carbolic acid instead of a dilute solution of carbolic acid as a dressing for neuritis in the arm.

An instance of nicotine poisoning was remarkable for the large amount of nicotine which could be tolerated by a heavy smoker. The victim recovered in hospital after four grains of the sulphate had been taken accidentally.

Following a bomb outrage at a residence in Auckland City a considerable amount of investigational work was carried out on the fragments of the bomb. The bomb had been made from a light-steel canister, filled with gelignite, and was fired by a striker with a steel spring.

A number of exhibits were examined in connection with three cases of arson.

A number of counterfeit half crowns and a genuine coin which had been gold-plated and sold as gold were also the subjects of investigation.

The etching-up of numbers filed off stolen articles has been continued with success.

Christchurch.—The following substances were present in exhibits submitted for toxicological examination ; Strychnine, luminal, and morphine.

In connection with deaths under anæsthetic, samples of ether and nitrous oxide were examined and found to be of good quality. This is in accord with experience over a long period, and it can be added that there is little danger of anæsthetics containing injurious impurities.

A considerable number of specimens of blood and urine were submitted in connection with motor accidents, &c. In three cases significant amounts of alcohol were found ; in one case it was in the form of methylated spirit.

Medicinal preparations suspected of being used as abortifacients were examined, also several samples of liquor in connection with " sly-grog " cases.

Analyses of lubricating oil and of petrol from motor-cars were required in connection with the alleged theft of these materials.

Dunedin.—No poisons were found in any of the exhibits submitted in cases of suspected poisoning of human beings.

A further case was investigated in which horses had been poisoned by strychnine being added to the chaff.

In a case where a very large number of rabbit-skins had been stolen by night from a warehouse, considerable assistance was rendered to the police by the identification as rabbit-fur of a number of fibres obtained from the clothing of a suspect and from a car which it was proved had been hired by the suspect on the night of the crime. The nature of the fibres was proved conclusively by microscopic examination, especially of the transverse sections, which are very characteristic.

Department of Health.

Milk.—A total of 9,416 samples of milk were examined at the main Laboratory and the three branches.

Wellington: Of 1,685 samples taken in Wellington City and suburbs, 8 were deficient in fat, 17 contained added water, and 24 were stale. This record, while satisfactory, is not up to the standard of the previous year, there being an increased number of samples reported as containing water and as stale.

From the country districts, which include Nelson, Marlborough, Wellington Province (except Wellington City and suburbs), Taranaki, Hawke's Bay, and Gisborne 700 samples were examined. Of these, 14 were low in fat and 6 contained added water.

During the year the school milk scheme was introduced and samples were regularly examined at Wellington, as well as the other centres, by the usual methods.

As the Department of Health requires such milk to be pasteurized, the samples were in addition examined for effective pasteurization by the phosphatase test.

The milks examined proved to be of satisfactory quality.

Auckland: For Auckland a total of 3,683 samples was analysed, representing a large increase on the 2,556 examined during the previous year. Of 3,179 samples taken in Auckland City and suburbs, 23 were below the standard for fat, 25 contained added water, and 27 were stale.

Of 1,127 samples obtained from other towns in the Auckland Province, 11 was below the standard for fat, 19 contained added water, and 7 were stale.

As in the other districts a considerable number of samples were examined in connection with the supply of milk to schools.

Christchurch: The number of milk-samples examined during the year was 2,210, of which 1,432 were from Christchurch City and suburbs, the remainder being from the provincial districts of Canterbury and Westland.

Christchurch City and Suburbs: The percentage of non-compliances for 1937 was 5·9, a slight increase on the previous year (4·3). Of these non-compliances, however, approximately half were very small deficiencies in fat or solids other than fat; if these are excluded the percentage of other non-compliances is only 3·1.

With reference to the reductase test, the legal minimum test is three hours, but the percentage of samples reducing in five hours or under was only 3·4, being the same percentage as for 1936.

Outside Districts: The number of samples examined was 778, of which 478 were from Canterbury and 300 from the West Coast districts.

By a combination of unofficial and official sampling the reductase test was extended to cover the milk-suppliers of all the larger towns of Canterbury and Westland. The unofficial samples were forwarded to Christchurch for examination, being transported in specially designed ice-boxes and tested immediately after receipt. In most cases the milk-supplies of the various towns were found to be satisfactory.

School Milk-supply: The supply has all been obtained from the only pasteurization plant in Christchurch large enough to cope with the demand. The laboratory has been called upon to control the quality of the milk both before and after pasteurization, and visits have also been made to the pasteurization plant. The number of samples examined was 669, of which 298 were producers' milk before pasteurization and 371 as delivered to the schools. In cases where producers' milk has been unsatisfactory, appropriate action has been taken to effect a remedy. At the inauguration of the scheme a few irregularities were noted in the milk as finally supplied to the schools, but these have been eliminated, and the supply has, on the whole, been very satisfactory. As in the other centres, pasteurization tests have been made by the phosphatase method. The scheme is gradually being extended to cover the province, and additional supplies are also under observation. In a number of cases farm water-supplies have been examined.

Dunedin: Of 610 samples examined, as against 445 for the previous year, 13 were deficient in fat, 6 contained added water, and 7 were stale. Although there is an increase in the number of samples taken, it could with advantage be increased further to at least 1,500 per annum.

From the other towns in the Otago and Southland Health Districts 528 samples were obtained. Of these, 16 were deficient in fat, 3 contained added water, and 3 were stale.

In addition, 208 samples from the Waipiata Sanatorium were examined. They were of satisfactory quality.

Reductase Test.—During the year further work, particularly in Auckland and Dunedin, has been carried out on the reductase test as modified by the Ministry of Health, Great Britain. The modified test has been found to have distinct advantages and will be substituted for the present test in the regulations under the Sale of Food and Drugs Act.

The use of the phosphatase test for pasteurization of milk has been continued in the main laboratory and the three branches, and its great value definitely established.

On the whole, the condition of the domestic milk-supplies of the Dominion can be regarded as very satisfactory.

It has been observed, however, that in some cases, pasteurized milk is not labelled as required by regulation, and customers are supplied with raw or pasteurized milk indiscriminately.

The use of the phosphatase test provides a means of checking this practice.

In addition to the work for the Department of Health, a larger number of samples of milk was examined for the Prisons Department. Many samples of human milk were examined for the Plunket Society.

Water.—A total of 257 samples from existing and projected water-supplies were analysed in the main Laboratory and the three branches. This work is carried out regularly from year to year as a guide to Medical Officers of Health in maintaining purity of water-supplies.

At the Auckland branch Laboratory a special investigation was carried out on the water of Lake Pupuke from which Takapuna draws its supplies. The presence of the organism *Ceratium* had caused serious trouble in 1934, as it imparts a most objectionable odour and taste to water. Regular samples had been examined since 1934, and when the organism reappeared in 1937 a special study was made of its life-history. A very large number of samples of water were examined. It was found that in cool weather the cysts of the organism were very resistant to copper sulphate. The copper sulphate treatment of the lake was therefore carried out when a microscopic examination of samples from selected points showed no cysts. The treatment was completely successful, as it was in 1934.

The same species of *Ceratium* was found in the sea-water of Auckland Harbour, and as Lake Pupuke is separated from the sea by a very narrow strip of land it would appear that the cysts are carried over from the sea.

The results of this investigation are to be published as a separate report.

Sewage.—As in the previous year, a large number of samples were analysed in the Auckland Laboratory in connection with problems of sewage disposal. A few samples were examined in the other centres.

Miscellaneous.—A large number of various articles used as food and drink were examined. They included apple-juice, baking-powder, barley-water, beer, bicarbonate of soda, biscuits, butter, cinnamon, cocoa, coffee and chicory, cordials, cream, cream of tartar, figs, flour, gin, ginger beer, ground ginger, honey, ice-cream, icing-sugar, iodized salt, jam, lemons, lemon tea, malt extract, malted milk, marrow, meat-paste, mustard, pepper, prunes, raisins, canned raspberries, rum and ginger, sardines, sausages, saveloys, tomato sauce, tinned peas, vinegar, whisky, wine, and wholemeal bread.

Of 375 samples of butter taken throughout the Dominion, 22 contained water in excess of the maximum allowed (16 per cent.).

All the brands of sardines which were procurable (forty in all) on the market, were examined for lead and tin. In four cases more tin was present than the maximum allowed by the regulations (2 grains per pound), and one contained an excessive amount of lead. The canners concerned were informed that such contamination must be avoided. On the whole the metallic contamination was negligible and goes to show that there is little risk of ingesting objectionable amounts of metals when eating canned food. It is intended to examine systematically other types of canned food for metallic impurities.

A most interesting investigation was made of various brands of tooth-paste on the market, thirty-four samples in all being analysed principally for the presence of abrasive and oxidizing agents. No abrasive was found in any of the samples, although in much of the advertising it is inferred that rival brands contain abrasives, as, for example, pumice-powder. In one case the paste contained a considerable proportion of potassium chlorate and would definitely be dangerous in continuous use. It was recommended that the sale of this paste be prohibited. Two other pastes contained undesirable amounts of iodides.

The most objectionable feature was the extravagant and misleading advertising matter that accompanied many of the samples. There appears to be no necessity for so many different brands, as, with one exception, the tooth-pastes appeared to provide simply an agreeable but somewhat expensive method of applying precipitated chalk to the teeth. Except that they are more attractive, they have no real advantage over simple cleaning-agents such as salt or precipitated chalk.

One of the pastes was acid in reaction, but this would have no advantage over a simple acid wash.

Drugs.—A number of drugs were examined to ascertain if they complied with the standard of the British Pharmacopœa. They included boric acid, camphorated oil, glycerine, hydrogen peroxide, liniments, malt extract, liquid paraffin, lysol, and tincture of iodine.

With the exception of some samples of camphorated oil, which were deficient in camphor content, the samples were of satisfactory quality.

"Cancer cures" on public sale by certain herbalists were examined. One of the cures consisted of lead plaster and another of camphor and "herbs." Action was taken which led to a modification of the claims made for such remedies, but the legal provisions for safeguarding the public in this respect appear inadequate.

Mines Department.

The Dominion Laboratory has carried out investigations and analyses on mineral samples, mine gases, coal-samples, &c.

Prospectors' samples have been assayed for gold and silver and occasionally for other metals, notably tungsten.

During the year the physical and chemical Survey of the coal resources of the Dominion has been proceeded with. The Laboratory is now fitted up and is working in conjunction with a geological field staff.

A report on the Blackburn area with two maps has been included in the annual report of the Geological Survey.

The field staff has commenced work in the Greymouth area, with headquarters at Rewanui. Systematic and accurate sampling of the area is undertaken in conjunction with geological and survey work, and the sealed samples are forwarded to the Laboratory for complete analysis.

It is hoped to extend the activities of the work of the survey to assist the Mines Department in finding new areas for co-operative mining and in locating supplies of coal suitable for the proposed iron and steel industry.

Government Stores.

The various Government Departments concerned with the purchase and use of materials are making increased use of the Laboratory for checking the quality of their supplies.

Most of the tests are now made with a view to ascertaining if the supplies conform with specifications. This phase of the work will expand with the modern tendency to order goods to comply with specifications. The activities of the Standards Institute are having a marked effect in encouraging this tendency.

The materials examined included aluminium solder, various lubricating-oils, copper cable, carbon tetrachloride, roofing-tiles, galvanized-iron wire, ammunition components, bronze, galvanized iron, enamelled goods, paints, porcelain, cast metal, steel, detergents, battery acids, rope-coverings, dust-preventatives, dusts, beeswax, sulphur, plaster board, petrol, electric cells, ropes, type metals, and soldering materials.

The investigations on the effectiveness of methods for reconditioning motor-lubricating oil were continued.

The various brands of petrol on sale were examined.

A number of corrosion problems were investigated.

A number of investigations were made where difficulties had occurred in the use of various materials by the Departments concerned.

Roading-materials.

As in previous years a large number of roading-materials were examined for the Main Highways Board to ascertain if they complied with specifications. In addition, investigations were made on methods of preparation of mixtures for special purposes.

Gas-inspection.

The gas-supplies of the four main centres and of the other principal towns of the Dominion are examined regularly for calorific value, purity, and pressure.

With a few exceptions, they were satisfactory in all respects throughout the year, and where trouble did occur the gas undertaking concerned took steps to rectify matters.

The systematic testing of gas-meters for accuracy was carried out as in previous years.

Special Investigations.

Tests for the Housing Department.—The Laboratory was called upon by the Director of Housing Construction to assist in the examination of a wide range of building materials. Concrete and clay roofing-tiles from makers all over New Zealand have been systematically tested, and useful information placed on record. Comparative examinations of sanitary ware from two New Zealand manufacturers were made and a report upon one works was drawn up for the Department of Industries and Commerce.

Regular analyses of paints used on various housing contracts have been made, and the necessity for such a systematic check-up on the composition of the ingredients has again been amply demonstrated.

Bentonites.—The examination of many samples of bentonite from the Whatatutu and Porangahau districts was continued during the year. The results having shown some promise, parcels of the best material have been distributed to various users overseas and in New Zealand and also to the Imperial Institute, London. Favourable comments upon the samples have in some cases been received, but it is not yet certain that the supply of high-grade material is sufficiently great or accessible to warrant commercial development. The position is, however, being closely watched and a search is being made for accessible deposits.

Diatomaceous Earths.—During the year a revival of interest in the diatomite deposits of New Zealand was evident and typical deposits from various localities were re-examined with a view to determining possible commercial uses.

A deposit from Kingsland proved to be of exceptional purity, but, unfortunately, is not likely to become available for commercial use, as it occurs in a public park.

Earths of good quality were examined from Ngongotaha, from Hemo Gorge, from near the Rotorua–Taupo Road, and from Kamo, but their commercial utilization would be dependent, in the first place, upon estimation of the amount available by means of accurate geological surveys.

The investigation of diatomites is being continued and advice in connection with their development is being sought from authorities overseas.

Investigations on New Zealand Clays.—In view of the known value of some of the white-burning clays of the North Auckland district, such as are used for the making of refractories at the Kamo Potteries, the necessity arose during the year of examining in detail the distribution and quality of the white-burning clays from Kauri, which occur as a low terrace at the foot of Mount Manganui. The clay is derived from the weathered dacite of this mountain.

The deposits were sampled by Mr. N. H. Taylor, of the Soil Survey Division, and subjected to chemical analyses and burning tests. As a result of this work it has been possible to put on record a fairly complete account of the properties of the clays and to sort out those most suitable for the making of refractories. None of the clays proved to be bauxitic.

It is to be regretted that in the past detailed and lengthy laboratory investigations upon our clay deposits have not always been preceded by accurate sampling and survey by expert geologists, although it is obvious that in every case this should be done.

Chrome-plating Solution.—At the request of the Superintendent of Workshops, New Zealand Railways, a detailed examination was made of a chrome-plating solution with which considerable trouble had been experienced. From the analysis it was clear that not only was the acidity of the solution too high, but also that the ratio of chromic oxide to sulphuric acid was much above the desirable limit. After examination of the literature it was found possible to make useful recommendations for readjustment of the solution. The original cause of the trouble was in all probability due to reduction of chromic acid to chromic oxide through the use of a wooden vat as a mixing vessel.

Citrus Fruits.—The investigation on grape-fruit was concluded after sufficient work had been done to show that the chemical characteristics would not give a practicable basis for time of picking the fruit.

The work on the curing of lemons is now nearing completion.

Cold-storage Investigations.—Preliminary investigations on the gas storage of apples were commenced during the year in the experimental cool store attached to the Laboratory, and provided data which are being used in planning the programme of work for 1938.

Experiments on the cold storage of asparagus and green peas were also carried out, and yielded useful information.

Further details of these experiments are given in the Fruit Cold Storage section of this Report (p. 48).

Coal.—The whole of the chemical work on coal is now being carried out in the newly equipped special laboratory.

Soils.—As in the previous year, the clay fractions of numerous soils have been separated and analysed for the Soil Survey Branch of this Department.

Phormium Tenax (*New Zealand Flax*).—The chemical examination of samples of fibre from the standpoint of varietal differences has been continued. Other work has included chemical examination and determination of degree of damage of fibrous material produced by various methods.

Ragwort.—Analyses of plant material for alkaloid content are being continued on series of samples collected at regular intervals from areas near Hamilton, the Hutt Valley, and Southland, with a view to determining the variation in toxicity in relation to locality, season, and stage of growth. Examinations have also been made of ragwort from hay and ensilage.

Kauri-gum.—Samples of gum have been analysed in connection with the investigation of methods in use on the field for the recovery and cleaning of chip gum.

Spray Materials (for Plant Research Bureau).—The year's work embraced the testing of various commercially available materials for certification as therapeutants. The testing covered samples of the following: Spray oil, lead arsenate, lime sulphur, hydrated lime, and nicotine sulphate.

In view of arsenical spray injury which had resulted to apples in the Nelson district, an investigation was conducted to ascertain the effect of the "spreader" Agral II, and also of certain hard waters upon the soluble-arsenic figure. The results showed that the Agral II caused no increase in soluble arsenic, but that the use of a hard water in the making-up of the arsenate spray gave rise to a dangerously high figure, in one case as high as 3·1 per cent. calculated on the dry material. In these cases it was found that the addition of hydrated lime at the concentration of 3 lb. per 100 gallons reduced the soluble arsenic to within a safe figure.

Quartz Spectrograph.—During the year experience was obtained in the use of the spectrograph. This method of analysis was applied in connection with the examination of various general laboratory samples. A method was worked out for the determination of trace elements in soils. This work, however, is not to be continued at present, as the committee set up to superintend the application of spectrograph methods to agricultural problems has considered that most useful results will be obtained by examining pasture samples. At the end of the year work was begun on the estimation of trace elements in the ash of samples of milk from various healthy and unhealthy areas in North Auckland.

Survey of the Thermal Region.—At the beginning of the year Dr. A. L. Day, late Director of the Geophysical Laboratory of the Carnegie Institution of Washington, visited the thermal regions of the North Island. During February and March a member of the staff was sent to Rotorua to carry out chemical work required by Dr. Day. The laboratory of the Rotorua High School was kindly made available for the work by the Director, Mr. Harwood. Under the direction of Dr. Day a survey was made of the hydrogen-sulphide content of the gases of hot springs from the main areas in the region. Simple yet sufficiently accurate methods were devised for analysing the gas-samples as soon as possible after collection, for hydrogen sulphide, other sulphur gases, and carbon dioxide. In addition, samples of water from the main hot springs were brought back to Wellington, and thorough analyses of these were made in the Dominion Laboratory.

Advisory and Consulting Work.—The Director and various members of the staff were called on for reports on matters of which they have special knowledge and for service on various scientific and industrial Committees.

During the year it became necessary to appoint a Librarian, which will make for a more efficient use of the technical library of the Laboratory.

A number of scientific and technical papers have been published in various journals, and lectures have been delivered before scientific societies by several members of the staff.

During the year arrangements were made with the Department of Agriculture for closer co-operation between the Chemical Section of that Department and the Dominion Laboratory with a view to further amalgamation of services when suitable accommodation is available. It has already been found that overlapping of work in certain directions has been obviated, and the closer contact has been to the mutual advantage of both Departments.

GEOLOGICAL SURVEY BRANCH.

REPORT OF DIRECTOR (DR. J. HENDERSON).

During the year ended 31st March, 1938, the Director officially visited Te Aroha, Raglan, Ohura, and Featherston in the North Island, as well as Maruia, Reefton, Greymouth, Kotuku, Green Island, and Nightcaps in the South. The observations made during some of these visits are recorded in this report; others will appear in the *New Zealand Journal of Science and Technology*.

Mr. A. M. Quennell continued the mapping of the Dannevirke Subdivision. He worked chiefly in the Takapau area, but also visited Porangahau to examine a deposit of bentonite.

Mr. M. Gage completed the re-examination of the lode-belts of the Reefton district, mapping in detail areas in the Alexander River, McConnochie Creek, and Kirwan Hill. Later he joined Mr. Fyfe on the Greymouth Coalfield.

Mr. H. E. Fyfe began work at Rewanui this season. The survey of the coalfield is being carried out in much greater detail than was the case thirty years ago when Mr. P. C. Morgan geologically explored the area described in *N.Z. Geol. Surv. Bull. No. 13*. The work now being done, the mining and prospecting of the last twenty years, and possible additional boring will allow of a more accurate determination of the amount of available coal.

Mr. D. A. Brown began the detailed examination of the Moeraki Subdivision of Eastern Otago and expects to complete the mapping of the area by the end of May. He also reported on a sand deposit at Mangati some twenty miles south-west from Timaru.

Mr. J. Healy and Mr. R. W. Willett started work in the Glenorchy district at the head of Lake Wakatipu. An expedition to Martin Bay and along the coast southward occupied about six weeks in February and March. Mr. Healy also collected fossils and rocks from several localities in the Hokonui Hills.

Dr. J. Marwick, besides identifying fossils sent in by field officers, paid short visits to Takapau and Moeraki, in which districts he examined critical sections and discussed problems of structure and sedimentation. He was two months in the Te Kuiti district, a subdivision mapped some years ago by the late Dr. H. T. Ferrar and by Messrs. N. H. Taylor and J. H. Williamson, who are now no longer with the Geological Survey. Dr. Marwick is writing the bulletin on this subdivision.

Mr. N. Modriniak continued geophysical examinations at Kotuku, where he is working out the sub-surface structure of the Tertiary rocks. Occasionally he visited Waiuta, where Mr. W. E. Hall, and later Mr. F. McNeill, used electrical methods to trace lode-channels in rocks concealed by gravels. Mr. Hall, who also did a little similar work in the Progress area during the season, has now joined Mr. Fyfe.

Mr. G. E. Harris prepared eleven photolitho drawings and several blocks, graphs, &c., for reproduction, and in addition did a good deal of miscellaneous drafting work before he retired on 31st December. Mr. W. A. Hampton, who succeeded him, has completed two large maps and coloured many prints.

The thirty-first annual report was issued during the year, as well as Bulletin No. 37, "The Geology of the Rotorua-Taupo Subdivision," by Dr. L. I. Grange. Members of the staff wrote the following papers that appeared in the *New Zealand Journal of Science and Technology* during the year: "The West Nelson Earthquakes of 1929" and "Petroleum in New Zealand," by J. Henderson. "Outline of Geology of Centre Bush District, Hokonui Survey District, Southland," by E. O. Macpherson; and "Mudholes containing Moa Bones at Upokongaro," by J. Marwick. Dr. Marwick also contributed a review of H. C. Schenck's publication on "Nuculid Bivalves of the Genus *Acila*," and Mr. D. A. Brown a review of G. Fischer's "Die Petrographie der Grauwacken."

There were several changes of staff during the year. Mr. G. E. Harris, for thirty-three years draughtsman to the Survey, retired on superannuation. His skill as a draughtsman and compiler of maps, his knowledge of lithographic work, and, above all, his ever-ready co-operation in all problems within his province are here gratefully acknowledged. Mr. M. Ongley, who joined the staff in 1913, is spending a year's leave of absence in New Guinea exploring for oil, and Mr. E. O. Macpherson, who has been with the Survey for seventeen years, while on leave is assisting the New Zealand Oil Development Co. Messrs. A. M. Quennell and D. A. Brown have resigned to join the New Zealand oil-exploration organization of the Shell Co. In October Dr. H. J. Finlay was appointed to the staff as micropalæontologist. He will specialize in the foraminifera, of which the importance in establishing the age and correlation of strata is increasingly manifest in the search for petroleum. Other additions to the staff, Messrs. A. W. Hampton, and W. E. Hall have already been mentioned.

DANNEVIRKE SUBDIVISION.

By A. M. QUENNELL.

Between 15th November, 1937, and 15th March, 1938, the writer, assisted by Mr. B. H. Mason, of Canterbury College, and Mr. A. W. Norrie, of Otago University, mapped in detail 115 square miles of Takapau and Norsewood survey districts. The area is part of the extensive belt of lowland along the east base of the Ruahine Range, is traversed by the Napier–Woodville railway, and includes portions of the upper basins of the Tukituki and Manawatu rivers. The Ruataniwha Plain continues the district northward, the terraced country of the upper Manawatu extends for many miles southward, and the basin of the Porangahau lies to the east beyond a belt of broken hills several miles wide.

West and south-west of Takapau are fluviatile terraces 400 ft. to 500 ft. above the flood plain of the Makaretu, the chief tributary of the Tukituki entering the district. These have been definitely traced south-west for ten miles to a point five miles south-west from Norsewood, and may continue

farther. The north-easterly slope of about 30 ft. per mile of their extensive accordant surfaces suggests that the Tukituki drainage system formerly covered part of the basin now belonging to the Manawatu. Remnants of terraces, shoulders on hill slopes, as well as mature surfaces and truncated upper valleys, occur at accordant heights at many points along the Ruahine Range and among the hills to the east.

The railway from Kopua to Makotuku is on the next lower prominent group of terraces in the Manawatu basin. The surface of this set is some 250 ft. lower than that of the highest group, and as it slopes down the Manawatu that stream had probably captured part of the old Tukituki basin at the time of their formation. In the Tukituki basin the terraces set next below the highest terraces are considerably lower than the corresponding group of the Manawatu.

The streams are still lowering their beds, and in addition to those mentioned there is a number of lower terraces, but, as none is wide, no long pause in down-cutting is represented. The local base-level of the Tukituki is about 100 ft. lower than that of the Manawatu.

Structure.

The great fault-belt along the base of the Ruahine highlands was not examined in detail. The few known faults seem to have an echelon pattern and, striking about south-south-west, make a small angle with the front of the range, which here trends a little west of south.

The hills to the east consist of tilted earth-blocks separated by strong faults which strike in a general south-west and south-south-west direction. This fault-belt in the area examined is six to seven miles wide and there are several strong sub-parallel faults as well as connecting fractures. The interfracture blocks, as judged from the dip of the young Tertiary strata that cover them, are tilted west at moderate angles. The faults are probably high-angle reverse faults, and there is strong evidence in the " drag " of beds along them that the blocks to the west, in addition to their upward movement, shifted horizontally toward the north-east.

The Oruawharo Range east and south-east of Takapau consists of a series of parallel dip-slopes of limestone and sandstone dipping west at moderate angles off the greywacke exposed for miles on the upthrow side of the fault along the east flank of the range. Northward these hills cease abruptly a mile south of Makaretu River. The fault along the east base of this range has been active within very Recent time. To the east, separated by the fault-angle valley of the Makarakeke, are the Tourerere Hills. This range, which continues north beyond the Tukituki Gorge, is also breached by the air-gap followed by the railway between Takapau and Waipukurau. Five miles south of Takapau the Oruawharo and Tourerere hills merge into a belt six miles wide of high broken country with many dip-slopes which continue far to the south-west. Here the Oruawharo Fault tends to die out and the greywacke no longer is exposed on its upthrow side, but a branch striking a little west of south becomes increasingly important. The south-west striking Rangitoto Fault offsets the Oruawharo Fault at its southern end to the west and brings greywacke to the surface at several points. The Waikopiro Fault, a little to the west, has a sinuous course. The Ruataniwha Fault, still farther west, crosses the main road a mile and a half west of Takapau, and, striking about S.30° W., has been traced to the Manawatu River.

A step on alluvial flats, in places 20 ft. high, is the surface trace of the last-mentioned fault, and proves movement along it of very late date. The Oruawharo, Rangitoto, and Tourerere faults also in places show as steps in the surface or as low narrow ridges.

Stratigraphy.

Except that some series are not present in the area mapped this season, the rocks belong to the same groups as outcrop in those parts of the subdivision examined in earlier years.

Mesozoic (?) Greywackes.—Greywackes similar to those mentioned in last year's report occur on the upthrow side of several of the major faults. They are indurated, light-coloured, fine- and coarse-grained rocks, usually deeply weathered. No positive evidence of their age is available.

Raukumara Series.—East from Ormondville hard blue-grey mudstone containing *Inoceramus* outcrops on the upthrow side of the south branch of Oruawharo Fault. It overlies Mesozoic (?) greywacke and is correlated tentatively with the Mangaotane mudstone of the Raukumara Series. The *Inoceramus* fragments are not specifically identifiable.

Ihungia Series.—Mudstones containing foraminifera of Ihungia age and lithologically identical with the Ihungia mudstone of other parts of the subdivision occur in the Tourerere Hills. No older Tertiary rocks were observed this season.

Tutamoe Series.—Thick, coarse sandstones with a few mudstone bands near their base overlie the Ihungia beds with a sharp clean contact. Both series have the same strike and dip. The foraminifera prove the younger set to be of Tutamoe age. North-east along the strike the coarse sandstones rest on Mesozoic (?) greywacke and Mangaotane mudstone.

Mapiri Series.—About four miles east of Ormondville between the Rangitoto and Oruawharo faults there are outcrops of blue-grey mudstone that on its fossil content is placed in the upper part of the Mapiri Series. The relation of these rocks to the Tutamoe beds was not observed in this district.

Opoiti Series.—Massive sandstones with shell bands near their base and grading upward into finer sandstones occur in the same locality as the Mapiri beds, with which they appear to be conformable. The molluscs and foraminifera collected from these sandstones show that they belong to the Opoiti Series. Similar beds occur west of Rangitoto Fault, where they rest on greywacke and have at their base a shelly conglomerate containing pebbles of greywacke and sandstone. The thicker oysters and

pectens in the strata are black, whereas the fragile shells are white. Opoiti beds also outcrop for two miles along the upthrow side of the Waikopiro Fault.

The series is about 1,200 ft. thick. Though the beds appear to be parallel with those of the underlying Tertiary groups, their base was observed to be directly on greywacke and also on Tutamoe beds, the Mapiri Series not being present. Evidently there was a period of uplift and erosion before the deposition of the Opoiti strata.

Te Aute Series.—The lowest bed of the Te Aute Series is a massive sandy limestone containing many shell fragments and at the base numerous pebbles of greywacke, sandstone, and mudstone. Blue sandy mudstone, 400 ft. thick, overlies, followed by a 50 ft. band of strongly cemented limestone, above which are blue-grey sandy mudstones with concretionary bands. The whole series is about 2,000 ft. thick.

In places the lower Te Aute limestone rests on a bored surface of Opoiti sandstone and this, with the sandstone pebbles it contains, suggests erosion of the underlying sandstones. The bedding in these massive layers is obscure, angular unconformity is not proved, and in two localities three miles apart the highest member of the Opoiti beds has the same thickness under the Te Aute limestone.

Petane Series.—The Petane Series consists of rocks lithologically similar to those of the Te Aute Series. The lowest bed, a strong limestone consisting largely of shell fragments, contains numerous shells as well as calcareous algæ. Fossiliferous blue sandstone and mudstone, 300 ft. thick, overlies, followed by limestone which weathers reddish-brown and has characteristic cemented layers. On this rests in upward sequence 200 ft. of less fossiliferous blue mudstone, 30 ft. of coarse current bedded sandstone with shell bands, 20 ft. of sandy shell limestone, and 300 ft. of blue mudstone and sandy mudstone that weathers to a dull-orange colour. Altogether about 1,100 ft. of strata are contained in the Petane Series of the district.

The lower limestone may be in contact with a worm-bored surface of Te Aute or Opoiti strata, and at one point there is angular discordance of about 15°. Movement and erosion separate this series from the Te Aute beds.

Mangatarata Series.—Current-bedded pumiceous sands and silts containing fragments of greywacke and mudstone, and interbedded with thick bands of well-consolidated greywacke gravels, predominate in the Mangatarata Series. A few lignite bands occur. Lithologically similar beds in the Clifton district east from Napier conformably overlie massive beds containing Castlecliff fossils. Near Norsewood finely banded lake silts and sands should perhaps be separated from the Mangatarata beds.

Pleistocene and Recent.—The greywacke gravels of the high terraces form the Pleistocene deposits of the district. Those of the flood-plains and low terraces, together with the red volcanic ash and the intermediate terraces near Norsewood, are of Recent age.

Economic Geology.

Shell limestone is quarried and pulverized in the Maharakeke valley for agricultural purposes. There are vast deposits of this type of limestone which, however, is usually not of high grade. Samples from this district so far examined show a content of from 20 per cent. to 40 per cent. of insoluble material.

The fine, well-graded silica sand forming lenses in the Mangatarata beds at a few points may have value in industry. The pumiceous silts of the same series could be used in sandsoaps or as a filler in bituminous surfacings. Some of these silts have pozzolanic properties.

Roadmaking materials occurs in vast amount.

Though there is definite evidence of the presence of petroleum farther east, the prospects of the Takapau district are distinctly unfavourable. The Tertiary beds of the district are 5,000 ft. or more thick, but likely source rocks such as shales and mudstones are relatively thin, and though several faults are active no oil-seepages or gas-emanations are known.

REEFTON GOLDFIELD.

By Maxwell Gage.

A geological re-examination of the Reefton goldfield which has been carried out during the preceding two field seasons in connection with the geophysical survey has now been completed. The eastern portion of the auriferous belt was studied at Alexander River and Kirwan's Hill, and a small antimony-bearing reef in McConnochie Creek was examined.

The area consists mainly of greywackes, quartzites, argillites, and phyllites of the Greenland Series. Considerable areas are occupied by granite, and, in addition, there are infaulted small blocks of mudstones, sandstones, breccia, and comglomerate of Tertiary age, denuded remnants of Tertiary cover, as well as basic igneous intrusions, morainic materials, and alluvium. No fresh localities of Devonian fossiliferous rocks have been discovered.

Attention was, as before, directed almost entirely to the gold-bearing series. The difficulties that in the past have hampered detailed geological mapping of these rocks were again encountered, and to combat them methods were employed similar to those described in the introductory paragraph to the previous annual report on the work in this area. These, however, proved rather less successful owing to the prevalence of faulting in the eastern area and to the common occurrence of massive greywacke in which the bedding is obscure over considerable distances.

Alexander River.

In the south-east corner of the Reefton Subdivision a narrow zone of auriferous greywackes lies between the main eastern granite mass and another belt of granite extending from the Big Grey River northwards to the Waitahu. Although the present boundaries between this greywacke strip and the granites are faults, visible in several localities, nevertheless there are indications, from a tendency in places to recrystallization, that the greywacke may originally have taken the form of an elongated roof pendant projecting down into the batholith. It is surprising, then, that no true dykes of pegmatite were encountered, and, further, that the lodes are of the mesothermal type characterizing the Reefton field. The granite encountered near the contact in the upper reaches of the Alexander River was of a type that suggests a magma of high viscosity and comparatively low temperature at the time of its uprise. From such a magma extensive apophyses might be expected to be absent. Modification will be necessary of the granite - Greenland Series boundaries as shown in the maps with *N.Z. Geol. Sur. Bull. No. 18* (Reefton Subdivision).

In addition to widespread normal faulting, westward-directed thrusting was again evident in the eastern area. An excellent example of a low-angle reverse fault, by which granite has been thrust over greywacke, was seen in the Alexander River Gorge. Massive complexly-jointed, quartzose greywacke is the prevalent type, and elucidation of fold structures was not accomplished; but where reliable dip and strike observations could be made the strata were everywhere steeply dipping and in many places approached verticality. It seems best to regard the field data as indicating a series of close folds aligned from 10° to 20° east of the meridian, dislocated and largely destroyed by numerous normal faults and compressional shear-zones. The more important faults typically are guided by the direction of strike of the rocks. They are well seen in the cross-sections provided by Mullocky Creek, Bull Creek, on the power-house race in the Alexander River, and in the mine. Faulting transverse to the structure may also be seen in the mine workings.

A strip of Tertiary rocks hitherto unrecorded was discovered in the upper Alexander River. It is about 10 chains wide, is bounded on both east and west by faults, and lies between granite and Greenland rocks. The occurrence is known to extend southwards to the head of the basin of Mullocky Creek, but the streams entering the Alexander River from the east below Mullocky Creek bring down no Tertiary detritus. Similarly, the creeks flowing into Absalom Creek from the east carry no Tertiary waste, so that the limit of these rocks in this direction cannot be far north of the Alexander River. These rocks, consisting of coarse breccia similar to the Hawk's Crag breccia, feldspathic grit and sandstone, are probably a fragment of a Tertiary cover elsewhere stripped off by erosion, but here entangled in what appears to be one of the major faults of the region. Another infaulted fragment of Tertiary rock occurs a short distance below the junction of the Alexander River with the Big Grey; here an arenaceous limestone passes upwards into soft dark sandstone.

The Alexander Reefs.

These consist of a fairly regular line of short ore bodies, evidently occupying a shear-zone or series of close-spaced vein fissures within the one fault-zone, conforming in trend with the general strike of the rocks. The several blocks probably represent local expansions of lode material at various points along the one main mineralized fault-zone. At present only the so-called Bull Block may be studied within the workings. This block, the most southerly worked, is pitching northwards, the usual condition in the Reefton field, and is dipping steeply east.

The quartz which first attracted attention to the Alexander area appears to have been loose blocks of shoad-stone that had been shed by reefs of which the situation at depth could not reliably be forecast from surface observations, trenching, &c. This was due partly to the effect of faults which are not readily detected by surface prospecting, and also to a large extent to the very steep topography, which, aided again by the fault-induced shattered condition of much of the rock, causes surface creep to a marked extent. The flattening of the Bull reef near the surface, which led to misconceptions and difficulties in the early development of the mine, is, it is believed, due to this combination of factors. The creep effect is strikingly evident in cuttings on the incline leading to the Mullocky Creek section of the mine.

The effects of faulting on the reef itself are important. The earliest faulting would appear to be that resulting from the breakdown and shearing-out of the close folds, providing means of escape to the surface of contemporaneously active magmatic solutions. Longitudinal constrictions in the ore bodies and their pinching out and dislocation vertically seems to be due to another system of faults, also more or less parallel with the strike, but of tensional origin. Small cross-faults which displace the reef laterally may be due to a later phase of thrusting, and perhaps represent the boundaries between a number of small blocks differentially thrust westwards.

Although it is the rule in the Reefton goldfields for values to be maintained at depth, the future development at deeper levels of the Bull block may be affected by faulting, which may prove to have dislocated the reef to a serious extent. Further prospecting south from the present workings should be carried out, driving south from the south end of the reef, and cross-cutting in both directions. Shoad-stone of interesting value has been reported on the surface to the south of the present workings, but surface prospecting is regarded by the writer as unreliable in the circumstances, and the possibility of other blocks existing in this direction should be tested from within the mine. Further, now that pneumatic rock-drills are in use and facilities improved for the transport of heavy machinery to the mine, it should be possible economically to extract the hard stone in the Mullocky and other northern sections, which defied hand-steel mining methods and was abandoned.

Kirwan Hill Area.

North of Waitahu River there is no division of the greywackes into two strips by a granite ridge, so that they are continuous from Capleston eastwards to the slopes of the Victoria Range, beyond the Montgomerie River, except for a small block of infaulted Tertiaries in the upper reaches of Boatman Stream. Faulting, massive rock types, and a deep cover of loose detritus prevent the establishment of good sections and obscure the structural relationships. There is an anticline in the Greenland rocks east of the syncline described in last year's report as having its axis near Potter Creek, a tributary of Larry Creek. Somewhat to the west of its crest in Larry Creek a group of granitic dykes occurs. Elsewhere less clear owing to faulting and other causes, this structure is best illustrated in the oblique section afforded by Larry Creek, Drysdale Creek, and the lower east branches of Montgomerie River. Farther south only the east flank is distinctly seen. It is notable that the greywackes and argillites are generally less metamorphosed than is usual in this area, the phyllitic types being largely absent, except adjacent to fault-zones. A possible inference from this is that we have here the upper beds of the Greenland Series, which, being less thickly covered, responded to tectonic stresses to a larger extent by faulting than by folding, as was the case in the western area.

In addition to the known occurrences, Tertiary beds were found between the eastern margin of the auriferous rocks and the granites of the Victoria Range. These outcrop as a narrow strip running along the eastern side of the Montgomerie Valley for about three miles above its junction with the Waitahu River. They may be continuous with the coal-measures between the Waitahu and Inangahua rivers in the neighbourhood of McConnochie Creek, but a cover of gravels obscures the position in the Waitahu Valley itself. This occurrence is evidently another example of entanglement of fragments of Tertiary cover within the zone of the important fault fronting the Victoria Range, a case analogous to that already described from the Alexander River. Coal-seams are contained in the rocks involved, but they are not of economic value owing to the extreme narrowness and faulted condition of the Tertiary strip. The large mass of intrusive dolerite discussed in the previous report was found to extend farther south than previously known.

Kirwan's Reefs.

The whole of the sinuous ridge known as Kirwan Hill and the surrounding country suffered a severe shaking from some geologically recent, although probably prehistoric, earthquake. Numerous earthquake escarpments and ridges are to be found, in general following the direction of the ridge, and large, overgrown ancient landslips exist in several places. Similar features are known to exist outside the subdivision in the Victoria Range and elsewhere in the region. One vast landslip in particular has descended from what is now a depression in the Kirwan Ridge, at the site of the rich Lord Brassey Claim, and now occupies an area represented roughly by a triangle with approximately half-mile-long sides, the base along the ridge, and the apex reaching well down into the Montgomerie Valley. The detritus was derived apparently from the collapse and projection down the eastern slopes during an earthquake, of the material of the ridge crest. Thus the loose auriferous rubble and "floaters" of rich stone mined on the Lord Brassey Claim were part of this great mass of slumped surface material. To restore all the slumped material to its original position would be to raise the height of the ridge by an amount of the order of 100 ft. The upper western slopes are cloaked with loose-slumped material, and that the entire ridge has been profoundly shaken even at places remote from the great slide is evident from the loose and broken condition of the country in which a tunnel is being driven by a leaseholder.

A strongly mineralized, steeply east-dipping shear-zone is showing in Drysdale Creek, is recognizable on the ridge above and, although it cannot be followed along its south-south-west strike across the intervening distance owing to the cover of slip detritus, may with some confidence be regarded as the same fault-zone as that which acted as an ore channel and contained a rich body of quartz where it crossed the south end of Kirwan Ridge. This ore-body may have cropped out at or near the crest of the ridge, as it was before the disturbances, on or about the site of the Lord Brassey Claim, its material being involved in the slip, from which the ore was mined, or rather, quarried. The other reefs outcropping farther north, more or less in the solid, and the other occurrences of quartz of similar appearance in the slumped area are nowhere as rich, but the most satisfactory explanation of these seems to be that they were separate shoots of quartz within the same lode channel but of lower gold content. Therefore to locate the downward continuation of the rich shoot that supplied the loose stone of the Lord Brassey Claim a prospecting-tunnel should be driven from the western side at about 250 ft. to 300 ft. vertically below the present ridge crest, and at such a point as will cause it to cut the probable line of reef some 200 ft. to the north of the open workings, in order to allow for a northerly pitch for the shoots. The adit now being driven is, it is believed, too far west and too high to strike the rich shoot.

The presence of the slip was recognized many years ago, but its significance in connection with the search for the roots of the ore-shoot does not seem to have been appreciated.

The Structural Control Hypothesis.

The work described in the two previous annual reports gave strong support to the theory that the sheared crests and troughs of anticlinal and especially synclinal folds were particularly favourable conducting channels for ore-depositing solutions. The data obtained this year, when applied to this problem are inconclusive. In the Alexander area the auriferous rocks are a fault-bounded fragment of which the relationships with the rest of the Greenland Series is not clear. The Kirwan reefs appear

to be a departure from the hypothesis, as they seem to occupy a mid-flank position on an anticlinal fold. Several factors, however, tend to obscure the evidence and render its interpretation more difficult than usual. Consequently we cannot ignore the success that has attended the application of the hypothesis in the past in this subdivision, and there is no doubt that in directing prospecting for auriferous lodes in new country the geological structure should be the first guide.

Blackwater Mine.

Through the courtesy of Mr. T. Hogg, manager of the Blackwater Mine, it was possible to examine an intersection between the main reef and a basic dyke. This was seen in Naylor's Stope, No. 11 level north. The dyke was also examined at other places where it is close to the reef in Nos. 12 and 13 north.

The dyke interrupts the reef in No. 11, and at no place in the mine does the reverse apply. Small inclusions of country rock are not uncommon within the reef, but no case of a fragment of dyke material being thus included in the reef has been recorded. These facts point strongly to a later age for the dyke. A number of minor faults intersect both dyke and reef, but both features seem to be equally affected. Hydrothermal alteration of the dyke rock where it is close to the reef has been suggested as evidence for the reef being the younger. It seems, however, more reasonable to attribute this, and also the presence of tiny veinlets of quartz, differing markedly in character and appearance from that of the main reef, to the action of later active solutions rising in or near the vein fissure, which would doubtless long continue to be an easy path for them. The dyke rock is of a type particularly susceptible to alteration of this kind.

The so-called "Prohibition Fault" obliquely cuts off the main reef at the north end in all levels. No. 13 level had at the time of this visit been driven north just through the fault, from the drag effect shown by the end of shear planes in the country rock, by dyke rock fragments in the pug, and by the material of a small leader in the roof, it can be seen that the country on the north side of the fault, which was steeply dipping where seen, has moved west as regards the horizontal component. The effects seen can only be accounted for either by a normal fault with relative upthrow to the north, or by a fault with some element of westerly thrust on the north side of the fault. In either case a search for the continuation of the reef beyond the fault would seem to be best effected by driving through it and crosscutting westwards. This should be done at the lowest level, to lessen the distance required to be crosscut, owing to the steepening of the reef in depth.

GREYMOUTH COALFIELD.

By H. E. Fyfe, M. Gage, and W. E. Hall.

Introduction.

The chief object of the present survey is to determine the amount of economically recoverable coal within the coalfield. A prerequisite to the establishment of secondary industries requiring large tonnages of coal is a thorough knowledge of the economically recoverable coal. Experience and knowledge gained from mining operations over the period since Bulletin No. 13* was published all suggest that the resources of the coalfield are extremely limited, and if this is the case the survey will be justified in proving this conclusively, so that efforts may immediately be made to conserve our resources, to prove the field systematically by boring, and to develop the field as a unit. A detailed geological survey is a means to this end. It cannot in itself provide all the essential data, but it can utilize all the information available, and direct boring operations.

The late Mr. P. G. Morgan was aware of the limited resources of the bituminous coals, for he wrote† :—

> "Too much emphasis cannot be placed on the question of utilizing the coal resources of New Zealand to the best advantage. Already much waste has occurred in almost every coalfield of the Dominion. The supplies of high-class coal are somewhat limited, and therefore their conservation is a matter of the greatest national importance.
>
> " . . . The amount of coal in the Grey Coalfield is estimated at 636,000,000 tons, less 6,000,000 tons already mined. Of this great tonnage, however, a very large proportion can hardly be considered as workable at a profit under any economic conditions ever likely to prevail. If present conditions continue to prevail in all respects, the writer has little hesitation in saying that not one-tenth of the coal in the ground will ever be extracted."

From what information has so far been gathered by the present survey it seems that 63,000,000 tons rather than any larger estimate represents more nearly the actual tonnage likely to be economically recovered from the field. The coal-mining industry on the Grey field would appear to be at, or rapidly approaching, a critical stage in its history. This is due not only to an impending exhaustion of the readily mineable coal, measureable within a couple of decades at most, but also to the scarcity of coal-seams workable under existing economic conditions.

There are few blocks, if any, within the whole coalfield that are so favourable for production as that in which Liverpool No. 2 Mine is now operating. Of the two seams there developed, the upper, or Kimbell, seam to date has been proved to carry workable coal over a distance of 70 chains meridionally and an average of 50 chains transversely. Southwards the seams may extend with a diminished width beyond the No. 3 Extended section of the State mine, but the fault that cut off the southern extension of the No. 4 section will probably intersect the Morgan and Kimbell seams from 15 chains to 20 chains

* Morgan, P. G.: The Geology of the Greymouth Subdivision, North Westland. *Bulletin No. 13* (New Series), 1911.

† *Ibid.* p. 28.

beyond the present dip-drive. What is more significant, the seam has definitely diminished in thickness towards the south from an average of 20 ft. at the north of the present workings to, at most, from 7 ft. to 10 ft. This is the largest coal-bearing block so far proved in the whole Grey field, and it is unlikely that any block will exceed this in areal extent and simplicity of structure. The amount of proved coal in the Kimbell and Morgan seams, as at present developed, is estimated at 4,000,000 tons by the manager, Mr. A. Smith, and of this about 50 per cent. will be recovered. To this must be added the estimated 6,000,000 tons recoverable from the new James Extended, giving 8,000,000 tons of recoverable coal that the State Mines Department can confidently rely upon.

The co-operative mines can work only those comparatively small blocks favourably placed for transportation, and consequently they are situated along or close to railway or road. These are blocks that have been faulted or folded into such a position that no costly development-work is necessary for their exploitation. The most accessible of these are now being mined, and in a few years will be exhausted.

From the foregoing, and from Mr. Morgan's considered statements, it is manifest that the resources of the Grey field must be conserved. How this may best be accomplished can be determined only after an exhaustive investigation of the whole field, and this entails an extensive boring programme. Two avenues suggest themselves. One is that the field should be developed as a unit; the other is that the possibility of mining stony seams, and of subsequently extracting the stone and washing the coal, should be investigated.

All the coal from any one area should be recovered while transport facilities are available and before the major seams of that area are exhausted, for in most areas it will not be possible economically to re-establish the transport system and to recover patches of coal that remain. Operations in one area should not be conducted so that in extracting coal from one seam the coal in an overlying seam is lost for ever through the country caving. It cannot be too strongly emphasized that on present prospects problematical areas where coal may exist at considerable depth, thin seams, or remnants of thick seams in remote localities, and seams with a considerable admixture of stone and dirt, all regarded as valueless at present, soon will be all that remain of the coal in the Grey field.

Much coal is lost in mining some of the large seams through stone bands interbedded with the coal rendering the seam unworkable, not on account of the cost of mining the coal and stone, but because there is no economical method of treating and separating such a mixture. Again many patches of coal contain bands of "holing dirt," a fissile highly carbonaceous shale, some of which finds its way into the marketed coal. There is quite a possibility that much of the coal at present lost in the stony areas could be recovered if a suitable treatment and washing-plant were available. Not only does this apply to areas in the State mine, but also to seams that can never be worked unless such treatment is possible. It is imperative at some future date, if we are to rely on our bituminous-coal resources for domestic consumption, to work seams containing stone and dirt bands, and the time has arrived when consideration should be given to this aspect as a possible means of conserving our resources. The economy of mining coal-seams containing stone, and subsequently washing the coal, is one that will present difficulties peculiar to New Zealand.

Faults and Structure.

Just west of the main divide from the junction of Edward Ridge with Tom Ridge, southwards towards Mount Davy, two sub-parallel faults strike slightly east of north, and enclose between them an elongated block averaging 5 chains across. This block, which is here called the Will Block, extends from Otto Creek, west of Will Ridge, south into the upper Davy Creek, where the two faults are 20 chains apart. An abrupt change in dip of the even-crested dip-slope at a point about 45 chains south-west of Trig. G, on the ridge south of Davy Creek, probably marks the trace of the eastern fault. A north-easterly striking fault traverses the upper part of Davy Creek from the saddle at the head of it to the fault just described, where it is terminated against the Will Block. The western fault crosses the divide between the Seven Mile and Coal creeks roughly 20 chains north-east of Trig NN, situated on this divide. The strata of the relatively upthrown block east of Will Block dip south-eastwards on the divide between Carroll Creek and Waiomo Creek headwaters, and the tributaries of Paparoa Creek to the east. South-east of the north-east striking fault at the head of Davy Creek the strata dip south-westwards in conformity with the dip-slopes of Mount Davy Block. Within Will Block westerly dips prevail in Waiomo Creek basin and in Carroll Creek basin the strata appear to be synclinally folded. South of this the structure is imperfectly known, but the synclinal fold appears to continue to Davy Creek, with a pitch to the south.

West of Will Block is the Liverpool Block, the largest comparatively unfaulted block yet mapped. On its west is Tararu Fault, which traverses Tararu Creek and cuts off the westward continuation of the seam previously worked in No. 1 section of the Liverpool Mine, the downthrow, 500 ft., being to the west. Southwards this fault strikes just west of Nos. 2, 3, and 3A sections, Liverpool Mine. It crosses the Seven Mile, 12 chains west of Goldlight Co-operative Party's bin. Broadly speaking, the Liverpool Block is a southward pitching anticline 65 chains across on the Ten Mile – Seven Mile watershed, and narrowing to 50 chains at the confluence of Davy Creek with the Seven Mile. Here the crest of the fold is 30 chains across, and the steeply dipping eastern limb has widened to 20 chains. As a consequence, the present Liverpool No. 2 Mine workings if carried south, will ever diminish in width should the seams continue to be of economic value to this point. Minor folds and fractures are superposed on this broad anticline, the most conspicuous being the zone of folding and faulting along the Seven Mile from Tararu junction southwards, in which direction the minor folding and fracturing diminishes, ultimately merging into a minor fold. Goldlight and O'Brien and Party's mines are situated on the crest of this fold in the Seven Mile.

A fault of some magnitude traverses the eastern slopes of the lower valley of Davy Creek. It crosses the divide between the Seven Mile and Coal Creek about 15 chains north-east of Trig. NN, and its trace in Davy Creek is indicated by disturbed country 3 chains east of the right-angled bend about 35 chains above its junction with the Seven Mile. A fault-zone in Carroll Creek, 20 chains above its junction with Waiomo Stream, seems to be the northward continuation of this fault.

West of Liverpool Block is the Mount Ike Block, a composite block which contains at least three sub-blocks that are not well established throughout their length. The fault-zone marking its western boundary is the north-eastward continuation of the Dunollie Fault. It traverses Spring Creek basin, and it may bifurcate at a point roughly 55 chains west-north-west of the junction of the Seven Mile and Waiomo Creek, one branch continuing north-north-east, and the other almost due north to Bishop Creek. It is probable, however, that the western one of these faults, which is definitely proved in a tributary to Biship Creek, is the continuation of a north-striking fault that has been proved at one locality on the west side of Spring Creek. The block contained between these two faults is the westernmost of the three Mount Ike sub-blocks. It is 25 chains across, is folded into a gently southward-plunging syncline, and is downthrown relativley to the central block. The middle sub-block is bounded on its east by the meridionally-trending Parawai Fault, and is comparatively steeply folded into a southward-plunging syncline. It is downthrown relatively to the eastern sub-block which is folded into an east- to south-east-pitching syncline, and appears as the downfaulted portion of the western limb of a synclinal fold on the west edge of the Liverpool Block. The southward continuation of the Parawai Fault cannot definitely be traced, but it may join the Tararu Fault. In the vicinity of Mount Ike the strata dip south-westwards without any marked folding, and probably form the crest of a comparatively broad, pitching anticlinal fold. This, the central sub-block, shows some complexity of structure in the Seven Mile where, west of the Tararu Fault, a southward-plunging anticline is followed by a plunging syncline, faulted on its west limb by a fracture that crosses the Seven Mile 7 chains east of Spring Creek. Steeply easterly-dipping beds outcrop west of Spring Creek, the section being terminated by the Dunollie Fault.

The Hall Ridge Block, part of which was examined this season, is west of the Mount Ike Block. At its north end it is bounded by a fault mapped by Mr. R. T. H. Dale, that strikes west-of-south from near the junction of Doherty Creek with the Ten Mile. North of the Ten Mile this fault was mapped and named the Wafer Fault by the late Mr. S. W. S. Strong. It may be expected to parallel more or less the strike of the Dunollie Fault and to cross the lowlands west of Dunollie, probably traversing Cavern Creek basin. The strata at the north of the block are shown by Mr. Dale to be folded into two southward-plunging synclines, alternating with two anticlines. Some reversals of dip in the headwaters of the Nine Mile seem to be but a minor structural feature, unless it be that the westernmost fault of the Dunollie zone extends through here. Southwards from Trig. C a southward-plunging anticline is followed by a syncline on the east. A fault which strikes due north separates these folds in a tributary flowing east to Spring Creek. The southern continuation of this anticlinal fold shows in the Seven Mile, a short distance upstream from Dunollie. On its crest are the old workings of No. 2 section of the Point Elizabeth Mine. A small synclinal fold parallels this anticlinal fold to the west, and this in turn is succeeded by an asymmetrical anticline, on the west flank of which are the group of co-operative mines north of Dunollie.

Viewed from a distance, the different blocks appear as tilted fault-blocks rather than as folded blocks. Their flanks, however, are folded to such an extent as to preclude the possibility of the folding being due merely to drag along the fault. It seems that the strata folded to a considerable extent before fracturing along the deformed zones.

Stratigraphy.

For a detailed description of the rocks of the coal-measures the reader is referred to Bulletin No. 13. Only the more important occurrences of coal-seams will here be mentioned, roughly in order of age, commencing with the oldest.

No coal-seam of any importance has been noted in the basal Paparoa conglomerate in Bishop Creek watershed, nor in the section north of Blackball Peak, though there are one or two minor seams interbedded with dirt and stone bands in the upper part of the conglomerate in this area. The overlying shales and sandstones classified as "Lower sandstones and shales" in Bulletin No. 13 contain, in a tributary that joins the Ten Mile 30 chains below its confluence with Bishop Creek, three coal-seams that are of workable thickness. These seams have been followed for a short distance, but a considerable amount of trenching and prospecting will be essential to prove their value. They outcrop at the north end of the Hall Ridge Block, and they should be worked in conjunction with the new James Extended Mine. A similar sequence is found in a tributary flowing north, and joining Bishop Creek half a mile above its junction with the Ten Mile. A north-north-east-striking fault, one of those comprising the Dunollie zone, determines the course of this tributary and downthrows the Hall Ridge Block 140 ft. In the western sub-block of the composite Mount Ike Block, which is immediately east of the fault just described, Mr. R. T. H. Dale, of the State Mines Department, has proved the continuation of one of the seams that outcrops in the Hall Ridge Block for a distance of 25 chains east, where it is again cut by a fault of the Spring Creek zone. A fair amount of prospecting in this sub-block is necessary to prove the presence of the other seams that outcrop in the block next west. East of the Spring Creek fault is the central synclinal Mount Ike sub-block comprising a

zone of comparatively highly folded strata, traversed undoubtedly by minor faults. One of the major seams crops out in it, but, owing to the cover of slip material and vegetation, it will be impossible to follow the seam without considerable trenching.

The seams described above do not apparently live to the east of this, unless perhaps the 12 ft. seam that outcrops on the ridge 20 chains south-east from Blackball Peak (Trig. K) is the equivalent of one of them, but this seam is regarded at present as the equivalent of that to be next described.

In the easternmost of the Mount Ike sub-blocks, and in a north-flowing tributary joining Bishop Creek a mile above its junction with the Ten Mile, is a seam that has been followed for 15 chains and shows at one locality 10 ft. of coal. There is sufficient proof that this seam is separated from the underlying shales by an important unconformity, for some distance below it is a conglomerate containing well-rounded pebbles of bituminous coal up to 2 in. across. But such is the difficulty of mapping in the whole area that this break has not been definitely established elsewhere.

The section exposed in a creek flowing north from the trig at Blackball Peak shows the upper part of the basal conglomerate with a minor coal-seam and a considerable thickness of overlying shale and sandstone, but no coal-seam that could be correlated with those above described at the north end of the Hall Ridge Block. South-east from Blackball Peak a distance of 20 chains, a 12 ft. seam crops out, which, when followed south-west, thins to less than a foot within 10 chains. Eastwards it will have to be prospected to prove if it lives for any distance.

The Morgan and Kimbell seams apparently belong to horizons above those of the seams just described. Neither has been found at the north end of the Liverpool Block nor in the Mount Ike Block to the west, and possibly they do not live so far to the north, for the Kimbell seam which crops out at the junction of Carroll and Waiomo creeks when followed for 35 chains up the latter stream is found to grade into carbonaceous shale.

At the north end of the Liverpool Block, and cropping out on the ridge between Seven Mile and Bishop creeks, are two seams that each show 6 ft. of coal at one or more of their outcrops. There is no great extent to these seams, as they have been considerably denuded. They are above the horizon of the Liverpool seam, and are probably to be correlated with remnants that crop out near the ridge-top on the westernmost of the Ike Peak blocks. Other remnants of seams corresponding roughly with this horizon, and showing up to 6 ft. of coal, crop out near the crest of the ridge north-east of the junction of Waiomo Creek with the Seven Mile. Three seams in a corresponding position in the sequence show thicknesses of 3 ft., 5 ft., and 11 ft. respectively, and crop out in a tributary of Waiomo Creek that flows south from the saddle at the head of Otto Creek. Two seams of this group appear on the west of the divide at the head of Waiomo and Carroll creeks. One seam is 5 ft. 3 in. thick and the other 9 ft. 6 in., but apparently they peter out southwards, for they do not show in the southern headwaters of Waiomo Creek. These seams outcrop also in the Will Block. The seams worked in the Bins section of the State Mine correspond with the seams here described. In the strip of country averaging 15 chains across west of Will Block are some minor seams, the greatest observed thickness of any one of which is 4 ft. 4 in. They outcrop in both Carroll and Waiomo streams, and are probably lower in the sequence than the other seams here described. No coal-seams have been observed in the overlying shaly mudstones.

Conclusion.

The conclusions reached by Mr. Morgan regarding the small coal resources within the field and their probable depletion at no distant date are substantiated by the present season's work, no thick seams of any extent other than those already known having been discovered They may exist at depth in areas of less extent than that in which the Liverpool Mine is at present operating, but their presence will require to be proved by deep boring. The horizons containing the thickest and most persistent seams are those now being mined. The untouched resources to-day consist of the hypothetical deeper seams, seams of lesser thickness overlying those now being extracted, and other seams which cannot economically be mined before the problem of utilizing stony seams has been solved. The amount of coal ultimately to be extracted from the Grey field will be still further diminished if the working of all workable overlying coal is not undertaken at the same time as that of the main seams.

MOERAKI SUBDIVISION.

By D. A. Brown.

In this subdivision, which embraces the Otepopo, Moeraki, Waihemo, and Dunback survey districts, field-work was commenced on 29th November, 1937, and up till 31st March, 1938, approximately 200 square miles had been surveyed and mapped. Field assistance was rendered by Mr. O. D. Paterson, of Otago University, from 2nd December, 1937, to 28th January, 1938, and a short visit was made by Dr. Marwick at the beginning of March. The aid given by Professor James Park in the elucidation of the Hampden Series and many other problems is also gratefully acknowledged.

The survey of Otepopo and Moeraki survey districts is almost completed, leaving the greater part of Waihemo and Dunback districts to be done. These latter, however, are small districts and appear fairly simple, so that it is hoped to complete the subdivision by the end of the field season.

Physiography and Structure.

As in the neighbouring Naseby Subdivision and, in fact, Central Otago as a whole, two major divisions of the rocks are apparent. First, the undermass of ancient sediments exhibiting various stages of metamorphism, and, second, the cover of younger unaltered material. Peneplanation of the older rocks was far advanced before the deposition of the overmass of Secondary and Tertiary sediments, and following this there occurred a period of extensive block-faulting resulting in the tectonic depressions and elevated block-mountains of to-day.

The Moeraki Subdivision is divided into two major structural units by the Shag Valley Fault, which runs north-west from Shag Point. The eastern upthrown block is tilted to the north-east and drained chiefly by the Kauru, Waianakarua, and Kurinui rivers. Its high south-west border is the Horse Range. The western block, forming the back-slope of the fault-angle, is tilted similarly and drained by the Shag River and its tributaries. On both blocks the stream-courses have little or no relation to the structure of the undermass—viz., the schists—and obviously have been superposed from the sediments of the overmass. This feature is particularly well shown west of Hampden and at Waihemo.

On the older rocks, which form the greater part of the district, the dissection is very sharp in contrast with that on the late Secondary and Tertiary formations which have gentle rolling topography.

Owing to the high competency of the basement rocks faulting rather than folding controls the structure. The most important fracture, the Shag Valley Fault, or Fault system, was described by S. H. Cox as early as 1882. From the base of Puke Hiwi Tahi, the peak at the east end of Horse Range, it runs up Woolshed Creek for three miles and ends abruptly in a cul-de-sac near the Horse Range Road. Here a transverse fault striking north-east causes a break in the major system. Beyond this point the dislocation in the crust is along two parallel north-west fractures, one passing west of Harry Peak, and the other, the major break, east of that peak and continuing almost unbroken beyond Waihemo and out of the subdivision. The elongated block between the faults forms the Blue Mountains.

Since the older beds (Wanaka Series) form the downthrown block, it is obvious that the Shag Valley Fault is of ancient origin and that the latest movement along the fracture was the reverse of that which originally took place. This was first pointed out by Cotton,* and the following cycle of events seems to represent the history of the terrain involved in the fault movements. After the deposition and metamorphism of the sediments which are represented by the Wanaka and Kakanui series of schists, a fracture with downthrow to the east occurred along the line of the present Shag Valley. Extensive erosion and even peneplanation followed, causing the removal of the younger (Kakanui) series from the upthrown block. In Cretaceous times negative epeirogenic movements took place and the rivers deposited conglomerates and coarse sands under conditions similar to those obtaining during Pleistocene and Recent times on the Canterbury Plains. Marine deposition of various sediments continued with slight breaks till the Pliocene, when faulting movements caused the Shag Valley to assume its present shape.

As would be expected, transverse and oblique faults are numerous, and in one case, at the Blue Mountains, the fracture has proved advantageous in that it has faulted limestone down from an elevation of 1,200 ft. to a workable level of about 400 ft.

Away from the Shag Valley faults are common—for instance, west of Herbert the limonitic sandstones have been depressed nearly 600 ft. along a north-south fault; near the Waianakarua Estuary south of Trig. B a fine fault-section is exposed with horizontal Waiarekan tuffs lying on a 30° plane against Hampden Clays; at Kakaho Creek a sub-Recent fault trending eastwards is nicely exhibited; in the Shag Point coal-mines trouble is experienced owing to the presence of strong faults; and west of Dunback a fracture running west-south-west passes from Wayne's to a considerable distance beyond the geodetic station at Dunback Hill. Other minor breaks are too numerous to mention.

The succession of strata on the eastern structural block indicates that the latter has been intermittently rising since late Mesozoic times; the sediments become increasingly younger as one passes eastwards. It is possible that this uplift has produced the syncline in late Cretaceous beds at Shag Point.

Stratigraphy.

A great succession of lithologically distinct strata occurs throughout the subdivision, but, unfortunately, fossils are extremely rare until the Tertiary formations are reached.

Wanaka Series.—Rocks of this series continue from the Naseby Subdivision and end abruptly at the Shag Valley Fault. They are foliated quartz-mica schists with schistosity planes dipping north-east about 20° or 25°. Quartz veins are common and are auriferous in many places.

Kakanui Series.—These rocks constitute the undermass of the eastern block and consist of argillaceous semi-schists and coarse sedimentaries affected relatively little by metamorphism and therefore best classed as greywackes. An interesting volcanic rock, probably an andesite, interbedded with vesicular material and displaying schistosity, was discovered west of the "Dasher" homestead in Waihemo Survey District, and belongs to this series.

Waihemo Series.—This term was introduced by Williamson† for a unit consisting of greywackes and argillites outcropping in the upper basin of Shag River on the east side of the main fault. They

* Cotton, C. A.: "Block Mountains in New Zealand," *Am. Jour. Sci.*, Vol. 44, 1917, pp. 249-93.

† Williamson, J. H.: *28th Ann. Rep. N.Z.G.S.*, 1934, p. 7.

extend across Mount Stalker to a few miles west of the "Dasher" homestead. The junction with the rocks of the Kakanui Series is not sharp, and no trace of Williamson's hypothetical fault was found, so that the Waihemo Series may merely be a competent phase of the Kakanui Series.

The three series described above are classed tentatively as Palæozoic in age. A sharp break is present above the Kakanui Series, and the next rocks encountered are of Cretaceous age. Professor Park had given to him a specimen of *Pleuromya* cf. *spitiensis* Holdhaus, a typical Jurassic fossil, reported as having been found in the strata west of South Peak, Hampden. Up to the present, however, the only rocks known in this locality are Kakanui semischists, so that further investigation is necessary.

Horse Range Series.—Coarse conglomerates with occasional sandstone bands occur throughout the western parts of the Horse Range and form the coal-measures at Shag Point. The pebbles of the conglomerate are up to 3 in. diameter and consist chiefly of schist and quartz. As noted earlier, the conditions of their formation were probably similar to those of the gravels on the modern Canterbury Plains, and ancient lagoonal swamps are represented by seams of lignite and coal.

Herbert Series.—This series is substantially the same as McKay's Limonitic Sandstone and occurs more or less continuously along the foothills from Island Stream southward to Puke Hiwi Tahi. These limonitic quartz sandstones are seen, in a few places, to rest unconformably on the Horse Range conglomerates, but difficulty is experienced in separating sandy phases of both series, so that it may be necessary to map them as one unit. Fossils are rare, but the presence of *Trigonia* indicates a Cretaceous age for this series.

West of the Shag Valley Fault limonitic sandstones and conglomerates are present as isolated caps on the mica-schists, and the deposition of these sediments was probably cœval with that of the Herbert Series. From Williamson's descriptions*, the Hogburn Series of Naseby Subdivision seems to be the nearest equivalent of the Herbert Series.

Otepopo Series.—High-grade greensands appear near Herbert Township and stretch southward to Waianakarua, where they seem to lens out between the Herbert Series on the west and the Hampden Series on the east. So far no fossils have been collected from these beds.

Katiki Series.—South of Waianakarua the Otepopo Series is replaced by a group of shaly, greyish-blue sandstones containing occasional spherical concretions. These are the Kartigi Beach Beds of McKay, and they extend to Shag Point, where a few belemnites have been collected.

Moeraki Boulder Beds.—These lie east of the Katiki Series and consist of buff-coloured shaly mudstones with large septarian concretions well exposed at the south end of Hampden Beach. The evidence of the Foraminifera is not yet definite, but this series appears to be merely a facies of the Katiki beds.

Hampden Series.—A richly fossiliferous group of pale-blue micaceous mudstones and clays appears to the south of the Waianakarua Estuary. A division into three stages has been made by Professor Park and is confirmed by the work of Dr. Finlay on the Foraminifera. The lowest strata are glauconitic clays with occasional fossils, greensands overlie, and the younger beds which extend north to Kakaho Creek, contain numerous Bortonian fossils.

Concretionary greensands overlying fine micaceous clays outcrop in the cuttings of the Shag River, near Dunback, and from foraminiferal evidence are placed tentatively in the Hampden Series.

Apart from rather weak stratigraphical evidence in favour of correlation with the Hampden beds, there is little to indicate the age of the fine-grained, pink, sandy mudstones and glauconitic sandstones occurring at and near Palmerston.

Waiarekan Volcanic Group.—Tuffs and volcanic breccias form the gently-undulating coastal strip between Kakanui and the Waianakarua Estuary. Associated closely with these rocks are the dolerites and basalts of Mount Charles, Look-out Bluff, and Moeraki Point. At Herbert the tuffs are extremely hard and fine-grained and have been used in the construction of the flourmill at Waianakarua. With this series are correlated the basalt and dolerite caps on such hills as North and South Peaks; Government Hill; Little Table Hill; and Trig. S, Maheno.

These caps appear to be the remnants of a once-continuous lava plateau, the origin of which is obscure, but the ancient craters and plugs at Kattothyrst and Siberia Hill offer some solution to the problem.

Caversham Sandstone and Goodwood Series.—Brown calcareous sandstones with poorly preserved echinoids, brachiopods, and molluscs underlie the basalt at Puketapu, Palmerston, and pass eastwards beneath limestones and mudstones of the Goodwood Series. Service† correlates the latter with the Awamoa beds and the former with the Hutchinson Quarry beds.

All-day Bay Series.—This is a group of light-blue and brown fossiliferous mudstones of Awamoan age lying in a synclinal basin of Waiarekan tuffs between Kakanui and Aorere Points.

Waipiata Series.—This name was introduced by Williamson for the basalt flows and caps of igneous rock lying above the Wedderburn sedimentaries. In this group are included such volcanic caps as Puketapu, Janet Peak, Smyler Peak, and Taieri Peak. The basalt is post-Awamoan in age since it overlies the Caversham Sandstone at Puketapu.

Pleistocene and Recent sediments form the terraces occurring in the valleys of the Shag and Waianakarua Rivers, and many of the terrace levels can be correlated with uplifted platforms on the coast.

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* Williamson, J. H.: *28th Ann. Rep. N.Z.G.S.*, 1934, p. 7.

† Service, H.: "The Geology of the Goodwood District, North-east Otago." *N.Z. Jour. Sci. & Tech.*, Vol. 16, 1934, pp. 270–1.

Economic Geology.

Coal.—Although seams of lignite and sub-bituminous coals occur at many points throughout the coastal ranges, this material is mined in two places only—viz., at Herbert and Shag Point, there being two mines in the latter locality. The coal at Shag Point is of fair quality and, apart from household uses, can be employed for welding.

Limestone.—A high-grade limestone or marble in the Kakanui Series occurs on the eastern wall of the Shag Valley at the Blue Mountains. The quarry at Inch Valley is served by rail, and several hundred tons of crushed and bulk stone are removed weekly for the manufacture of cement.

A soft, coarse-grained limestone of good quality outcrops in the fault-angle at Green Valley, north-west of Dunback, and should be of great value in top-dressing.

Gold.—In the past the river sediments in the subdivision have yielded much wealth; but little interest in prospecting is shown to-day. Old workings and drives are common on the mica-schist country between Dunback and Macraes Flat. A rich alluvial claim was located at Yankee Gully near the head of Woolshed Creek. After heavy easterly gales "colours" are frequently reported on Hampden Beach, but no serious work is carried out in the search for the metal.

Road Material.—No difficulty is experienced in roadmaking on the schist terrain and unlimited supplies of river gravels are available. The quartz conglomerates also make good surfacing material, whilst the tough, hard basalt at Smyler Peak, Palmerston, is used extensively by the Neuchâtel Asphalte Co. as a base in their product.

Building-stones.—Mica-schist is widely employed in the construction of bridge buttresses and approaches. The limonitic sandstone is displayed in the churches at Hampden and Palmerston, and weathers well.

A fine-grained indurated facies of the Waiarekan tuffs was quarried at Herbert and used in the construction of the flourmill at Waianakarua.

Roofing-slate.—Slate was quarried over sixty years ago in the north-west section of the Otepopo Survey District. Three factors combined to hinder the success of the project—viz., difficulty of access, dwindling of demand for such stone, and excessive waste occasioned by the presence of numerous quartz stringers throughout the rock.

Greensands.—As in the neighbouring districts of South Canterbury, the Moeraki Subdivision abounds in greensands and glauconitic mudstones. The richest member of this type is the Otepopo greensand outcropping near Herbert, particularly well exposed in the railway-tunnel cutting. Samples of the higher-grade greensands have been collected in order to test their value for water-conditioning, but results are not yet to hand.

Petroleum.—A sand smelling strongly of oil was discovered by Mr. A. Craig, of Hampden, at the extreme south end of Hampden Beach. The deposit is of small extent and occurs immediately on the beach, being involved in a huge slump which dislocates mudstones of the Moeraki Boulder Beds. The relation of the sand to the latter is not clear, and the opinion of the Dominion Laboratory that the oil is possibly a highly-refined one makes it appear that the local beach sand has been contaminated. A further examination will be made before the end of the season.

Iron-ore.—West of Herbert, near Government Hill, a large deposit of rich hæmatitic sandstone belonging to the Herbert Series is found outcropping on the hillsides. Analyses are not yet available, but McKay in 1887 reported that similar material contained up to 37 per cent. of iron.

GLENORCHY SUBDIVISION.

By J. Healy and R. W. Willett.

During the 1937–38 field season approximately 120 square miles was mapped in detail, comprising parts of the Glenorchy and Earnslaw survey districts. The area, bounded on the east by the Richardson Mountains, extends north from Creighton Creek along the eastern shores of Lake Wakatipu to the Twenty-five Mile Creek near the headwaters of the Rees River, and on the west by Mount Alfred, together with the high ridge west of the Earnslaw Burn. It includes the Township of Glenorchy and the important scheelite-producing lodes of Mount Judah. The work in this subdivision was closed down for five weeks from 1st February to 7th March, in order to carry out geological work in the Martin Bay district. From November to the end of January Mr. A. G. Reid was employed as field assistant.

Topography.

The principal topographic feature of the district is the Richardson Mountains, which extend from the southern extremity, Mount Creighton, to the Forbes Range in the north. The general summit level of these highlands is fairly even, ranging from Stone Peak (7,222 ft.) and Mount Larkins (7,432 ft.) in the south to their highest point, the Centaur Peaks (8,284 ft.).

The western slopes of the Richardson Mountains drain into the Rees River, which from its source in the Forbes Mountains flows south-south-west to discharge into the head of Lake Wakatipu. In the lower part of its course, from Lovers' Leap to its mouth, the Rees flows for about eight miles as a braided stream along a wide gravel-filled valley. This gravel-filled valley is roughly triangular in shape, having its apex at the head of Lake Wakatipu, its sides and

base being determined by the Richardson Mountains, Mount Alfred, and the truncated spurs of Mount Earnslaw respectively. At the base of the eastern flank of Mount Alfred lie two small shallow lakes which discharge into the Rees—namely, Diamond Lake (21 acres) and Reed Lake (2½ acres). Near the north-east corner of the triangular area is a small schist roche moutonnée, Camp Hill, rising to a height of some 200 ft. above the valley-floor. The Rees River impinges on its eastern side and on the west. There is a strong development of gravel terraces rising in two stages to the 170 ft. level. The major part of the 170 ft. terrace occupies the area between Camp Hill and Lovers' Leap and serves as Earnslaw airplane-landing field. Earnslaw Burn flows along the western margin of these terraces to discharge into Diamond Lake.

On the western boundary of the area Mount Alfred forms a most conspicuous landmark, being a vast pyramidal shaped roche moutonnée, rising to a height of 4,548 ft. It is entirely surrounded by the delta gravels of the Rees and Dart except for the low saddle at Paradise connecting Mount Alfred to the high, precipitous western ridge of Mount Earnslaw. Into this ridge the Jordan Stream has cut deeply and has, with the assistance of other minor streams, formed a large steep gravel fan at the northern end of Diamond Lake.

The upper Rees Valley, extending from Lovers' Leap back to its headwaters in the Forbes Range passes through gorge for the first few miles to Muddy Creek, then opens out into a wide alluviated valley which extends to the source.

The Earnslaw Burn flows parallel to the Rees and has its source in the great cirque on the southern flank of Mount Earnslaw. For two miles this stream flows along a U-shaped valley, possessing minor terraces and great piles of moranic material; it then enters the narrower part of its valley, down which it flows for a distance of five miles to the gravel flats of the lower Rees Valley.

Along the whole length of the western slopes of the Richardson Mountains the major streams—Stone Creek, Buckler Burn, Temple Creek, and Twelve-mile Creek—have cut deep, narrow gorges back into the mountains. There has also been an extensive delta development by these streams, the remnants of which can still be seen as large 170 ft. terraces at the mouth of the Buckler Burn—the large, flat terrace, locally known as "The Bible," and at the mouths of Temple and Twelve-mile creeks.

East of Glenorchy and lying between Buckler Burn and Temple Creek is a low, rounded ridge about 1,000 ft. above the lake, and separated from the main hillslopes by a gravel-filled valley some two miles long—Chinaman Flat. A continuation of this ridge can be traced south along Trig. G ridge to Pigeon Island and Pig Island about four miles from the head of the lake; northward topographic features suggest linking it with Camp Hill.

At the southern end of Mount Alfred the delta of the Rees unites with that of Dart River, a much larger stream, and forms flats, some two miles wide and three miles long, which cover the entire head of Lake Wakatipu. Both rivers are at present actively engaged in building out their common delta at quite an appreciable rate, as is shown by the Railways Department having to shift the Glenorchy Wharf some 15 chains down the lake to enable the lake steamers to berth.

The main ranges and ridges of the district all terminate in the Forbes Range in the north, which rises to its highest points, Mount Earnslaw (9,250 ft.) and the East Peak (9,165 ft.) in the extreme north-west of the Earnslaw Survey District.

Glaciation.

Throughout the whole subdivision the topography shows strong and distinct evidence of intense glaciation. The westward flank of the Richardson Mountains has been smoothed, and in many places longitudinal parallel ridges have been cut by the ice. These ridges, which can be seen to advantage on the slopes between Temple and Twelve-mile creeks at an elevation of some 3,000 ft. above sea-level, may owe their origin to variations in the dip of the schist on the original surface, for where the ice truncated the dip of schists it cut somewhat deeper than where the dip-slope and surface are parallel. Such grooves, however, cannot be altogether regarded as a result of varying hardness of the rock, for in the area in question the schists show little or no variations. Rising above the glaciated slopes, which extend to a height of nearly 5,000 ft., the topography becomes much more rugged and the slopes steeper. This marked change is noticeable along the whole length of the Richardson Mountains and the main ridges of Mount Earnslaw. West of the head of the lake on the Humboldt Range between Elfin Bay and Kinloch the change is particularly apparent. Mount Alfred, 4,548 ft., has a well-rounded and smoothed appearance that strongly suggests having been overridden by the ice. The ridge of Trig. D that lies east of the township is distinctly rounded, and in a similar manner the continuation south of this ridge to Trig. G, Pigeon and Pig islands shows evidence of having been subject to intense ice-action. Pig Island is particularly striking, having been planed practically flat, rising to a low point some 110 ft. above the present lake-level. Pigeon Island has more of the typical roche moutonnée appearance with a gently sloping and smooth northern flank and rough steeper southern face. Camp Hill, at the head of the Lower Rees Valley, is another roche moutonnee showing evidence of its having been subjected to the action of ice moving from the north and north-west. Again at the head of the Lower Rees Valley the action of the ice in "plucking" back the ends of the spurs is most apparent at Lovers' Leap, a large imposing schist bluff rising nearly 3,000 ft. above the flats. Similar cliffs can be followed from the Earnslaw Burn to Jordan Stream at Paradise.

Along the western side of the main valleys the ice has truncated the schistosity planes, thus enabling the plucking action to go ahead apace, with the result that to-day these valley-sides are steep and rugged with numerous cliffs 200 ft. to 300 ft. running parallel to the direction of the valley for considerable distances. On the eastern sides of the valleys, however, the ice has moved over

surface more or less parallel to the schistosity planes resulting in smoother and gentler slopes. This feature is well shown in the upper Rees Valley, in the Earnslaw Burn, and to a certain extent on the lake-sides and on Mount Alfred.

Apart from the purely physiographic evidence of glaciation, glacial deposits, though not particularly common, have been observed. At the mouth of Buckler Burn, about 2 chains below the footbridge, a hard, well-compacted, dark-coloured glacial till rests directly on solid schist. In this deposit one or two small schist pebbles showing characteristic glacial striæ were discovered. Similar glacial till in a small depression about 2,500 ft. above sea-level on the slopes of the Richardson Mountain, a mile north of Temple Creek, also yielded a large schist cobble showing distinct striæ. In the Upper Rees valley a few chains north of Arthur Creek a small creek has exposed a considerable thickness of till that has been deposited on the hillside.

Towards the head of the Rees, from Arthur Creek onwards, the valley widens, becomes strongly U-shaped, and has all the features of a glaciated valley. There is a distinct shoulder on its side about 800 ft. to 1,000 ft. above the valley-floor where occurs a notable change in slope which gives a valley-in-valley structure. On the walls of the lower younger valley the streams from the hanging valleys above cascade down in long waterfalls. At the head of the Earnslaw Burn, starting at a point equidistant from Lover's Leap as Arthur Creek, is a similar glacial valley running back to the cirque of Mount Earnslaw. Here are most marked evidence of glaciation, the schist walls are smoothed and striated, and the valley-floor covered with moranic and outwash material; near the valley head a large recessional moraine practically blocks the valley and rises to a height of 50 ft. above its floor.

On the whole the evidence for two periods of glaciation is quite strong, especially as regards the physiographic features of the valley just described.

From this evidence it appears that the first glaciation carved and smoothed the country to approximately its present topography. The second was in comparison less intense, the ice filling the heads of the main valleys only, oversteepening and deepening them to give the present valley-in-valley structure. The large glaciers of the first period, occupying what is now the Rees and Dart valleys, appear to have met at the head of the present Lower Rees valley, where their combined efforts deepened the valley and truncated the ends of the ridges from Mount Earnslaw. The amount by which the combined glaciers deepened the Rees Valley between Mount Alfred and the Richardson Range may have been nearly 1,000 ft. or more, and the ice must have been at least 5,000 ft. thick. This, however, is a conjecture, as the depth to the schist below the present gravel is unknown.

Structure.

Many minor faults, which generally strike about N. 10° E., can be observed on examination of the small quartz veins, but direct evidence of major faulting is comparatively difficult to obtain.

Observations on Mount Judah, Temple Peak, and on the 1,000 ft. wall of the Mount Earnslaw cirque show a series of parallel faults striking N. 20° E. and hading to the east at angles ranging between 40° and 50°.

A large zone of crushed and sheared schist is exposed in the Buckler Burn Gorge from the footbridge to Chinaman Flat. This strikes about 15° E. of N. and appears to run towards Chinaman valley and thence across the ridge at the head of Temple Creek, though evidence for this is rather scanty. The whole east flank of Mount Judah, especially the Bonnie Jean Creek basin, has been strongly sheared and crushed, the general appearance suggesting a large intense shear-zone. Crushing and shearing was also observed in the schists in the Jordan Creek Gorge; whether this is a part of the fault along the Dart valley has yet to be discovered.

Schists.

Apart from the Pliestocene and Recent gravels, the area is composed of foliated quartz-mica-schist belonging to the Wanaka Series, with the grade of metamorphism increasing from west to east. Towards the eastern boundary of the subdivision greenish chlorite schists bands of considerable width were observed interbedded in the mica-schists.

As a whole the schistosity planes consistently strike about N. 10° W. and dip to the west at angles ranging from 20° to 75°. Where bedding-planes have been observed they are, except rarely, parallel to the schistosity. Along the slopes of the Richardson Mountain the schistosity planes dip west at an average angle of 43°, though there is a tendency for the dip to increase as the summits of the ridges are approached. Along the ridges of Mount Earnslaw the dips of the schistosity planes flatten to an average of 23°, while the schist outcropping on the eastern flank of Mount Alfred is practically horizontal.

The development of quartz veins and reefs is a notable feature of the schists throughout the whole subdivision. In addition to the major scheelite-bearing reefs which strike N. 20° W. and dip to the east at an average angle of 20°, there are numerous small veins up to an inch wide, one set parallel to and the other cutting directly across the schistosity at high angles. Where the schists have been sheared and crushed these minor veins, especially those cutting across the schistosity, are strongly developed; these are common in the lower Buckler Burn Gorge and in the Jordan Gorge.

Gravels.

One of the most notable features of the topography is the presence of a number of prominent and well-developed gravel terraces, ranging in steps to a general level 170 ft. above the present level of Lake Wakatipu. Their composition is uniform throughout the district. They consist of well-rounded pebbles and cobble of schist and quartz, and possess no great degree of consolidation.

Along the eastern margin of Lake Wakatipu remnants of the gravel terraces can be traced, though in places they are no more than a veneer over the schist. They are best developed at the old fans the streams formed when the lake was at a higher level, as, for example, at Shepherd's Hut Creek, where three distinct, even steps can be observed rising to a height of some 150 ft. above the lake. The creek, like the others in the district, has entrenched itself in the fan and is actively engaged in building a fresh delta at its present mouth. Where the streams, including Rough Creek, flow into the lake round the southern end of Trig. G ridge they also have entrenched themselves in the terraces, which have risen to 170 ft. above the Lake, showing no less than seven distinct levels.

The greatest development of the gravel terrace is to be found from Stone Creek to point south-east of Glenorchy. The development of three distinct levels is again noteworthy and is especially clear on the north flank of "The Bible"—a triangular remnant of the old delta of the Buckler Burn, some 50 acres in extent, which rises in steps of 60 ft., 130 ft., and 170 ft. above the lake-level. A small creek has cut deeply into the gravels, exposing some fore-set bedding together with bands and lens of fine-grained lake-beds. Along the southern bank of the Buckler Burn, where a 120 ft. terrace is exposed for nearly a mile, finely-developed fore-set beds are shown dipping to the west at about 25° to 30°. At the point where the terrace commences to rise toward the higher level gravel, an example of back-set bedding similar to the fore-set, but dipping to the north-east, was observed.

The main terrace rising to 170 ft. level can be again seen at Temple Creek ford, where small remnants have escaped erosion, near Scott's homestead about a mile and a half north of Temple Creek, and at Twelve-mile Creek. These terraces correspond in all their characteristics to those developed at "The Bible."

The remaining occurrences of the 170 ft. level terrace is in the vicinity of the Rees Bridge and Camp Hill, where a large area has been preserved between Lovers' Leap and Camp Hill. This can be traced from the mouth of the Earnslaw Burn valley along to the Jordan Creek, and on the opposite side, at the base of Mount Alfred at Paradise, a corresponding terrace remnant was observed. As a considerable area of this large terrace has been removed by erosion it would suggest that a fairly large river was responsible, and as all the present streams flowing on the gravel flats of the Lower Rees valley are small and would be incapable of removing such a vast amount of gravel, the suggestion that the Dart at one time flowed through at Paradise to the present Rees valley must be seriously considered. This view is strengthened by the structure of the gravels on the Paradise Saddle and by the 170 ft. terrace occurring on both sides of the valley. The actual reason why the Dart chose this course in not clear, but the possibility of the Routeburn having blocked the Dart valley with an enormous fan should not be overlooked.

At higher levels than the 170 ft. level considerable gravel deposits occur, the best example being at Chinaman Flat, where the valley lying between the Trig. D ridge and the main mountain ridge is completely filled with gravel similar to that of the other terraces.

From Chinaman 40 ft. terraces can be traced round the southern end of the Trig. D ridge and can be observed to spread out and extend down to the 170 ft. terraces. Extensive patches of high level gravel are to be found between the Mount Judah Road and the Buckler Burn. These correspond to those on the opposite slope and seem to be an old delta of the Buckler Burn, built when the lake was at a higher level than it is to-day. Patches of similar high level gravels occur on the hillslope between Temple and Twelve-mile Creek at about 1,000 ft. above the lake-level.

In the Upper Rees valley 40 ft. to 50 ft. terraces have been cut in the gravels which were deposited by the Rees at an earlier stage of alluviation. These terraces are particularly well developed north of Muddy Creek. Similar terraces were also observed in the upper valley of Earnslaw Burn.

From the evidence afforded by the gravel terraces just described it seems safe to conclude that Lake Wakatipu was about 170 ft. higher than its present level and must have remained at that level for some considerable period, thus enabling the main streams to build out their large deltas. This level corresponds with terraces occurring at other points around the lake and with the Kingtson Moraine at the southern end of the lake. The relation of the higher gravels to the lake-level must remain for the present an unsolved problem.

Economic Geology.

Scheelite.—The production of calcium tungstate or scheelite, an ore of tungsten, has for many years been the chief mining activity, its value and quantity making it an economic mineral of first importance to the district.

During the late "eighties" the Wakatipu Scheelite Co. pioneered the mining for this mineral at Mount Judah, producing 18 tons of ore, for which was received the net price of £12 per ton. In 1892 the price fell and production ceased. It was not until the early years of this century that the production again took an upward trend, a certain amount of alluvial scheelite being produced from the Buckler Burn, Precipice, or Temple and the Twelve-mile creeks in response to the increasing overseas demand. During the year 1906 the newly formed Glenorchy Scheelite Co. reopened the original mine on the Glenorchy lode, Mount Judah, producing 13¼ tons of concentrates. As the overseas demand and price steadily increased, the scheelite production of the district rose in accordance, resulting in a considerable number of new claims being worked, some by the Glenorchy Scheelite Co., or Syndicate as it was known after 1911, and others by independent parties of miners. This production reached its maximum in 1917, when 116¼ tons of concentrates valued at £22,753 was shipped from Glenorchy. After

the Great War the market collapsed and production here practically ceased, only 21⅓ tons being produced between the years of 1921 and 1933. With the increasing demand for tungsten since 1934 the price has had an upward trend, reaching in 1937 the remarkable level of £500 per ton, resulting in renewed mining activity in the district. Most of the old claims were reopened and prospected farther along the lodes. Recently a sharp decline in the price of scheelite has been recorded, which if it continues will result in a considerable slackening off in the mining activity at the head of the Lake.

The instability of the market and the fluctuation in price are two important factors that prevent any extensive or expensive mining operations, with the result that the main object has been to produce as much scheelite as possible while the price was high without paying any attention to development-work for the future. In spite of this, however, the total production of the district up to 1936 was 1,199 tons of ore, having a total value of £165,963.

The scheelite itself occurs in the lodes as veins and stringers, which may range from a mere fraction of an inch to several feet in thickness, and in nests and bunches. Apart from the mineralization of the reefs by pyrites and arsenopyrite, calcite generally, though not invariably, occurs with the scheelite. Some miners claim calcite as an indicator, though there is diversity of opinion on this matter.

The major reefs of the district are those found on Mount Judah and strike about N. 30° W. dipping to the east at angles of from 12° to 30°. The Glenorchy lode is the only one on the western face of Mount Judah at present being worked extensively, though a certain amount of prospecting work is being carried out on its southward extension. On the eastern face of Mount Judah, the Sunshine, Groves', and several other claims are worked, the reefs here striking much as before, but the dip varying as the county rock has been intensely crushed and sheared since the lodes were formed.

On the ridge to the east of the Bonnie Jean Creek above the Buckler Burn is the Heather Jock Claim, the best productive mine of the district. The reef here is extremely shattered and crushed and strikes about N. 10° W. and dips at a low angle to the west. Small quartz reefs which have been worked for scheelite outcrop to the south on the Heather Jock ridge at Alaska 6,000 ft. and Mount Larkins 7,432 ft. On the MacIntosh-Temple Peak ridge of the Richardson Mountains small reefs generally rich in scheelite striking N. 13° W. and dipping at angles from 30° to 50° to the east have been worked at Mount MacIntosh, Black Peak, and Temple Peak. On the hillside just north of Twelve-mile Creek and about 300 ft. above the road is a much crushed and shattered quartz reef formation at present being worked and producing a fair quantity of scheelite. At the old Mount Alfred Mine, Paradise, a massive quartz reef strikes N. 20° W. and is practically vertical; no work has been done on this mine for quite a number of years.

The quartz reefs carrying scheelite lie in a belt extending approximately north-west from Mount Larkins to the northern end of Mount Alfred, and are connected with the north-east faulting of the district.

In addition to the quartz-mining, a considerable amount of interest is being taken in the recovery of alluvial scheelite from the Buckler Burn and Temple creeks, the gravels of both streams being comapratively rich in this mineral. Till recently this was carried out on a small scale by a few subsidized miners, but mining companies have become interested and extensive developments are foreshadowed.

Gold.—Compared with the scheelite production, the amount of gold-production in this district is rather insignificant, though it realized a considerable value in the "eighties."

In 1880 the Invincible quartz reef was discovered 1,200 ft. above the Rees River on the Richardson Mountain, and a few miles north of the Rees Bridge. This was extensively and profitably worked, until 1890, when, on account of the low returns, the company went into liquidation. During its period of activity some 6,518 oz. of gold was produced. Little trace can be seen of the actual workings today.

A minor amount of gold has been found in the quartz of the Glenorchy lode, but nothing of importance. Alluvial mining has never been very extensively developed, though the gravels of the Buckler Burn, Temple, Twelve-mile and Chinaman creeks have been prospected with varying degrees of success. At the present day little to no gold-mining, either alluvial or reef, is carried on. Some sluicing was carried out on the gravels resting on the schist a few chains below the present Buttery, locally known as Wilson's Dream, with quite a considerable measure of success. Work on this claim has now been abandoned for several years.

PALÆONTOLOGY.

By J. Marwick.

The fossil mollusca collected by the field officers during the past year have been examined, in large part prepared and identified. These collections have come chiefly from Wakaia, Dannevirke, and Moeraki subdivisions. Collections from a number of other localities have also been identified as far as time has permitted.

The Reference Collection of New Zealand mollusca has been augmented by specimens kindly donated from Lower Waipara by Dr. R. S. Allan, and from Hawke's Bay by Mr. J. D. H. Buchanan. The Foreign Collections received two useful additions through exchange from Australia and from Texas.

Field-work.—About a month was spent in examining Te Kuiti Subdivision preparatory to writing up the field-work done by the late Dr. H. T. Ferrar by Mr. N. H. Taylor and by Mr. J. H. Williamson. A fortnight was spent in the Moeraki Subdivision with Mr. D. A. Brown examining critical sections and collecting fossils. Professor James Park kindly showed us over the Hampden section and gave us the benefit of his knowledge of the district. A short visit was paid to Takapau, and important fossiliferous outcrops were examined.

MICROPALÆONTOLOGY.

By H. J. Finlay.

Routine examination of numerous samples sent in by field officers has been carried out, and has thrown light on the stratigraphy of several districts. In Takapau Survey District a number of localities of otherwise uncertain age proved to have a definite Opoiti foraminiferal fauna, though confused, on account of poorly preserved mollusca, with the Mapiri. The ranges of *Nonionella stachei* and *N. Parri* were found to give conclusive evidence here.

Mr. D. A. Brown sent important collections from the Kakanui and Hampden districts, and the Awamoan and Bortonian of those localities are now well known from good sections. There is now no reason to doubt the Awamoan age of the upper blue clays and brown sandstones at All Day Bay, a series of nine samples at 14-chain intervals showing rich faunas identical with that of Awamoa Creek, and differing so slightly *inter se* that no practicable zoning could be recognized. Unfortunately, the underlying Hutchinsonian beds yield poorly preserved specimens, and no adequately comparably strict Hutchinsonian fauna has yet been observed. Numerous large faunas examined from Clifden, Pakaurangi, Greymouth, and Takaka are only doubtfully exactly of this age, and this and the facies difference of all Ototaran samples examined makes exact correlation with the Poverty Bay and other distant areas difficult. Complete faunas from all these and many other type localities have been lately examined and mounted for reference.

The Moeraki-Hampden beds yielded good faunas over almost the whole of a complete section along the beach taken at 120-chain intervals. The upper micaceous beds have very rich faunas showing at least three definible zones, the middle glauconite bed is almost unfossiliferous, but belongs to the upper series, while the lignitic marls below are devoid of calcareous species, but again show several minor zones based on the arenaceous foraminifera. These horizons can be almost exactly correlated with quite distant ones in Dannevirke and Poverty Bay, the Wanstead of the former and Waitangi bentonitic shale of the latter being facies equivalents of the upper Hampden beds.

A large series of samples sent by Mr. A. M. Quennell from the Dannevirke area is in process of examination, and the faunas from Raukaumara (Cretaceous) to Tutamoe (middle Tertiary) show that assignment to the Poverty Bay series of beds, and more or less exact equivalence to the South Island horizons mentioned can be demonstrated.

GEOPHYSICAL WORK.

By N. Modriniak.

The activities during the past year were concerned in the investigation of part of the Kotuku oilfield, the General Gordon area near Reefton, and the Waiuta area. Concurrently, tests were carried out with the new seismic recorder, ratiometer, and power-buzzer. These instruments were made in the Department's workshop, and required testing under working conditions.

Kotuku.

Field-work was resumed in the middle of January and continued till the middle of April. The Seismic Refraction method was used throughout the study of the area, which covered approximately two and a half square miles. The area was topographically surveyed by Mr. R. J. Bagge.

The preliminary investigation of the area carried out during part of 1937, which was mainly concerned with the testing of an area reasonably well known by previous boring, gave some indications which supported the possible presence of a structural feature, probably a fault, striking in a north-west direction, and offered thereby an explanation of the immediate origin and position of the petroleum and gas seepages. In consequence of this conception the area of interest shifted to the south-west of the above-mentioned fault, and it was therefore selected for the geophysical investigation.

The evidence obtained from this study is not convincing enough to justify the assumption of faulting, and the steep slopes indicated by the previous and present surveys are most probably due to erosion of the Blue Bottom formation. Bore No. 14 provides independent evidence for this assumption, as it passed through 482 ft. of Pleistocene gravels and sands without encountering the Blue Bottom formation. All evidence supports Morgan's assumption that Lake Brunner extended northward and that the Pleistocene gravels were deposited in a glacial lake.

The slight arching of the Cobden Limestone, known to exist in the northern portion of the area, could also be traced southward, and it was demonstrated that the area is controlled by a single structural unit. Additional information was obtained as to the depth to greywacke basement in this locality, and with this information it could be shown that the pre-Cobden Limestone strata are not sufficiently developed to permit a favourable conception of this locality. This negative interpretation of the results does not apply to the whole area, and merely shows that the chances of success in the localities studied are not favourable enough to start a development programme. Though the expected progressive overlap of pre-Cobden Limestone strata does not occur in a north-south direction, it is probable that such will be the case in a westerly direction towards the Brunner Anticline, where the lower beds missing at Kotuku are fully developed. It is reasonable to assume an accumulation of petroleum, sealed by overlap on the western flank of the Kotuku Anticline.

The geological data from surface observations are so inadequate that no deductions as to subsurface structures can be made, and therefore no assistance can be obtained from this source. Consequently, if the potentialities of the south-western area are to be fully tested, geophysical prospecting and structure drilling are the only methods available in the search for oil at Kotuku. The whole of the area cannot be regarded as fully prospected. The west flank of the Kotuku Anticline should be subjected to additional geophysical examination. Shallow refraction shooting to the surface of the Cobden Limestone would suffice to test the hypothesis of a meridional fault, which would account for the orientation of the seepages at Kotuku, but reflection shooting is required in the same area to determine the depth to greywacke basement, and likewise to determine the presence and thickness of the beds underlying the Cobden Limestone. It is advisable to combine refraction and reflection shooting with a test bore, to permit a correlation of theoretical and practical results, and to assure correct interpretation. The depth and position of the bore would be determined by the preliminary investigation. The extension of the topographical survey will also be necessary.

General Gordon Area.

This area is situated in the Reefton gold-belt, approximately half a mile east of the Progress Mine. The survey was commenced on the 18th October, 1937, and occupied two months. The main object of the survey was the tracing of the General Gordon Reef northward across Union Creek, towards the Globe and Ballarat workings. The potential drop-ratio method was used, and the survey proceeded on standard lines previously adopted in the area. Anomalies were recorded and mapped and flagged on the ground for trenching. The results indicated the probable southward continuation of a reef known to exist near the Ballarat workings up to Union Creek, where it is dislocated by a crushed zone, probably a fault striking in a north-west direction. It does not appear as if the General Gordon Reef continues unbroken in a northerly direction, although the survey was not extensive enough to prove that its northward continuation is not farther to the east.

Waiuta Area.

Geological reconnaissance by E. O. MacPherson and M. Gage showed that the Blackwater Reef is structurally controlled by an anticlinal fold. To determine its extent and position in a northerly direction from the known reef system, and to determine probable similar features, was the object of the geophysical investigation.

The survey commenced on the 11th October, 1937, and is still in progress. Preliminary research was directed to the possible tracing of the diabasic dyke known to exist and to cross the Blackwater Reef at an oblique angle. The magnetic method was employed, but the observations showed that the magnetic properties of the dyke are not sufficiently active to have a decided influence on the magnetic balance, and the work was therefore discontinued. The potential drop-ratio method was next used, and is still in progress. While the study of the results during field observations has not been neglected, it was found difficult to interpret anomalies over a small area, and therefore it is intended to carry on with the observations until the survey reaches Big River, approximately one mile and a half north of the Prohibition Shaft. It is hoped that with the sum of this information it will be possible to interpret the results on a wider basis and to draw conclusions as to the desirability or otherwise of continuing the survey towards Merrijigs. Since the actual observations have, so far, only covered part of the area intended for study, only a tentative summary can be given at present.

One major structural feature has been observed as continuous through the area. This is an apparently small anticline, which enters the area in the south near Absolom's Mine, passes close to the Waiuta swimming-pool, crosses Blackwater and Krantz Creeks, and may connect with the fold previously observed near the junction of Big River and Sunderland Creek. This anticline has the Blackwater Reef on its left flank.

The numerous anomalies observed north of the Prohibition Shaft appeared, at first, to be only associated with irregular fissures of no importance and no prevailing direction. Additional observations towards the north, however, permitted better interpretation of the results, and disclosed the existence of three major groups of anomalies, of which their parallelism is a striking feature. The general strike of the anomalies is slightly east of north. In the majority of cases evidence of previous prospecting by trenching, driving, and shafting has been observed close to the recorded anomalies, which shows also that the survey has not yet been extended into an area which could be regarded as inaccessible to previous prospecting methods. Most of the early prospecting is confined to creeks and to the main ridge between Blackwater Creek and the Big River drainage system. The area has been mapped and contoured. It is the intention of the survey to reconsider the recorded results during the winter months and to arrange the future programme accordingly. The field-work was in charge of W. E. Hall and F. A. MacNeill, who observed the area north of Line 13.

QUARTZ-SAND DEPOSITS AT MAUNGATI.

By D. A. Brown.

Maungati is in Waimate County, about twenty miles south-west by good road from Timaru. The sand forms a 50 ft. band in the face of a cliff which extends for 60 chains north of the road past Maungati School. Mr. Bower, the lessee, has already shipped some 226 tons to different parts of New Zealand.

Fireclays, about 20 ft. thick and dipping gently north, outcrop along Maungati Stream, which flows at the base of the cliff. Occasional thin bands of inferior coal and coaly material are interbedded. Above the slips and loose debris, which obscure the section for about 50 ft., the white sands are exposed and, if, as is probable, they rest on the fireclays, they are about 100 ft. thick. Soft brown sandstone 75 ft. thick and capped with limestone overlies.

The white and light-coloured sands, which occur in lenticular beds up to 6 ft. thick, are separated by thin layers of clay and contain occasional 1 in. bands of small (up to $\frac{1}{4}$in.) quartz pebbles. The white sand occurs at the west end of the cliff. They have not yet been tested for glass-manufacture, but have been used as moulding sands and for colouring purposes.

NOTES ON THE HOKONUI DISTRICT.

By J. Healy.

Collections were made in several places of pebbles from different conglomerate beds of the Mesozoic rocks of the Hokonui Hills. The aim of collecting is to compare the igneous rocks of the conglomerates with types from the Otama intrusive mass, as a large number of sections have been made from specimens from the latter in the course of the work in Wakaia Subdivision. The conglomerates were also examined for the presence of schistose rocks.

Traverses were made across the strike of the beds in several places where large thicknesses of strata could be most easily examined. The previous work done by Cox and McKay was used as a basis, and collections were made near the lines of several of the sections shown on their map. No great difficulty was experienced in following the sequences described by them, and practically all the conglomerates recorded in their reports were visited. One traverse was made from Mandeville up the Otamita Stream to its junction with the Coneburn, and thence up the latter stream. A second traverse was made at Flag Hill, a third up Taylor Stream, and a fourth along the road from Glenure to Dipton.

The writer has as yet had no chance to examine the collection in detail. The specimens have been sent to Dr. F. J. Turner, under whose supervision the sections are being made. So far eighteen sections have been completed, including rhyolites, greywackes, schists, semi-schists, and one diorite. None of the plutonic igneous rocks have yet been sectioned. Dr. Turner states that the schistose rocks do not resemble the Otago Central types of schists, but appear rather to be products of contact metamorphism. In all the conglomerate beds examined the pebbles were well rounded and composed of extremely resistant rocks. The pebbles had been subjected apparently to considerable wear, and it seems unlikely that pebbles of schists similar to those from Otago Central would survive in such deposits.

A search was made for some Tertiary fossils reported from Whisky Gully, six miles north-west from Gore. In a disused water-race leading from an old dam a few chains below the picnic ground quartz conglomerates similar to those of the Welshman Series at Wakaia were seen, with strike south-west and vertical dip. Nearby in the creek are fragments of porcellanite. These facts suggest that the conglomerate is separated from the Hokonui beds by a fault along which basalt was injected. No fossiliferous beds were found, but probably the fossils reported previously occur in sandstones of the Chatton Series.

Six miles south of Lumsden the low ridge of Ram Hill projects above the level of the Waimea Plains. It runs parallel to the Hokonui Hills for approximately two miles and lies about three-quarters of a mile from them. The ridge is composed of very coarse greywacke, containing small fragments of red argillite. This suggests that the rocks belong to the Clinton Series, as in the Clinton district the presence of this red argillite distinguishes those rocks from those of the Hokonui Series. Between Ram Hill and Glenure there are further numerous small ridges parallel to the strike of the beds. This evidence, together with the presence of rocks of the Clinton Series at Otama, suggests that they continue from Clinton through to Lumsden, with strike and dip similar to those of the Hokonui beds.

MARUIA HOT SPRINGS.

By J. Henderson.

The Maruia hot springs rise at the foot of the steep wooded slope on the north side of the long east-west reach of the upper valley of the Maruia River. Clear, slightly mineralized water, smelling decidedly of sulphuretted hydrogen, discharges from two shallow wells sunk in the gravels of the flood-plain. The water-level in the wells is approximately the same as that of the adjacent river, and rises and falls with it. The river gravels and talus from the hills conceal the fracture along which the hot water is thought to rise from a deep source. The run-off from the hills saturate these loose deposits to ground-water level, the surplus constituting the surface streams. A cross-section of the valley at the springs would show a large mass of subsurface water, saturating the gravels and practically identical with river water, but moving much more slowly, and, in the immediate vicinity of the springs, grading into a much smaller body of hot water derived from and overlying the fracture. Just as the Maruia River is that part of the run-off from its drainage basin that, owing to the friction in, and the insufficient porosity of the gravels, finds readier escape down the valley on the surface, so the visible discharge from the wells is the surplus flow of hot water from depth not seeping through the gravels.

The hard rock of the district, a siliceous greywacke which north-westward grades into schist, outcrops at the back of the springs and the small rills a few chains east and west flow over the rock to the fans which grade into or overlie the gravels of the valley-floor. Mineral water

seeps out at the north edge of the river at a point 7 chains west of the wells. The stream here impinges against coarse talus of light-coloured quartz-veined greywacke. About 4 chains east of the springs warm water flows in small amount from two cuts in slope deposit. The mineral water thus reaches the surface at points over a length of 11 chains along the north side of the valley. This suggests that the fault along which the springs rise has an east-west strike. Partings in rock outcropping a chain west of the springs suggest that the fault dips steeply west. The dip and strike are thus sub-parallel with the small lenticular quartz vein (up to 2 ft. wide) exposed at a point rather less than two miles north-east from the springs, near the head of a small east branch of Jack Creek, which itself enters the Maruia from the north half a mile up the valley. This lode, as well as several strong pug bands in a wide crush-zone, dip steeply north.

The overflow from the wells was roughly gauged and found to be rather more than a gallon a second. All the water escaping from the underlying fracture is not concentrated in the two existing wells, which are merely two square holes a few feet deep, boxed with concrete, and sunk in the gravel flat where the water discharged most freely. More hot water can be obtained (1) by pumping from the existing pools, (2) by sinking other wells in their immediate neighbourhood or along the line of the gravel-concealed fracture, (3) by driving into the talus slope 4 chains east of the springs where hot water has already been found, or (4) by boring through the hanging-wall of the fissure to tap it below its outcrop. The small fan of the rill a chain west of the springs suggests itself as a possible site for boring, but probably the first prospecting should be in the talus slope to the east of the springs.

Water from the springs has been chemically examined on several occasions. The Colonial Analyst in 1900 reported that a sample of the water contained 46 parts per 100,000 of fixed saline matter, principally chlorides of the alkalis and alkaline earths, and smelt strongly of sulphuretted hydrogen (Col. Lab., 33rd Ann. Rep., 1900, p. 23). Three analyses of the fixed salts are available, the results being given in ions:—

	(1)	(2)	(3)
Na	18·0	15·01	16·50
K	0·6	0·72	0·79
NH_4	..	..	0·36
Ca	0·7	0·50	0·57
Mg	Trace	Trace	0·07
Fe	Trace	0·06	0·02
Cl	..	14·50	15·18
HCO_3	..	14·85	13·91
SO_4	..	..	5·07
Al	..	..	0·18
Al_2O_3	..	0·10	..
SiO_2	7·1	7·00	7·18
Total solids, parts per 100,000	52·1	53·11	59·83

No. 1. (Col. Lab., 36th Ann. Rep., 1903, pp. 14–15).—The temperature is given as 140° F., the results are here expressed in parts per 100,000, and an obvious slip in the silica is altered.

No. 2 (Dom. Lab., 48th Ann. Rep., 1915, p. 24).—The sample also contained 2·72 parts of H_2S per 100,000 of water.

No. 3. (sample collected H. E. Fyfe in 1930).—The sulphate content of this sample may be derived from the oxidation of the H_2S.

The Dominion Analyst suggests that No. 3 analysis corresponds to a possible mineral content as follows:—

NH_4Cl	1·07
KCl	1·51
Na Cl	22·69
$Al_2(SO_4)_3$	1·14
$Fe_2(SO_4)_3$	0·07
Na_2SO_4	6·01
$Ca(HCO_3)_2$	2·30
$Mg(HCO_3)_2$	0·42
$Na\,HCO_3$	16·29

Residual Na (1·15) combined either as sodium sulphide or sodium silicate.

Mr. Fyfe also collected samples of the gas which is given off from the wells in small amount. It consisted almost entirely of nitrogen and methane.

UNDERGROUND WATER, RAGLAN.

By J. Henderson.

Raglan is built on a sprawling peninsula that extends from the south side of Whaingaroa Harbour, an east-west inlet eight miles long formed by the sea invading the low parts of a stream system. Opoturu Arm, a tidal flat two miles long and 20 chains wide, lies west of the peninsula, and its branch, Kaitoki Creek, fully as wide and nearly a mile long, extends along the south side. To the east lies the estuary of Ohira Stream, and the small Aroaro Creek cuts deep into the peninsula from the north. Raglan itself is built on a low flat a few feet above the sea, but the peninsula for the most part has a gently

undulating top from 100 ft. to 130 ft. above the sea, though at its base the scoria cone of Kirikiripu rises to 381 ft. Karioi (2,420 ft.), a wooded, much-dissected volcano with rich farm lands on its wide lower slopes, lies six miles south-west of Raglan and dominates the landscape. To the south-east is the deforested Kiorewaro Plateau (1,154 ft.) with patches of basalt, and to the east the bushed Hakarimata highlands separate the Whaingaroa basin from the lowlands of the Waikato. Opposite Raglan, north of the inlet, there is an extensive and much-dissected plateau with tops from 400 ft. to 500 ft. above the sea.

Outline of Geology.

The oldest rocks of the district are the folded and indurated Mesozoic mudstones, sandstones, and conglomerates that form the high country to the east and south-east. Three miles east of Raglan outcrops of these rocks occur along the shore of the south lobe of Karakaringa Peninsula which, projecting three miles from the east, divides the upper inlet into two large basins. The old rocks appear at a few points round the northern basin, but are known neither along the north shore of the lower half of the inlet nor at or near any part of its south shore.

The land of early Tertiary time, consisting of Mesozoic strata, was reduced to a surface of low relief, and in the Raglan district during depression was planed by the waves before the next series of beds was laid down. These are sandstones, mudstones, limestones and their intergradations, marine strata of early middle Tertiary age, and all calcareous. The basal beds of the series, terrestrial coal-measures, thick and extensive in other regions, are not known to occur about Whaingaroa Inlet. The rocks form nearly all the shore on the north side of the inlet and round Karakaringa Peninsula. On the south side they extend for a mile east from Raglan and along both shores of Ohira estuary, whence they extend west across the root of the peninsula to Kaitoki and Opoturu Arms. Round the inlet these beds everywhere lie flat or undulate gently. They belong to the lower part of the group, and near Raglan the contact with the underlying Mesozoic strata is probably nowhere more than 200 ft. below sea-level.

The district was above the sea toward the close of Tertiary time, earth stresses were being adjusted, and volcanoes were active, the land for miles south and south-west from Raglan being covered with basaltic scoria and lava. The broad features of the topography were much as at present and volcanic, and much other debris accumulated in low parts. The area since this time has been both higher and lower than it now is; the inlet with its branching arms indicates depression, whereas shore benches and dissected terraces indicate uplift. The low flats on which the town and dairy factory stand are formed of loosely consolidated beach sands and prove a recent uplift of some 15 ft., and the flat-topped terrace (100 ft. to 130 ft.) at the back is part of a higher bench built of somewhat older clays, sands, and gravels.

Springs.

Water seeps out at several points from the terraces at the back of the Raglan flat, probably marking the outcrops of the more porous lenses of fluviatile and estuarine deposits that form them. The beds as exposed in road-cuttings about Raglan are decidedly clayey, and even the pebbly lenses can have but small permeability. These deposits form the upper part of the shore-cliff east of the wharf, their base, consisting of fine gravels with a tight sandy matrix, seems more promising as a water-carrier than other parts of the sequence. Altogether the deposits cover perhaps 300 acres of the Raglan Peninsula north of Kaitoki Arm. Any water-supply from them is likely to be small and exposed to contamination; some of the springs show rusty deposits of iron hydrate.

Waipatukahu Spring, two miles south of Raglan, has been suggested as a possible supply for the town. Beautifully clear water rises in a pool perhaps 6 ft. across on the floor of Omahina Creek at a point some 10 chains up from the south end of the tidal flat and a few chains above sea-level. Mr. W. Arthur Gray has gauged the flow as amounting to 900,000 gallons per day, and has reported on the means of getting the water to Raglan.

The water from the spring is not derived from Omahina Creek, which is a small stream with a large estuary joining Opoturu Arm from the south. There are a few outcrops of Tertiary limestone on the valley-bottom near the spring, but the rest of the basin is entirely in volcanic rocks which extend for miles west, south, and east. Half a mile to the east Tertiary rocks outcrop at sea-level in Takapanui Creek, extend along both sides of this stream and its estuary in narrow strips for over a mile, and farther east make contact with the Tertiary area at the base of Raglan Peninsula. Here they rise to 200 ft. above the sea and, as judged from the distribution of the Tertiary and the overlying volcanic rocks, this contact has a general westward slope. Waipatukahu Spring is at the most westerly exposures of this contact and very little above sea-level. The volcanic rocks are loose and highly porous, whereas the Tertiary beds are compact and impervious, and undoubtedly the spring is one of the points of outflow for the water which, sinking into the volcanic rocks, seeps along the contact with the tight Tertiary beds to the most convenient places of escape.

Bores.

In the bore at the back of the hotel at Raglan the water rises to about 8 ft. from the surface, the same height as in an adjacent well, and this may be taken as the ground-water level at this point. The well yielded at the rate of 80 gallons per hour, an amount increased to 180 gallons after shooting with six plugs of gelignite. The water is somewhat hard, tastes slightly of iron, and as it might readily be contaminated is not suitable for all domestic purposes. The drillers, M. Welsh and Son, of Ngaruawahia, report that the bore was 2½ in. in diameter

and was taken to 160 ft. The first 50 ft. was in clay formation, followed by 4 ft. of hard blue shingle tightly packed with a minimum of sandy matrix and then papa to the bottom of the hole.

The bore-hole supplying the dairy factory is sunk on a terrace remnant 70 ft. above sea-level a few chains south from the factory. It is 225 ft. deep, 3 in. in diameter, and is cased to a depth of 80 ft. Pumping for eight hours daily provides a supply of excellent water ample for all purposes. No log is available, the only information obtained being that 8 ft. of hard rock was drilled through in some part of the well. This hard rock may be a strongly calcareous layer interbedded in the Tertiary claystones that are exposed along the shore between the factory and the wharf and that the bore must have penetrated before reaching sea-level. If the hard rock is at the bottom, the bore has probably reached the underlying Mesozoic strata, indurated rocks with many partings much more likely to yield water than the overlying impervious Tertiary beds. The low temporary hardness due to the presence of calcium salts also suggests that the water from the factory bore is derived from the non-calcareous Mesozoic rocks rather than from the lime-bearing Tertiaries.

Mr. K. M. Griffin, of the Auckland Scientific and Industrial Research Laboratory, examined samples of water the Health Department collected from the spring and the bores. He reports that the water from the spring is of good quality, that the hotel bore yields water too high in iron to be suitable for domestic use, and that the ammoniacal nitrogen in the water from the factory bore suggested surface pollution and that the chlorides were rather high. The total (and temporary) hardness of the three waters was respectively 7·0, 6·5, and 3·0. According to the Acting Dominion Analyst, ammoniacal nitrogen in water from deep bores does not necessarily indicate surface pollution.

There seems then to be two possible sources of water for domestic use at Raglan—the Waipatukahu Spring and water from bores into the underlying Mesozoic rocks. A supply from the spring involves the cost of bringing the water to some convenient point in or near Raglan or distribution. If water is to be obtained from the same source as tapped by the factory bore several points must be considered. The capacity yield of the factory bore is not known; eight hours' daily pumping at an undetermined rate is sufficient to supply all the water required in the engine-house and in the factory. That the water is derived from the Mesozoic rocks underlying the Tertiary beds is highly probable, but this point must be established beyond doubt. If this is the source it is not likely that all parts of the great thickness of Mesozoic beds, which range from indurated claystone through strong sandstones to massive conglomerates, will be equally productive. Again, some parts more strongly folded, shattered, or otherwise deformed may have a much greater induced porosity than other parts. The bore near the factory may be in a particularly favourable position. If this source is considered for the town supply, the first thing to be done is to ascertain the capacity of the factory bore; if the yield is satisfactory another bore should be sunk in the same locality to the same horizon and similarly tested.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1937–38.

General.

The Branch has again been preoccupied principally throughout the year with the provision of the requisite service for aviation. In New Zealand there have been various extensions to existing air services. During the year it was announced that a trans-Tasman service would be inaugurated in the near future. At the same time Pan-American Airways were arranging to commence regular flights on their trans-Pacific route. It became clear that a conference of the Meteorological authorities of the south-west Pacific should be called without delay. With the support of the British and the Australian authorities one was eventually arranged. These matters are discussed elsewhere in this report. The securing of a qualified staff continues to present difficulties, but some of the more senior of the recent appointees have made considerable progress in meteorology, valuable experience has been gained, and the special forecasting and reporting routine for aviation is beginning to settle down into its final form. The closest co-operation has been maintained with the Air Department. The most important prerequisite for a modern forecasting service is the provision of adequate facilities for rapid and frequent inter-communication. In this direction we have had the greatest possible assistance from the Post and Telegraph Department and the Aeradio Committee.

Observing-stations.

The establishment of branch offices at the Royal Air Force bases at Auckland and Christchurch has involved the provision of first-class stations at the Hobsonville and Wigram aerodromes. New climatological stations have been set up also at Gisborne, Wanganui, Westport, Onawe (in Akaroa Harbour), and at the new radio station at Jackson's Bay. The State Forest Service has equipped a station at their Roto-chu Plantation.

Eight new rainfall stations have been provided, while five have been discontinued.

With the help of Union, Cook Strait, and East Coast Airways a considerable amount of inspection has been done. It is possible, however, to give very little instruction to observers. It would be a very great advantage to the service if observers at both reporting and climatological stations could be given short periodical courses of instruction at the Meteorological Office. At present observers have to rely almost entirely on written instructions and the knowledge gradually gained by experience. In view of the conditions the majority of observers do remarkably well, and their co-operation, which is almost entirely voluntary, is once more gratefully recognized.

Forecasting.

The above subject is discussed to some extent in reference to Aviation Meteorology and the Regional Conference. There have, however, been extensions of the forecasts for the general public. A number of additional district weather forecasts for publication in the newspapers or for broadcasting from the National and National Commercial Broadcasting Services have been instituted. The number of requests for forecasts for special occasions by institutions or private individuals has increased greatly. The broadcasts of weather for aviators during the day have enabled people to keep in close touch with developments and have resulted in much more attention being given to the weather and the forecasting of it.

It is hoped that it will be possible before long to introduce an improved weather reporting and forecasting service for shipping. This would be particularly valuable to overseas vessels, and His Majesty's ships and would be some return for the increased demand for co-operation from shipping arising from developments in aviation.

Aviation Meteorology.

During the year Aviation Service Stations have been set up at the R.N.Z.A.F. bases at Auckland and Christchurch. Dr. W. A. Macky is in charge of that at Hobsonville, and Mr. L. N. Larsen of that at Wigram Aerodrome. Each of these stations has, at present, a staff of four. The Auckland station is concerned principally with the work involved in giving a meteorological service for trans-ocean flying and will become of increasing importance as this field of aviation develops. The chief function of the Christchurch station, on the other hand, is the provision of instruction in meteorology for Air Force trainees. It acts also as a local forecasting centre for aviation purposes, while, in addition, very useful information is being obtained by means of periodical meteorological flights from which are obtained data regarding the pressure, temperature, and humidity of the atmosphere from various levels up to a maximum of about 20,000 ft. All the weather reports received at the Wellington office are reissued, in international code, to Hobsonville and Wigram Aerodromes by means of short-wave radio.

During the year regular broadcasts of aviation weather reports have been introduced and are issued through station 2YA of the National Broadcasting Service at 6.50 a.m., 10 a.m., and 1 p.m. each day (10 a.m. and 1 p.m. only on Sundays). These broadcasts, which include weather reports from sixteen of the principal aerodromes throughout the country, are particularly useful to aero clubs and private fliers and in connection with aerial-taxi work. It has been found also that considerable use is made of these reports and the accompanying forecasts by the general public.

Weather information for the regular commercial air services is provided by means of special forecasts and route reports which are sent to the various aerodromes shortly before the departure of each machine. The organization involved in this work is varied from time to time to meet the requirements of the expanding services and various changes in time-table, but at the present an average of about twenty such special reports are prepared each day, including Sundays and holidays. The first is issued at 6.30 a.m.

The development of aviation has involved a steady increase in the number of weather reports collected by the Meteorological Office, and between sixty and seventy New Zealand stations are now included in the network. In this organization very valuable and cordial assistance has been received from the Post and Telegraph Department, especially in the provision of new reports, often at very short notice.

Regional Meteorological Conference.

During recent years meteorological organizations in all parts of the world have experienced difficulty in keeping pace with the increasing demands of very rapidly expanding aviation services. It does not appear to have been generally appreciated that there is no source of ready-made meteorologists available to meet the demand as it arises, and that it is essential that adequate preparations should be made in anticipation of requirements which will obviously have to be met in the near future.

The next major development to be expected in New Zealand is the introduction of regular trans-ocean flying. Pan-American Airways have already started a trans-Pacific service, which has been interrupted only temporarily by the tragic loss of the Samoan Clipper, and it is likely that a trans-Tasman service will be inaugurated in the near future. To meet the meteorological requirements of trans-ocean flying involves an extensive organization and very close co-operation between all meteorological services in the region. To enable this organization to be built up on a sound basis the Government gave permission for the calling of a Conference for the south-west Pacific region towards the close of 1937. Invitations to send representatives were issued to the Meteorological Services of Great Britain, France, Canada, the United States of America, Netherlands East Indies, Australia, and Fiji. In addition, invitations to send technical delegates were addressed to the Civil Aviation Board of Australia and to Imperial Airways and Pan-American Airways.

The Conference met in Wellington from 29th November to 3rd December, 1937, and the proceedings were formally opened by the Hon. D. G. Sullivan, Minister in Charge of Scientific and Industrial Research. The following is a list of the delegates and guests attending:—

Major E. H. Bowie, Principal Meteorologist, United States Weather Bureau.
F. Entwistle, Esq., Head of Overseas Division, Meteorological Office, London.
W. S. Watt, Esq., Commonwealth Meteorologist, Australia.
E. W. Timcke, Esq., Senior Meteorologist, Melbourne.
Wing-Commander A. H. Cobby, D.S.O., D.F.C., Controller of Operations, Civil Aviation Board, Australia.
Captain G. B. Nasmyth, Harbourmaster and Government Meteorologist, Suva.
L. V. M. Osborn, Esq., Assistant Meteorologist, Suva.
Dr. E. Kidson, Director, New Zealand Meteorological Office.
Dr. M. A. F. Barnett, Assistant Meteorologist, Wellington.
Dr. W. A. Macky, Assistant Meteorologist, Auckland.
Wing-Commander T. M. Wilkes, C.B.E., M.C., R.N.Z.A.F., Controller of Civil Aviation, New Zealand Air Department.
Lieut. J. E. Smallwood, R.N., H.M.S. "Achilles," N.Z. Naval Defence Department.
W. R. Newall, Esq., Principal, Telegraph Division, New Zealand Post and Telegraph Department.
E. H. R. Green, Esq., Radio Engineer, New Zealand Post and Telegraph Department.
H. C. Gatty, Esq., Representing Pan-American Airways.
E. B. Buxton, Esq., Meteorologist, Pan-American Airways.

Dr. E. Kidson was elected Chairman, and Dr. M. A. F. Barnett acted as Secretary. The general procedure followed by the Conference was similar to that of a Regional Commission of the International Meteorological Organization. All the resolutions adopted have followed as closely as possible corresponding resolutions of the International Meteorological Organization dealing with the particular problems concerned. To facilitate the work of the Conference, seven sub-committees were set up. As giving an indication of the scope of the deliberations, the sub-committees are listed below:—

I. On Codes.
II. Centres from which Collective Issues are to be broadcast; stations to be included in broadcasts, nature of radio signals, &c., broadcasting of ships' reports; areas for which different services are to be responsible.
III. Provision of Information for Aviation.
IV. Co-operation with, and from Shipping.
V. Uniformity of Charts.
VI. Upper Wind Data and Aerological Investigations.
VII. Ocean Swell.

The proceedings of the Conference have been issued in the form of a 68-page cyclostyled report, and will probably be published in due course by the International Meteorological Organization. It is proposed to deal here only very briefly with some of the more important aspects of its work. Of the sub-committees listed above, the two most important and those from which most of the recommendations came were numbers II and III. In all, the Conference passed forty-nine resolutions, many of them of the greatest importance to the development of an adequate service for trans-ocean flying.

Several of the resolutions recommended the adoption in this region, from amongst various alternatives approved internationally, of codes and procedure most suitable to local conditions. Others dealt with such matters as reporting times for ships, forecasts for shipping, uniformity of charts, the study of ocean swell, &c. The majority of the resolutions, however, are concerned with the improvement of the weather-reporting systems, particularly from the islands of the south-west Pacific, and with details of the co-operation required between adjacent services in the actual provision of information for trans-ocean flights.

So far as Australia and New Zealand are concerned, if advantage is to be taken of the modern methods of charting and analysing the weather, there must be a more frequent interchange of data; the reports must be more complete and constitute a much closer network over the areas concerned, and they must be made available more promptly after the making of the observations. In Europe, where conditions are more highly organized, real progress is now being made towards developing weather forecasting as a process of calculation instead of, as in the past, having to depend as much on experience and practice as the application of physical principles.

The sparse distribution of islands in the south-west Pacific makes it imperative that complete, regular, and reliable weather reports should be supplied from as many of them as possible. At the time of the Conference there was a good deal to be desired in this connection. In particular, there was a serious gap in the reports on Sundays and holidays. Considerable improvement is also aimed at in the rapidity with which the appropriate reports are gathered in and reissued as a collective broadcast message from the principal centres. Recommendations were made that pilot-balloon observations should be undertaken at Tulagi, Vila, Canton Island, Suva, Nukualofa, and Rarotonga, in addition to those already proposed at Lord Howe Island, Norfolk Island, and Raoul Island in the Kermadecs. The Conference also affirmed the recommendation of the International Meteorological Committee that the use of radio-sondes for obtaining aerological data should be introduced in Australia, New Zealand, Fiji, Samoa, and the Society Islands, and, if possible, at one station on or near the Equator. The procedure to be followed in the exchange of forecasts and reports between terminal stations and also for messages to trans-ocean aircraft in flight was laid down in some detail. This scheme was based on that worked out by the International Commission for Aeronautical Meteorology, with particular reference to trans-Atlantic flights. The Conference was particularly fortunate in this respect in having as the British representative Mr. Entwistle, who is also Secretary of the International Commission for Aeronautical Meteorology.

Throughout the Conference reference was continually made to the fact that the efficiency of the meteorological organization is entirely dependent on the provision of an adequate system of radio communication. So far as New Zealand is concerned this aspect of the work is in the hands of the Aeradio Committee, and it is understood that steps are being taken to provide the necessary communication facilities.

The Conference was very successful and much useful work was accomplished. There is no doubt, too, that it was called at an opportune time. One important gain from it was that delegates representing civil aviation and those responsible for communications were able to appreciate thoroughly the meteorological problem. Their regular attendance and co-operation were greatly appreciated. Indeed, as is fortunately usual at meteorological conferences, a genuine desire for co-operation and a willingness to compromise where necessary was shown by all delegates. It is regretted that owing to the shortness of notice it was not possible for France and the Netherlands Indies to be represented.

It now remains for the various administrations concerned to give effect, so far as may be possible, to the various recommendations which were made. By this means only can a really adequate meteorological service be made available for trans-ocean flying in this region.

Staff.

During the past few years there has been a demand for University graduates with special qualifications in mathematics and physics which, for New Zealand, has been unprecedented. At present the supply of first-class men falls short of the demand.

Towards the close of the financial year Mr. B. V. Pemberton, who joined the Meteorological Office staff in September, 1910, proceeded on long leave prior to retiring on superannuation. Mr. Pemberton had throughout his service at the Meteorological Office taken a large part in the daily forecasting and the preparation of climatological data for the annual publications. In recent years he has prepared the great majority of the daily notes on the weather which appear in the Wellington press, as well as shared with the Director the preparation of the forecasts for the general public on Sundays and holidays, as well as ordinary week-days. Mr. Pemberton gave ready assistance to all inquirers for information, and was universally respected for his high character. The retirement, at this stage, of the only other senior officer with long experience has thrown a great deal of additional routine work on the shoulders of the Director.

It is a pleasure to record the loyal and cordial co-operation received from the staff during the present period of expansion of the service.

A list of the professional staff with their location follows:—

Meteorological Office, Wellington—

Kidson, E., Director, O.B.E., M.A., D.Sc., F.R.S.N.Z., F.Inst.P.
Barnett, M. A. F., Senior Meteorologist, M.Sc., Ph.D. (Cantab.), F.Inst.P.
Crust, A. G. C., Meteorological Assistant, M.Sc.
Seelye, C. J., Meteorological Assistant, M.Sc., Ph.D. (Edin.).
Gabites, J. F., Meteorological Assistant, M.Sc. (Hons.).
Ewing, R. A., Meteorological Assistant, B.Sc.
Robertson, N. G., Meteorological Assistant, M.Sc. (Hons.).
Green, C. G., Meteorological Assistant, M.Sc. (Hons.).
Watts, I. E. M., Meteorological Assistant, M.Sc. (Hons.).

Aviation Service Station, Auckland—
Macky, W. A., Meteorologist, M.Sc., Ph.D.
Stewart, C. W., Meteorological Assistant, B.Sc.
Dyer, W. R., Meteorological Assistant, B.Sc.
Aviation Service Station, Christchurch—
Larsen, L. N., Meteorologist, B.Sc.
Howell, E. H., Meteorological Assistant, M.Sc. (Hons.).
Rutherford, G. T., Meteorological Assistant, M.Sc. (Hons.).
Holding a Commonwealth Service Fund Fellowship—
Simmers, R. G., Meteorologist, Wellington, M.Sc. (Hons.).

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.
Notes 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 during the previous year for all stations.

(2) Volume of "Meteorological Observations": This contains monthly and annual means of pressure, temperature, wind, sunshine, and other climatological data from upwards of forty stations; monthly means for each hour of the day of pressure, temperature, rainfall, and sunshine at Wellington, and temperature at Alexandra; and a map showing departure from normal of rainfall over the whole country for the year concerned. The 1936 volume, the last to appear, contains reproductions of the barograph records at Wellington for the polar year, August, 1932, to February, 1934.

With so large a proportion of the staff having joined only recently and the great pressure of routine and organization work, it has again been possible to devote little time to investigations.

The following papers have been published:—

Meteorological Office Note No. 18, on "Some Comparisons of the Invigorating Effect of the Climate in Different Parts of New Zealand," by Dr. W. A. Macky. Reference was made to this last year.

Meteorological Office Note No. 19, on "Atmospheric Pollution at Wellington," by C. E. Palmer.

The following are in the press:—

Meteorological Office Note No. 20, on "Visibility and Upper Winds at Auckland, Wellington, and Christchurch," by L. N. Larsen.

Meteorological Office Note No. 21, on "Climatological Observations at Eastbourne, Wellington, and some Comparisons," by Dr. W. A. Macky.

Mr. Palmer's paper gives an account of a series of observations made at Wellington with a "dust-counter" of the type designed by Dr. J. S. Owens. This not only gives a count of the number of solid dust particles present in unit volume of the atmosphere, but enables their nature and size to be determined. The results are important from the point of view of health.

The paper by Mr. Larsen was prepared largely in his own time. It presents, in the forms prescribed by international agreement, the results of observations of visibility, cloud-heights, and wind direction and speed in the upper air from the available observations at Auckland, Wellington, and Christchurch. This information will be of use, particularly, to aviators.

Note No. 21 gives the results of a short series of observations made by Dr. Macky at Eastbourne, one of the eastern suburbs of Wellington, and then proceeds to discuss the variation of temperature in various parts of the Wellington area.

Dr. C. J. Seelye has commenced work on new monthly and annual rainfall maps of New Zealand for incorporation in the Centenary Atlas.

The Director himself has spent much time, almost entirely out of office hours, on the discussion of the Meteorology of the Australian Antarctic Expedition, 1911–1913, under the leadership of Sir Douglas Mawson. It is hoped that it will be possible to bring this to a conclusion within about a year.

Notes on the Weather for 1937.

January.—A cool and humid month. Rainfall above normal except in parts of Taranaki, Canterbury, and Otago, and particularly heavy in the north-eastern and far northern portions of the North Island. Cyclonic depressions visited the northern part of the Dominion on three occasions. Easterly gales in association with one of these caused damage in the Auckland Province on the 14th and 15th. In the south a series of deep westerly depressions passed between the 19th and 23rd and were accompanied by gales in many places. Pasture was abundant but rather soft. The milk yield was well maintained, but lambs did not fatten well. Shearing, which had been held over in some districts, was still further delayed, and the weather was rather unfavourable for crops.

February.—Cold and unsettled. In the North Island it was generally dry till towards the end of the month, when heavy rains fell in Taranaki and Western Wellington. Over the South Island the month was a very wet one. It was one of the coldest Februaries hitherto experienced. Frosts occurred on several occasions and snow fell on the ranges. The weather was controlled, principally, by a series of westerly depressions. Conditions were unfavourable for stock and also for the harvesting of crops. There was some sprouting of the wheat in the ear in Canterbury. Considerable mortality occurred amongst lambs. Floods were experienced in Taranaki, Western Wellington, and Otago and Southland in the latter part of the month. In the south they were very severe.

March.—Cold in the first half, but warm in the second. The weather was drier than in the preceding months and conditions more favourable for stock. The harvesting of the wheat crop continued, however, to be adversely affected by damp conditions. The crop of grass-seed was a poor one. A cyclonic depression which had developed in the New Hebrides region passed Norfolk Island on the night of the 25th, causing heavy rain and hurricane winds, but finally died out to the west of New Zealand on the 27th.

April.—Warm, dry, and pleasant during the first half; cold and wet in the second. The cold weather checked the growth of vegetation, and damage was done by early frosts. Snow fell on the mountains. Rainfall and temperature were both generally below average. Some deep westerly depressions passed in the latter part of the month.

May.—Cold during the first week; mild thereafter. Rainfall generally above normal. There was unusual growth of pasture for the time of year, but conditions continued to be more favourable for the dairying industry than for fattening stock. There was more snow than usual on the ranges at the end of the first week. The last week, however, was almost summerlike and much of the snow disappeared.

June.—Cold and damp. The growth of vegetation practically ceased. Rainfall was below average, but there were few drying winds. Many severe frosts occurred. Snow was down to low levels on the ranges. Conditions were unfavourable for agricultural work.

July.—Cold for the first eight days, but mild thereafter. Rainfall and mean temperature were again below average. Snow fell to low levels on the ranges on the 6th and the 16th to 17th.

August.—Mild, pleasant, and springlike. Rainfall much below average. Sunshine also below normal.

September.—Cloudy, but comparatively mild. Rainfall was, on the whole, below average, especially in the South Island, but conditions generally were sufficiently moist for vegetation to put forward good growth. There was snow on the ranges on the 27th.

October.—Cool, windy, very dry, and very sunny. Few places had less than 200 hours of sunshine. The atmosphere was clear and dry, and though the days were mild the nights were cold. There was a good deal of snow on the ranges. Frosts were frequent, but not specially severe and, though garden crops were damaged, fruit-trees were little affected. The growth of vegetation was generally poor and rain was badly wanted at the end of the month. Stock were in good condition.

November.—Continued dry during the first half, but beneficial rains fell in the second half. The total rainfall was above normal over the northern half of the North Island, but below it everywhere else. The shortage was very great over the South Island. Temperature and sunshine were both above average. Except in Marlborough, Otago, and parts of South Canterbury, feed for stock was generally plentiful. Lambs were fattening very well. There was some frost damage to vegetables and fruit-trees in the South Island.

December.—Very warm. Rainfall generally somewhat above average. In the North Island some very warm weather was experienced at the end of November and the beginning of December, and very high temperatures were recorded. On some of these occasions the atmosphere was extremely dry, and very serious forest fires occurred. There was little wind. Crops and pastures generally fared well. There was a tendency for early flowering and seeding, especially of grasses, but many good crops of hay and ensilage were gathered. Lambs were not faring quite so well as previously, but otherwise stock were in good condition and the milk yield well maintained.

Year.—The outstanding feature of the year was the cold and wet summer. Though there was good growth of vegetation, flowering and fruiting processes were very adversely affected. One result was that plants tended later on to bud and blossom at abnormal times, whenever a spell of mild weather gave encouragement. The effects seem scarcely yet to have disappeared entirely. The wheat crop suffered through damp conditions during harvest and some sprouting in the ear took place. The apple crop was a poor one. Conditions were unfavourable for the production of fat lambs. The milk yield was, however, satisfactory. April and May were relatively milder than the preceding months, but there was another cold spell in the early winter which gave vegetation a setback. After the first week in July mild and generally dry weather prevailed. At one stage it appeared that there might be a shortage of pasture, but such rain as occurred came at opportune times, and ultimately there was abundant growth in most districts. The lambing season was an excellent one, but again the feed was rather too soft for fattening. The apple crop promised very well, but the wheat crop only moderately so.

DOMINION OBSERVATORY.

REPORT ON THE ACTIVITIES OF THE DOMINION OBSERVATORY DURING THE YEAR ENDED 31ST DECEMBER, 1937.

BUILDINGS AND GROUNDS.

The Observatory buildings have been kept in good order. During the latter part of the year some of the officers of the Geophysical Survey were stationed at the Observatory, but in order to accommodate them arrangements had to be made with the Wellington Philosophical Society for the ante-room of their Observatory to be used temporarily as an office.

The Observatory grounds have been attended to periodically by the Wellington City Council.

TIME SERVICE.

Observatory Clocks.—During 1937 a total of 350 short-wave wireless time signals were received, from abroad, for checking the Observatory clocks. These were supplemented by 26 local transit observations. Interruptions in the daily checking due to disturbances in short-wave radio transmission made it more difficult to maintain the required accuracy in the time service, and errors exceeding half a second in the outgoing radio time signals occurred on three occasions during the year.

These circumstances point to the necessity of installing a precision clock at the Observatory, and as a step in this direction one of the Synchronome Co.'s Type B Slave clocks was installed in December. Just after the installation of this clock Mr. F. Hope-Jones, managing director of the Synchronome Co., London, visited the Observatory in the course of a world tour. He examined the clock, and expressed satisfaction with its installation.

Time Signals sent out.—The Observatory provides the following time signals, most of which are sent out automatically by the signal clock :—

(1) Time Signals by Radio :—

(*a*) Through Wellington Radio Station ZLW, daily at 10 h. 30 m. N.Z.M.T. (= 23 h. G.M.T.). In transmitting radio time signals the call sign of the Observatory is ZMO.

The following table indicates the order of accuracy of the ZLW signals during the year 1937 :—

Number of times error did not exceed 0·25 sec.	351
Number of times error between 0·25 and 0·50 sec.	11
Number of times error between 0·50 and 1·00 sec.	3
Number of times error exceeded 1·00 sec.	0
Total number of signals sent out	365

The errors of individual signals can be obtained on application to the Observatory.

There was a partial failure of the signals through ZLW on February 16, and a complete failure on April 13, both due to faults at the radio station. There was also a partial failure on April 24 due to a faulty clock contact at the Observatory.

(*b*) Through the National Broadcasting Stations, 2YA, Wellington, and 3YA, Christchurch, at 10 h. 30 m. : 15 h. 30 m. ; and 19 h. 30 m. N.Z.M.T. (=23 h. : 4 h. ; and 8 h ; G.M.T.) on week days and at 15 h. 30 m. N.Z.M.T. (=4 h. G.M.T.) on Sundays.

(2) Time Signals by Telegraph :—

(*a*) To the General Post Office and the Railways Department, Wellington, at 9 h. daily (except Sunday), for transmission to telegraph offices throughout New Zealand and railway-stations in the North Island.

(*b*) To the General Post Office, Wellington, for transmission to Auckland, at 20 h. 30 m. N.Z.M.T., on Tuesdays and Fridays. This signal was discontinued after October 31, 1937.

(3) Time Signals by Lights :—

(*a*) By signal lights exhibited at the Observatory daily at 20 h. 30 m., up to October 31, 1937.

(*b*) By signal lights exhibited at the Ferry Buildings, Auckland, transmitted to Auckland by telegraph, on Tuesdays and Fridays at 20 h. 30 m., up to October, 31, 1937.

The time signals by lights at Wellington and Auckland were discontinued after October 31, 1937. These signals were instituted in the early days of the Observatory for the benefit of seamen and others, but they have now been superseded by radio time signals.

(4) Time Signals by Telephone :—

Time signals are given in response to telephone calls. If specially required, the time is given to the nearest second : otherwise to the nearest minute only. During 1937 times to the nearest second were given on fifty-three occasions, and to the nearest minute on seventy-five occasions.

Public Clocks.—The Government Buildings clock was checked daily at 9 h. The rate of this clock is subject to erratic changes, and the error occasionally exceeds half a minute. The question of an automatic control from the Observatory is under consideration. During 1937 the maximum errors observed were 25 sec. fast and 61 sec. slow. On April 7 the clock was overhauled and reset by the Post and Telegraph Department. It was again adjusted on April 26.

The General Post Office clock was checked at 9 h. daily by observing the first stroke of the hour broadcast by station 2YA. The maximum errors observed during 1937 were 6 sec. fast and 9½ sec. slow.

A synchronous electric clock was checked daily at 9 h. and 15 h. The maximum variation in the readings during 1937 was 21 sec. This variation was observed over a period of seventy days, which was the longest uninterrupted run of the clock during the year.

Astronomy.

Apart from the time service, the official astronomical work of this Observatory is practically confined to solar observations and observations of occultations of stars by the moon. Other astronomical work, however, is carried out by Mr. Thomsen, in collaboration with the New Zealand Astronomical Society. This Observatory also makes provision for Mr. M. Geddes to carry out aurora and other astronomical observations in Southland.

Solar Observations.—During 1937 a total of 101 observations of sunspots was made with the 5 in. refractor of the Wellington Philosophical Society's Observatory. These observations are normally carried out by Mr. Thomsen, but during his absence at the solar eclipse in May and June the work was carried on by the Acting-Director. Results of the sunspot observations are sent to Zurich, and reports are published by the Solar Section of the New Zealand Astronomical Society. Reports of particularly active groups are also supplied to the local press.

Occultations.—Observations of occultations have been carried out by officers of this Observatory with the assistance of voluntary observers of the New Zealand Astronomical Society and in co-operation with the Wellington City Observatory. Occultations have also been observed at New Plymouth by the local astronomical society. During 1937 conditions for observing were not good, and consequently the number of observations was small. In order to facilitate the carrying-out of occultation observations, Mr. Thomsen keeps the 4 in. telescope and a chronometer at his residence. The New Zealand occultation observations are sent to the Computing Section of the British Astronomical Association.

Auroral Work.—The photographic recording of auroræ has been carried on in Southland under the direction of Mr. M. Geddes, assisted by Mr. D. C. Berry, of Invercargill. The two observing-stations are located at Winton and Invercargill respectively, giving a base line of about twenty miles. The installation of wireless as a better means of communication between the two stations has been proceeded with, and should be completed early in 1938. Better communication will result in a larger number of simultaneous photographs for the determination of the heights of auroræ. In the matter of establishing better communication, assistance given by the Radio Emergency Corps of the New Zealand Amateur Transmitters is gratefully acknowledged. During 1937 a number of important auroræ were recorded, and a total of 532 single photographs were taken, including 79 simultaneous sets. The working-up of these observations involves a considerable amount of labour, but a start has been made with the work. Reports of the aurora observations are published in the *Journal of the New Zealand Astronomical Society*, and Mr. Geddes also reports direct to Professor Stormer.

Solar Eclipse of June 8, 1937.—The expedition organized and led by Mr. C. W. B. Michie to observe the total solar eclipse of June 8, 1937, at Canton Island included Mr. I. L. Thomsen, of this Observatory, as official representative. The Department of Scientific and Industrial Research also made arrangements to enable Mr. M. Geddes to join the expedition. The expedition left Auckland by mail-steamer for Suva on May 14, and was conveyed thence to Canton Island in one of His Majesty's ships. Twelve days were spent on the island in preparation for the eclipse, which was observed under favourable conditions. After the eclipse, the expedition returned to New Zealand by way of Samoa. The results of observations of this eclipse appear to be very satisfactory. Preliminary reports have already been published in the *Journal of the New Zealand Astronomical Society* and elsewhere, while more detailed reports are still in course of preparation. The nine corona plates taken at Canton Island have been deposited at the Observatory by Mr. Michie.

Other Astronomical Work.—Other astronomical work carried out during the year included observations of the moon, Jupiter, Saturn, star clusters, and the zodiacal light, by Mr. Thomsen, the results of which have been published in the *Journal of the New Zealand Astronomical Society*. Mr. Thomsen gave lectures in astronomy at Wellington College and the Teachers' Training College. He also computed an ephemeris for Comet Finsler, which was well observed in the Northern Hemisphere.

A study of the spectrum observations of the eclipse of December 14, 1936, made by Mr. B. E. Stonehouse, was completed and published in the *Journal of the New Zealand Astronomical Society*.

Besides auroral work, Mr. Geddes has carried out other astronomical work, mainly solar observations, with the 5 in. refractor which he has on loan from this Observatory. Reports of his work are published in the *Journal of the New Zealand Astronomical Society*.

Seismology.

Seismic Activity in New Zealand during 1937.—Seismic activity in New Zealand during 1937 appears to have been slightly greater than during 1936. A larger number of shocks were reported felt, and the maximum intensity slightly exceeded that of 1936. The principal features of the activity in 1937 were as follows:—

(1) Three moderately powerful shocks and six aftershocks, all occurring on June 3 in the Coromandel Peninsula.
(2) Continuous activity along the zone of the main ranges of the North Island, preponderating between Dannevirke and Napier.
(3) Continuous activity along the depression or graben to the west of the main ranges of the North Island; from Wanganui through Taupo and Rotorua to Whakatane.
(4) Some minor shocks near New Plymouth.
(5) Continuous activity in west and north-west Nelson, comprising mainly small shocks of shallow origin.
(6) Occasional shocks in north Marlborough.
(7) A few minor shocks in the vicinity of Akaroa Peninsula.
(8) An occasional minor shock in Otago.

The North Auckland Peninsula has remained quite inactive. The apparent inactivity in the Southern Alps is somewhat surprising and may be due partly to lack of recording-stations in the region. Steps are being taken to establish one or two more reporting-stations on the west coast of the South Island.

A somewhat more detailed distribution of earthquake activity is shown on the accompanying map, where earthquake epicentres are indicated by black circles and crosses. The black circles indicate the positions of the 43 epicentres determined from seismograph records. Most of these are accurate to within about fifteen miles. The crosses indicate small shocks which it was possible to locate within about thirty miles solely from non-instrumental reports. Preliminary epicentres in the south-west Pacific generally are shown on the small inset map.

Information regarding felt earthquakes is furnished by officers of the Post and Telegraph Department, officers of the Marine Department, and several private observers. There are about 120 non-instrumental reporting stations distributed throughout the Dominion.

A total of 179 shocks was reported felt during the year, of which 126 were felt in some part of the North Island and 56 in some part of the South Island. Only three shocks were felt in both Islands. The maximum intensity was R.-F. 6–7, which occurred in the Hauraki Peninsula on June 3.

The following table shows the number of earthquakes reported felt and the maximum intensity reached, for each month of the year 1937:—

Month.	Number of Earthquakes reported felt.				Maximum Intensity R.-F.	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Whole of New Zealand.		
January	15	4	..	19	5+	Waiotapu.
February	9	3	1	11	6	Hastings.
March	5	5	1	9	5	Stephens Island.
April	10	7	..	17	5+	Puysegur Point.
May	18	16	1	33	5	Whakatane.
June	17	3	..	20	6–7	Hauraki Peninsula.
July	13	1	..	14	6	Hawke's Bay, Manawatu.
August	6	7	..	13	5	Hicks Bay.
September	9	1	..	10	4	Dannevirke, Upper Takaka.
October	11	4	..	15	6	Opotiki, Kahurangi Point.
November	3	2	..	5	6	Southern Hawke's Bay.
December	10	3	..	13	5	Waipawa, Upper Takaka.
Totals	126	56	3	179	..	

The following list gives some particulars of those earthquakes during 1937 in which the maximum intensity reached or exceeded R.-F. 6:—

New Zealand Mean Time.	Approximate Position of Epicentre.		Remarks.
	Latitude.	Longitude.	
1937. d. h. m.	°	°	
Feb. 3 05 42	..	..	Felt at Hastings, R.-F. 6.
Apr. 11 16 20	45·5	166 E.	Felt at Puysegur Point, R.-F. 5+.
June 3 11 34	37·0 S.	175·8 E.	Felt in Hauraki Peninsula, max. R.-F. 6–7; also felt at Auckland.
July 8 00 20	40·4 S.	176·6 E.	Felt in southern part of North Island, R.-F. 6 at Palmerston North.
13 22 22	39·4 S.	177·25 E.	Felt fairly widely in North Island, max. R.-F. 6 in southern Hawke's Bay.
Oct. 12 03 22	41·2 S.	172·2 E.	Felt in West Nelson region, max. R.-F. 6.
24 04 24	37·9 S.	177·8 E.	Felt Raukaumera Peninsula, max. R.-F. 5–6.
25 22 04	37·9 S.	177·8 E.	Felt at Opotiki, R.-F. 6.
Nov. 15 13 48	39·7 S.	176·4 E.	Felt at Waipawa and Hastings, R.-F. 6.

DOMINION OBSERVATORY.

NEW ZEALAND

SHOWING

Distribution of Earthquake Activity in 1937.

SCALE

MILES 10 0 50 100 150 200 MILES

KILOMETRES 10 0 100 200 300 KILOMETRES

INDEX OF EPICENTRES.

1	Feb. 3	29	Sept. 1
2	,, 14	30	,, 28
3	,, 16	31	Oct. 1
4	Mar. 24	32	,, 2
5	Apr. 9	33	,, 11
6	,, 11	34	,, 12 (2h. 16m.)
7	,, 13	35	,, 12 (8h. 40m.)
8	,, 20	36	,, 23 (1h. 54m.)
9	,, 23 (3 shocks)	37	,, 23 (16h. 54m.)
10	May 19	38	,, 25
11	,, 30	39	Nov. 12
12	June 3 (3 shocks)	40	,, 15
13	,, 6	41	Dec. 28
14	,, 15	42	,, 29 (13h. 15m.)
15	,, 18	43	,, 29 (14h. 20m.)
16	July 2		
17	,, 7		
18	,, 13		
19	,, 19		
20	,, 28		
21	,, 30		
22	Aug. 2		
23	,, 12		
24	,, 13		
25	,, 14		
26	,, 18		
27	,, 22		
28	,, 30 (4 shocks)		

● ... Epicentres determined.

+ ... Small shocks felt in localities indicated. (Epicentres of these not determinable, but in most cases within about 30 miles of position of cross.)

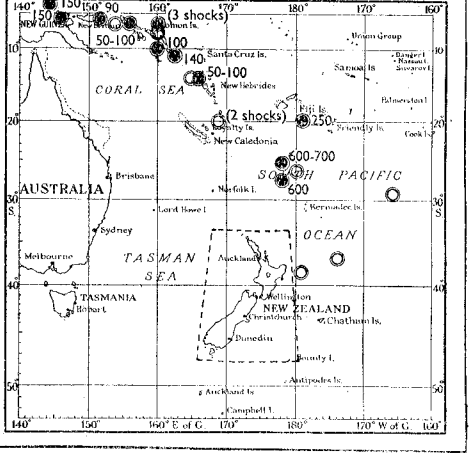
Places named indicate seismograph stations.

KAITAIA
ARAPUNI
TUAI
NEW PLYMOUTH
STRATFORD
HASTINGS
BUNNYTHORPE
TAKAKA
WELLINGTON
GREYMOUTH
CHRISTCHURCH
MONOWAI

EPICENTRES IN SOUTH-WEST PACIFIC.

(Not including those shown on main map).

Normal focus ◎ Deep focus ◉ (Depths given in kms.)



Seismograph Stations.—Besides the Dominion Observatory, Wellington, and the Magnetic Observatory, Christchurch, thirteen subsidiary stations were operating in New Zealand during the whole or part of 1937. Eight of these are operated by officers of other Government Departments, two by officers of Electric-power Boards, and three by private individuals.

The following table gives the number of earthquakes recorded at the New Zealand Seismograph Stations during the year 1937 :—

Stations.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Class I.													
New Plymouth	10	16	5	7	1	13	9	14	12	13	3	7	110
Wellington	20	29	24	51	49	23	28	22	28	35	30	24	363
Christchurch	8	13	6	12	20	4	11	15	12	11	11	5	128
Class II.													
Rotorua	4	2	..	0	0	0	0	0	0	0	0	0	6
Tuai	..	1	1	2	1	0	1	3	0	4	1	1	15
Stratford	..	1	..	0	0	0	0	..	0	0	1	0	2
Hastings	5	9	2	5	1	2	7	1	2	4	3	5	46
Bunnythorpe ..	..	..	..	0	2	0	2	0	0	0	0	0	4
Takaka	1	3	..	0	0	0	1	0	0	0	0	0	5
Greymouth	..	..	..	0	0	0	0	0	0	0	0	0	0
Monowai	2	..	..	1	0	0	1	0	0	0	0	0	4
Class III.													
Kaitaia	..	..	1	..	..	..	..	..	..	..	..	..	1
Arapuni	9	3	1	3	2	6	7	5	10	3	6	4	59
Wellington	28	12	10	13	13	13	21	23	30	35	38	27	263
Chatham Islands ..	..	..	..	3	..	..	3	2	..	3	1	2	14
Christchurch ..	29	15	9	14	23	15	16	21	24	26	38	40	270

Blank spaces in the above table indicate that the records have been rendered incomplete through a temporary breakdown of the seismograph. It will be seen that in Class II there are gaps in the records of all the stations except Hastings; and in Class III for Kaitaia and Chatham Islands.

The stations in Class I possess sensitive Wood-Anderson seismographs for recording local earthquakes; those in Class II local strong-motion recorders, mostly of Jaggar type; and those in Class III teleseismic instruments only. As Wellington and Christchurch have both local and teleseismic instruments, these stations appear in both Classes I and III. The numbers recorded by stations in Class I therefore represent local earthquakes of all intensities. The greater number recorded at Wellington may be due partly to conditions being more favourable there for recording small local shocks, but also indicates greater activity in the region. The numbers in Class II represent only the more prominent local shocks, while those in Class III represent mostly distant earthquakes. Here the larger numbers recorded at Wellington and Christchurch are due to the instruments at these stations being more sensitive than those at Arapuni and Chatham Islands.

Improvements to the seismograph equipment at this Observatory carried out during the year include (1) the installation of a three-component strong-motion seismograph of low magnification for the recording of heavy local shocks; (2) improvement in the installation of the Wood-Anderson seismograph; and (3) the temporary erection of a Jones short-period vertical seismograph for the better recording of P-waves from small local shocks.

The E.-W. component Milne-Shaw was moved to Kaitaia in January to operate as a new station there. The records so far have been very incomplete owing to various difficulties arising in connection with the installation of the seismograph. The chief trouble appears to be due to excessive tilting of the ground in the locality of the seismograph station, but attempts are being made to overcome this.

The Jaggar station previously operating at East Cape lighthouse has been closed temporarily, it having been found impossible to maintain the seismograph there under present circumstances.

The Jaggar seismograph at Rotorua, formerly operated by the Tourist Department, was taken over by the Public Works Department in July.

The Wood-Anderson seismograph at New Plymouth suffered occasional interruptions during the year owing to stoppages of the driving clock. However, as the result of an overhaul of the clock carried out in November, and other adjustments made during the year, there has been a marked improvement in the records from this station.

In July the original Imamura strong-motion seismograph was re-installed at Takaka, and the station was equipped with apparatus for maintaining accurate timing on the records.

The installation of a new synchronome clock at the Magnetic Observatory, Christchurch, has resulted in an improvement in the timing on the records of this station.

Tiltometer.—During February, 1937, the Ishimoto Silica Tiltometer which was broken by the severe earthquake of March 5, 1934, was successfully repaired by Mr. J. M. Steele, of the National and Electrical Engineering Co., Auckland, and the instrument was re-installed in the Observatory cellar to record the E.-W. component of the tilting of the ground. It is considered that tilt records are likely to provide valuable data on local land movements, and may finally be of some assistance in the problem of earthquake prediction. It would be desirable to have tiltometers of some sort located in various parts of the country.

Research Work.—The following seismological research work was carried out by the Acting-Director during the year: (1) Further investigations into the effects of atmospheric pressure on the

occurrence of earthquakes, followed by publication of a paper on this subject; (2) preliminary investigation of the Observatory tilt records for the period 1930 to 1934, and the preparation of a report for publication.

The improvements to some of the seismograph stations recently carried out have enabled some definite progress to be made with the study of local earthquakes and related problems, but some additional well-equipped stations are required. Mr. Jones has made a detailed study of the data provided by recent local earthquakes, and has prepared some material for publication. At the same time Dr. Bullen has also been working on this problem, using earlier data. There appears to be reasonably good agreement between different investigators as to the general nature of the crustal structure in the New Zealand region, but a determination of the actual thickness of the various layers, the focal depths of local earthquakes, and the velocity of seismic waves cannot be satisfactorily carried out without some additional stations with sensitive local recorders and accurate timing apparatus. Steps are being taken to establish additional stations on these lines.

Dr. Bastings has been working on the determinations of south-west Pacific epicentres and related problems in co-operation with the Observatory.

Geophysical Work.—Mr. Watson-Munro carried out radioactive investigations from time to time during the year. In February and March he was engaged in magnetic work in the Rotorua district in connection with a survey of the volcanic and thermal regions by Dr. Arthur L. Day, of the Carnegie Institution of Washington.

Mr. Jones was engaged in magnetic work in the Takaka-Collingwood district during part of January and February.

These officers have furnished reports of their geophysical work direct to the Secretary of the Department.

Officers of the Geophysical Survey were stationed at the Observatory during the latter part of the year.

Workshop.

During the year the Observatory workshop has been improved by the addition of a Driver electric-power drilling-machine, and a Starrett dial-test indicator, as well as tools and other small appliances. During the first part of the year the construction of a new Imamura strong-motion seismograph was carried on, and the work was completed in June. Further work on the construction of seismographs was interrupted owing to the workshop being required for urgent work on the apparatus for the geophysical survey during the latter part of the year. A large amount of instrument-making work is at present in hand.

The maintenance of a workshop at the Observatory has the advantage of enabling instruments to be constructed at considerably less cost than otherwise, and, in addition, urgent repairs can be carried out on the premises with a minimum loss of time.

Publications.

The Observatory has continued to publish a monthly cyclostyled seismological bulletin giving readings from all New Zealand seismograph stations. The bulletins published during 1937 cover the period 1936 January–April and 1936 December–1937 November.

The following Observatory bulletins were also published during 1937:—

Bulletin 108.—A Subsoil Survey of Wellington City. (L. Bastings.)
Bulletin 111.—The Seismicity of New Zealand Cities and Towns. (R. C. Hayes.)
Bulletin 118.—Observations during the Disappearance of the Rings of Saturn, June, 1936. (I. L. Thomsen.)
Bulletin 119.—Tables for the Reduction of Apparent Travel-times of P and S Seismic Waves. (K. E. Bullen.)
Bulletin 120.—The Position of New Zealand Auroræ. (M. Geddes.)
Bulletin 121.—The Seismological Aspects of the Wairoa Earthquake of September 16, 1932. (R. C. Hayes.)
Bulletin 123.—The Hawke's Bay Earthquake of 1921, June 29. (K. E. Bullen.)
Bulletin 124.—Earthquakes and Atmospheric Pressure (2nd paper). (R. C. Hayes.)
Bulletin 125.—Annual Report of the Dominion Observatory for 1936.
Bulletin 126.—Some Seismological Aspects of the Buller Earthquake—Part III. (L. Bastings.)
Bulletin 127.—Some Seismological Aspects of the Buller Earthquake—Part IV. (L. Bastings.)

An article on "Earthquakes in New Zealand" was prepared for the "New Zealand Official Year-Book," 1938, and articles on "Time Service Arrangements" were prepared for the Year-Book and for the "New Zealand Nautical Almanac."

Staff.

During 1937 the following officers were engaged in the Observatory work: Mr. I. L. Thomsen, Observatory Assistant; Mr. C. M. N. Watson-Munro, Observatory Assistant; Mr. W. M. Jones, Assistant Seismologist; Mr. G. S. Marshall, Instrument-maker; Miss K. R. Tullett, Shorthand-typiste.

R. C. Hayes, Acting-Director.

APIA OBSERVATORY, SAMOA.

Director: J. Wadsworth, M.A.

The observatory at Apia continued during the year 1937–38 its usual routine of work in geophysical subjects.

Terrestrial Magnetism.

The Godhavn balance and the Eschenhagen variometers of declination and horizontal force operated continuously except during a period of three months commencing in July, 1937, when the roof of the Gauss House was under repair. The kerosene burners of the recording lamps were replaced in April by electric bulbs taking current from the mains through a transformer. A test of the variometers for temperature compensation showed that we cannot annul completely the effect of temperature on the Godhavn balance; but we were able to eliminate it almost completely in the variometer for horizontal force.

The instruments used for absolute observations were magnetometer No. 9 C.I.W. (on loan through the courtesy of the Carnegie Institution of Washington) and the Schulze earth inductor No. 2. These instruments were standardized in June, 1937, on behalf of the Carnegie Institution by Mr. W. C. Parkinson.

The revision of declination measurements for the period 1932–34 rendered necessary by the discovery in 1935 of a defect in the old Tesdorpf magnetometer has been satisfactorily completed.

Seismology.

The seismographs at Apia—namely, a Wiechert horizontal seismograph (mass 1,000 kilograms) and a Wiechert vertical seismograph (mass 80 kilograms) originally installed more than thirty years ago—have been maintained in use during the year under consideration. The vertical seismograph was unsatisfactory until July, 1937, when Mr. Wadsworth introduced some slight modifications of design which have increased the sensitivity of the instrument and improved the scope of the records of all three components. In particular the instrument is able to record the vertical component of microseisms.

The approximate geographical positions of five important earthquakes since July, 1937, were indicated by the records of the instruments at Apia alone, and in one example the depth of focus was correctly given as well. A swarm of small shocks of unknown origin were recorded in October, 1937.

Meteorology.

The routine work in meteorology comprises surface observations made twice a day and frequent measurements of upper winds. Climatological summaries are also prepared, and synoptic charts of the weather in the south-west Pacific Ocean are plotted every day. New charts for synoptic work were introduced in September, 1937, having a scale of 1 : 20,000,000. The Piché evaporimeter was removed from its position on the veranda in November and placed in a small Stevenson screen.

Meteorological Summary, Apia, 1937.

Month.	Pressure.	Temperature.	Rainfall.	Humidity. (9 a.m.)	Sunshine.	Wind.
	In.	°F.	In.	Per Cent.	Hours.	Miles per Hour.
January ..	29·744	80·2	15·20	80	220·7	7·4
February ..	29·779	80·3	15·85	81	151·5	7·6
March	29·769	79·3	16·15	81	187·2	5·9
April	29·814	80·0	9·41	80	212·2	6·3
May	29·872	79·0	15·59	77	218·0	7·5
June	29·867	78·8	0·65	76	245·7	7·9
July	29·861	79·0	2·02	76	259·7	7·8
August	29·861	78·8	6·26	78	223·4	11·0
September ..	29·902	78·4	5·46	74	223·2	6·9
October ..	29·866	79·2	9·28	77	205·5	8·4
November ..	29·799	79·7	4·56	74	225·1	5·8
December ..	29·767	79·7	11·17	76	192·5	5·4
Total ..	..	..	111·60	..	2,564·7	..
Mean ..	29·825	79·4	..	77	..	7·3

Atmospheric Electricity.

The observations with the Benndorf electrometer were continued under the guidance of the Carnegie Institution of Washington, who provide a grant-in-aid for this purpose. Absolute observations during the dry season of 1937 showed that the fall of a tree standing near by had not affected the value of the reduction factor. The leak-free method for absolute observations was used for the first time in March, 1938.

The mean values, expressed in volts per metre, of the gradient of potential at Apia during 1937 are as follows: January, 120; February, —; March, 97; April, 113; May, 115; June, 127; July, 133; August, 121; September, 124; October, 122; November, 130; December, 147. These figures refer to days during which no negative potential occurred.

Time Service.

The "Synchronome" clock, which provides time marks for the seismographs and magnetographs, and the standard clock by Strasser and Rohde No. 381 were cleaned and adjusted during the year. The indications of the standard clock were controlled by time signals received by wireless telegraphy from Honolulu and San Francisco.

Tides.

The tide-gauge at the Lagoon House remained in operation throughout the year, the readings obtained with it being sent as in former years to the Coast and Geodetic Survey at Washington, D.C., U.S.A.

Buildings.

Besides the repairs in the Gauss House described in the section on terrestrial magnetism, the roof of the transit hut was repaired in June, 1937, and a new wing of the office consisting of three rooms was completed in February, 1938.

Staff.

The Director returned from the Meteorological Office, Wellington, to assume control of the Observatory again on 16th April, 1937. Mr. W. R. Dyer was appointed to a position in New Zealand as Meteorological Assistant, and left Apia on 24th June, 1937.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

Director: H. F. Skey.

SUMMARY OF OPERATIONS FOR THE YEAR ENDED 31st MARCH, 1938.

During the year the usual magnetic, seismological, and meteorological observations have been made.

Terrestrial Magnetism.

The Eschenhagen magnetographs at Amberley Substation and the high-speed La Cour and the Adie magnetographs have been kept recording continuously. From hourly measurements of the magnetograms and twice monthly absolute observations the mean hourly values of D, H, and Z have been collected and tabulated. The mean monthly values of the magnetic elements obtained from the mean hourly values for all days for 1937 are :—

1937.	D.	H.	Z.
	° ′		
January	18 12·2 E.	22305γ	—55204γ
February	18 12·3	22289	55208
March	18 12·6	22280	55201
April	18 13·3	22270	55199
May	18 13·9	22271	55212
June	18 14·1	22283	55226
July	18 14·5	22286	55215
August	18 14·9	22281	55218
September	18 15·4	22288	55208
October	18 15·2	22268	55208
November	18 14·9	22284	55189
December	18 15·7	22288	55194
Year	18 14·1	22282·7	55207·2
Δfrom 1936	+4·2	—18·5γ	+12·7γ (numerical decrease).

	Y.	X.	T.	ϕ
Year	06972·5γ	21163·8γ	59534·3γ	—68° 01′·20
Δfrom 1936	+19·9γ	—26·1γ	—18·0γ	—0′·74

The rate of mean annual change, or secular change, is somewhat larger than for the previous year. The increase of sun-spottedness has continued, and at present the indications are for a high maximum.

In response to requests, a large amount of data has been got out and sent to overseas investigators and others in connection with magnetic storms during the year.

To improve local observations a Synchronome clock has been provided for the Observatory, and is performing well. It has been found that there is a decided diurnal variation in the variability of H within the hour here. Special tabulation of this has been made for ionosphere research. A minimum at 10 h. a.m. (N.Z. summer time) and a maximum at 16 h. to 18 h. have been shown to exist, with a secondary maximum at 8 h. a.m. and a maximum rate of increase just before noon. It seems impossible to ascribe this to anything else than variation of ionization in the higher atmosphere, and it seems very desirable that continuous recording of the virtual heights of reflecting regions in the ionosphere should be carried out. It is understood that preparations are being made for this.

The Bendorf electrometer has been kept continuously recording.

Cosmic-ray observations have been continued successfully, and variations with certain magnetic storm effects have been detected.

Research on microseisms is proceeding.

STAFF.

The following is a list of the administrative and professional officers of the Department as at 31st March, 1938:—

HEAD OFFICE, WELLINGTON.

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New Zealand House, London.

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Assistant Scientific Liaison Officer: W. M. Hamilton, M.Agr.Sc., Dip. Hort.

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Research Officer: K. Cottier, B.Agr.Sc.

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Assistant Botanists—
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V. D. Zotov.

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Assistant Chemist: L. H. Bird, M.Sc.

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Assistant Leather Research Chemist: F. G. Caughley, M.Sc., B.A., A.N.Z.I.C.

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